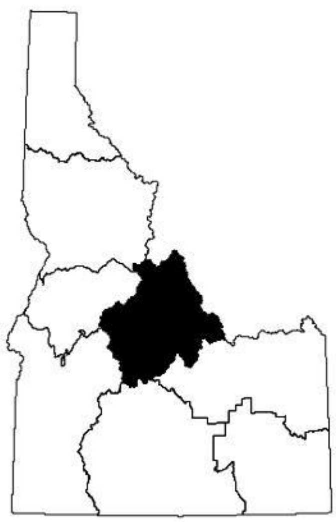
FISHERY MANAGEMENT INVESTIGATIONS

IDAHO DEPARTMENT OF FISH AND GAME

FISHERY MANAGEMENT ANNUAL REPORT

Jim Fredericks, Director



SALMON REGION

2022

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ABSTRACT

Regional fisheries staff coordinated with Mackay Fish Hatchery and Sawtooth Flying Service to stock 52,047 fish across 58 high mountain lakes in the Salmon Region in 2022. A total of 37 lakes were stocked with a combined total of 24,067 Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, 8 lakes with 5,653 triploid Rainbow Trout *O. mykiss,* five lakes with 2,583 Golden Trout *O. aguabonita*, four lakes with 1,503 Arctic Grayling *Thymallus arcticus*, and one lake with 400 tiger trout (Brown Trout *Salmo trutta* × Brook Trout *Salvelinus fontinalis*). Fish were stocked via fixed wing aircraft (*n* = 53 lakes) or hiked in with backpacks (*n* = 2 lakes) between August 1 and October 13, 2022. Aerial stocking costs totaled $6,840 for three separate flights in 2022. Fisheries staff also surveyed 23 high mountain lakes to determine fish and amphibian presence, species composition, relative abundance, and evaluate population size structure and fish condition (W_r). Lakes were chosen based on statewide fisheries research needs, lack of recent data, and perceived public use. Surveys were conducted between August 10 and October 6, 2022. Fish were present at all 23 surveyed lakes. Westslope Cutthroat Trout was the most common species, occupying 65% of lakes, followed by Rainbow Trout (26%), Rainbow Trout × Westslope Cutthroat Trout hybrids (17%), Golden Trout (17%), Arctic Grayling (4%), Brook Trout (4%), and tiger trout (4%). Amphibians were present at 14 of the lakes. Columbia spotted frogs *Rana luteiventris* occupied 57% (*n* = 13) of HMLs, long-toed salamanders *Ambystoma macrodactylum* occupied 9% (*n* = 2) of HMLs, and Western toads *Anaxyrus boreas* occupied 4% (*n* = 1) of HMLs.

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INTRODUCTION

High mountain lakes (HMLs) offer unique angling opportunities in scenic areas and are an important contributor to Idaho's recreational economy. These lakes are generally only accessible by foot or horseback and offer anglers solitude in remote backcountry terrain. Anglers in Idaho have consistently expressed high satisfaction with their HML fishing experience (IDFG 2019). As such, Idaho Department of Fish and Game (IDFG) has management objectives to continue to provide quality HML fishing opportunities (IDFG 2019).

The Salmon Region contains approximately 1,200 HMLs. These range from small ponds less than one hectare in size to 70 ha Sawtooth Lake #1 in the Sawtooth Valley. Regional HML elevations range from 1,970 m to over 3,000 m. Fisheries staff estimate that nearly 400 HMLs in the region provide fishing opportunity, either aided by stocking or natural reproduction.

Since the vast majority of HMLs in Idaho were historically fishless, fish stocking plays a critical role in providing and managing high mountain lake angling opportunities. The Department primarily stocks four fish species in high mountain lakes, typically on a three-year rotation: Westslope Cutthroat Trout *O. clarkii lewisi* (WCT), Rainbow Trout *O. mykiss* (RBT), Arctic Grayling *Thymallus arcticus* (GRA), or Golden Trout *Oncorhynchus aguabonita* (GNT). Fish are typically stocked as fry (TL <76 mm). The three-year stocking rotation helps maintain a diverse size structure of fish and provides angling opportunity in mountain lakes where natural reproduction is not sufficient to support fishable populations. The stocking rotation list is adjusted annually to reflect the most currently available survey information and current management goals. As of September 2022, 55 lakes are scheduled for stocking on rotation A, 70 lakes on rotation B, and 54 lakes on rotation C.

In particular cases, IDFG will introduce and supplementally stock predator species such as tiger muskellunge (Northern Pike *Esox lucius* × Muskellunge *E. masquinongy*) or tiger trout (Brown Trout *Salmo trutta* × Brook Trout *Salvelinus fontinalis*) in HMLs to reduce abundance of other fish species (e.g., Brook Trout; BKT). Currently, the Salmon Region maintains two HMLs where tiger trout have been introduced to eradicate or suppress BKT.

Although HML fisheries and anglers benefit from fish stocking, another aspect of stocking that IDFG considers is the potential ecological effects on native fishes and amphibians. Due to the potential of introgression or hybridization between hatchery and wild fish, IDFG's hatchery programs have developed a process to produce triploid fish (Koenig et al. 2011). These triploid individuals are unable to reproduce, thereby reducing the potential effects on downstream native salmonid populations. The two species generally stocked in HMLs as triploids are RBT and WCT. IDFG also documents the existence of native amphibians, and, where feasible, will maintain certain HMLs as fishless to provide suitable amphibian habitat. Overall, IDFG staff use available fish and amphibian distribution and abundance data in efforts to balance native species conservation with providing diverse alpine angling experiences.

To assess fish and amphibian occurrence and relative abundance and evaluate fish stocking densities within HMLs throughout the Salmon Region, fisheries staff conducted 23 standardized HML surveys in 2023.

OBJECTIVES

High Mountain Lake Stocking

Provide diverse high mountain lake fisheries throughout the Salmon Region (i.e., diverse species and size structure), with emphasis placed on high-use areas where natural reproduction does not occur.

High Mountain Lake Surveys

- Assess fish growth and relative abundance in stocked high mountain lakes and gather current fish community data in lakes where stocking never occurred or was discontinued.
- Identify lakes that currently support naturally reproducing fish populations and determine if natural reproduction is adequate for maintaining quality fisheries.
- Provide up-to-date fishery information to anglers and statewide databases.
- Inform future mountain lake fisheries management and stocking recommendations.
- Consider ecological effects of fish stocking on the long-term persistence of native fish and amphibians to inform future stocking decisions.

STUDY AREA

There are an estimated 1,200 HMLs within the Salmon Region. These range from small temporary ponds less than one hectare in size to large lakes up to 70 ha, with elevations up to 3,182 m. High mountain lakes stocked (*n* = 58) and surveyed (*n* = 23) in 2022 (*n* = 58) were within the Salmon-Challis National Forest or Frank Church-River of No Return Wilderness (Figure 1). Predominant land cover throughout the region consists of coniferous forest at high elevations (up to 3,277 m) and sagebrush-grass steppe at low elevations.

METHODS

High Mountain Lake Stocking

High mountain lake stocking densities and species requests are coordinated between regional staff and Mackay Fish Hatchery staff each spring. Fish are hatched and reared at Mackay Fish Hatchery, who coordinates with the contracting aviation company (Sawtooth Flying Service, McCall, ID) to stock the lakes with the correct species and numbers of fish. Actual stocking numbers and locations can vary from the request in some years, due to a surplus or deficit in fish, or to accomplish specific management objectives. Rotation C lakes were requested to be stocked in 2022 (Table 1; Figure 1). Each stocking rotation usually requires multiple flights or days to complete. Flight routes for each rotation were refined in recent years to keep flight time and fuel costs efficient. Further details of regional aerial stocking methodology were reported in Flinders et al. (2013). U P Lake was stocked via backpack, as there was a flight restriction associated with the fire activity from the Moose Fire complex. Quake Lake was also stocked via backpack.
High Mountain Lake Surveys

Salmon Region fisheries staff surveyed 23 HMLs in 2022 (Figure 1). Of the 23 HMLs surveyed, 21 are currently on a three-year stocking rotation (C) and the other two lakes were opportunistically surveyed. Fish presence and relative abundance at 18 HMLs was assessed using a combination of angling and one to two (depending on lake surface area) mountain lake gill net(s) fished overnight. Gill nets were either floating- or sinking-style depending on equipment availability and sampling logistics (e.g., sunken woody debris, etc.). Fish presence and relative abundance at the remaining five lakes were estimated via angling surveys. Fish collected during angling surveys were measured to the nearest mm total length (TL), and then released alive. For each sampling gear (e.g., sinking gill net), relative abundance was indexed as CPUE by summing the number of fish caught divided by the number of sampling hours exerted (fish/hour).

Monofilament gill nets were 36 m long by 1.8 m deep, and composed of six panels of 10.0-, 12.5-, 18.5-, 25.0-, 33.0-, and 38.0-mm mesh. Captured fish were measured to the nearest mm (TL) and weighed to the nearest gram (g). Mean TL for each species, at each lake, and standard errors (± SE) were calculated. Relative weights (W_r) were also calculated for BKT (TL ≥ 120 mm), GNT (TL ≥ 120 mm), GRA (TL ≥ 150 mm), RBT (TL ≥ 120 mm), and WCT (TL ≥ 130 mm) using the standard weight (W_s) equation:

$$Log_{10}(W_s) = a + b * Log_{10}(\text{total length (mm)})$$

where *a* = the intercept value and *b* = slope derived from Neumann et al. (2012) for BKT, GNT, RBT, and WCT, and Gilham et al. (2021) for GRA. The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$W_r = \left(\frac{\text{weight (g)}}{W_s}\right) * 100$$

Fish spawning potential and the presence of natural reproduction was visually and subjectively assessed at each lake based on the presence of redds, juvenile fish (fry, fingerlings, or both), and a review of past stocking history. Physical characteristics of each lake, weather conditions at the time of survey, access information, and the amount of human use were also recorded. Human use was subjectively classified as none, low, moderate, or high based on visual observation. The presence and relative abundance of amphibians was assessed using a modification of the timed visual encounter survey (VES; Crump and Scott 1994). The main deviation from the VES methodology was that the survey crew performed a full perimeter search without accounting for various habitat types. All survey data was entered into the statewide 'Lakes and Streams Survey' database.

RESULTS AND DISCUSSION

High Mountain Lake Stocking

Fifty-five HMLs in the Salmon Region were stocked between August 1 and October 13, 2022 (Table 1; Figure 1). Lakes were stocked via either backpack (*n* = 2 lakes) or fixed-wing aircraft (*n* = 53 lakes). Flight costs totaled $6,840.00 across three flights, equating to approximately $127 per lake. In total, 42 lakes were stocked with 41,908 WCT, 8 lakes with 5,653 RBT, 5 lakes with 2,583 GNT, 4 lakes with 1,503 GRA, and 1 lake with 400 tiger trout (BB; Table 1).

High Mountain Lake Surveys

Twenty-three HMLs were sampled in the Salmon Region between August 10 and October 6, 2022 (Figure 1; Table 2). Fish were present at all 23 surveyed HMLs, consisting of seven different trout species. Westslope Cutthroat Trout was the most common species, occupying 65% (n = 15) of HMLs, followed by RBT (26%; *n* = 6), RBT × WCT hybrids (17%; *n* = 4), GNT (17%; *n* = 4), GRA (4%; *n* = 1), BKT (4%; *n* = 1), and BB (4%; *n* = 1; Table 3). Amphibians were present at 14 HMLs. Columbia spotted frogs *Rana luteiventris* occupied 57% (*n* = 13) of HMLs, long-toed salamanders *Ambystoma macrodactylum* occupied 9% (*n* = 2) of HMLs, and Western toads *Anaxyrus boreas* occupied 4% (*n* = 1) of HMLs.

Airplane Lake

One sinking-style gill net was set in Airplane Lake for 14.4 h and caught nine RBT, seven WCT, three RBT × WCT, and two GNT (combined CPUE = 1.5 fish/h; Table 3). Two anglers caught five WCT and five RBT × WCT in 3.5 h (combined CPUE = 2.9 fish/h; Table 3). Total length of RBT ranged from 94 to 360 mm with an average of 257 mm (± 28.7; *n* = 9; Figure 2), WCT ranged from 90 to 330 mm and averaged 249 mm (± 22.7; *n* = 7; Figure 2), RBT × WCT ranged from 183 to 255 mm and averaged 207 mm (± 9.3; *n* = 3; Figure 2), and the two collected GNT were 205 and 212 mm (Figure 2). Relative weights varied by species but were generally near or below 100 (mean W_r = 92, range = 78 to 105; Figure 3). Relative weights of RBT appeared to decline with TL (Figure 2). Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. Airplane Lake offers diverse fishery opportunities by harboring multiple species and natural reproduction was documented. Currently, Airplane Lake is stocked at a density of 159 WCT/ha (*n* = 1,000). A reduction in the stocking request or discontinuing stocking will likely allow natural reproduction to sustain the fishery and potentially increase size structure and average relative weight. Reducing the stocking density to 80 WCT/ha (*n* = 500) is recommended.

Birdbill Lake

Four anglers caught 13 WCT in 4.5 h (combined CPUE = 2.9 fish/h; Table 3). Total length of WCT ranged from 200 to 267 mm with an average of 226 mm (± 5.8; *n* = 13; Figure 2). Adult Columbia spotted frogs were observed during the amphibian VES. Birdbill Lake offers high catch rates of WCT, though a smaller size structure of fish. No change in stocking density is recommended to maintain high catch rates since this lake is easily accessible from the trail, and angler use is moderate to high.

Buck Lake

One floating- and one sinking-style gill net was set in Buck Lake for 14.5 and 14.1 h, respectively. The floating-style gill net caught three RBT (CPUE = 0.2 fish/h), and the sinking-style gill net caught seven RBT (CPUE = 0.5 fish/h; Table 3). Four anglers caught one RBT in 4.5 hours (combined CPUE = 0.2 fish/h; Table 3). Total length of RBT ranged from 320 to 385 mm with an average of 360 mm (± 6.5; n = 11; Figure 2). Relative weights were above 100 for all but one fish (mean W_r = 113, range = 97 to 120; Figure 3). Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. While the average size and condition of fish in Buck Lake is above average, catch rates were low. To increase catch rates, an increase in stocking density from 417 RBT/ha (*n* = 500) to 626 RBT/ha (*n* = 750) is recommended.

Crater Lake

One sinking-style gill net was set in Crater Lake for 13.8 h and caught 23 GNT (CPUE = 1.7 fish/h; Table 3). One angler caught zero fish in 1 h (CPUE = 0 fish/h; Table 3). Total length of GNT ranged from 85 to 283 mm with an average of 209 mm (± 12.4; n = 23; Figure 2). Fish were generally in average or above average condition (mean W_r = 104, range = 75 to 144); however, relative weights appeared to decline with length (Figure 3). No amphibians were observed during the VES. Although no fish were caught during the angling survey, gill net data showed that GNT were at a density high enough to maintain fishing opportunity. It may have been that the angling technique used was not effective for GNT at the lake conditions encountered at the time of the survey. No change in stocking density is recommended.

Doe Lake

One floating- and one sinking-style gill net was set in Doe Lake for 14.4 and 14.2 h, respectively. The floating-style gill net caught two RBT (CPUE = 0.1 fish/h), and the sinking-style gill net caught one RBT (CPUE = 0.1 fish/h; Table 3). Three anglers caught one RBT in 3 h (combined CPUE = 0.3 fish/h; Table 3); however, no length was recorded. Total length of RBT ranged from 339 to 382 mm with an average of 362 mm (± 12.5; n = 3; Figure 2). Relative weights were near or above 100 for all three fish (mean W_r = 117, range = 99 to 131; Figure 3). Columbia spotted frog adults and juveniles were observed during the amphibian VES. Similar to Buck Lake, RBT in Doe Lake are at low density but body condition and size structure were above average. An increase in stocking density from 386 fish/ha (*n* = 500) to 772 fish/ha (*n* = 1,000) is recommended to increase angler catch rates.

Glacier Lake

One sinking-style gill net was set in Glacier Lake for 14.7 h and caught seven GNT (CPUE = 0.5 fish/h; Table 3). Two anglers caught zero fish in 2.5 h (combined CPUE = 0.0 fish/h; Table 3). Total length of GNT ranged from 262 to 356 mm with an average of 306 mm (± 15.0; n = 7; Figure 2). Relative weights were below 100 for all fish (mean W_r = 77, range = 66 to 90), but appeared to increase with length (Figure 2). An adult long-toed salamander was observed during the amphibian VES. Catch rates (angling and gill net) were low in Glacier Lake, and body condition was below average for all individuals. While a reduction in stocking density may increase growth of individual fish, the current population density does not appear high. Currently, no change in stocking density is recommended. Consideration should be given to removing this lake from the stocking rotation if catch rates remain below 1 fish/hr upon the next representative angling survey.

Gooseneck Lake

One floating-style gill net was set in Gooseneck Lake for 15.1 h and caught one GNT (CPUE = 0.1 fish/h; Table 3). An angling survey was not conducted on Gooseneck Lake. Total length of the GNT collected was 278 mm and relative weight was 86. Survey results revealed that GNT have poor survival, and are in below average body condition, despite existing at a very low fish density. Furthermore, this suggests that the lake's habitat may not be suitable for GNT. Removing this lake from the stocking rotation or trying a different species such as WCT or RBT is recommended. No amphibians were observed during the VES.

Harbor Lake

One floating- and one sinking-style gill net was set in Harbor Lake for 13.1 and 12.8 h, respectively. The floating-style gill net caught 13 WCT (CPUE = 1.0 fish/h), and the sinking-style gill net caught 23 WCT (CPUE = 1.8 fish/h; Table 3). Two anglers caught 12 WCT in 2 h (combined CPUE = 6 fish/h; Table 3). Total length of WCT ranged from 175 to 315 mm with an average of 225 mm (± 6.1; n = 48; Figure 2). Relative weights were highly variable at smaller size classes and generally below 100 (mean W_r = 87, range = 59 to 132; Figure 3). No amphibians were observed during the VES. Harbor Lake offers moderately high catch rates, though body condition results suggest that growth is hindered by density dependence. A reduction in stocking density from 367 fish/ha (*n* = 3,000) to 184 fish/ha (*n* = 1,500) is recommended to increase average body condition and size structure of the fishery.

Hat Creek Lake #1

One sinking-style gill net was set in Hat Creek Lake #1 for 16.2 h and caught seven WCT (CPUE = 0.4 fish/h; Table 3). Two anglers caught three WCT in 2 h (combined CPUE = 1.5 fish/h; Table 3). Total length of WCT ranged from 170 to 309 mm with an average of 261 mm (± 14.2; n = 10; Figure 2). Relative weights averaged 100 (range = 70 to 147) and appeared to decline sharply with length (Figure 3). However, sample size from larger size classes of fish is lacking. Additionally, one fish was removed from relative weight calculation due to a suspect weight value. Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. Hat Creek Lake #1 offers adequate angling catch rates and overall body condition was average compared to the national standard. No change in stocking is recommended.

Hat Creek Lake #2

One sinking-style gill net was set in Hat Creek Lake #2 for 15.4 h and caught three GRA (CPUE = 0.2 fish/h; Table 3). Two anglers caught three GRA in 2 hours (combined CPUE = 1.0 fish/h; Table 3). Total length of GRA ranged from 320 to 335 mm with an average of 329 mm (± 2.2; n = 6; Figure 2). Relative weights were above 100 for all three fish (mean W_r = 109, range = 105 to 115; Figure 3). Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. Hat Creek Lake #2 offers adequate angling catch rates and average body condition is above average. No change in stocking is recommended.

Hat Creek Lake #3

Two floating-style gill nets were set in Hat Creek Lake #3 for a total of 30.5 h and caught nine RBT and five WCT (combined CPUE = 0.5 fish/h; Table 3). Two anglers caught three WCT and two RBT in 4.0 h (combined CPUE = 1.3 fish/h; Table 3). Total length of RBT ranged from 283 to 420 mm with an average of 318 mm (± 11.7; n = 11; Figure 2) and WCT ranged from 285 to 385 mm and averaged 330 mm (± 10.4; n = 8; Figure 2). Relative weights were approximately evenly dispersed above and below 100, but higher on average for RBT (mean W_r = 104, range = 81 to 120) than WCT (mean W_r = 91, range = 83 to 105). Columbia spotted frog adults and larvae were observed during the amphibian VES. Hat Creek Lake #3 offers adequate catch rates, diverse species opportunities, and large size structure of both RBT and WCT. No stocking change is recommended.

Hat Creek Lake #4

Two floating-style gill nets were set in Hat Creek Lake #4 for a total of 30.8 h and caught four RBT (combined CPUE = 0.1 fish/h; Table 3). Two anglers caught eight RBT in 4.7 hours (combined CPUE = 1.7 fish/h; Table 3). Total length of RBT ranged from 255 to 510 mm with an average of 359 mm (± 24.4; n = 12; Figure 2). Relative weights were generally near or above 100 (mean W_r = 102, range = 82 to 121). Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. Hat Creek Lake #4 harbors large size classes of RBT that are in good body condition on average and offers adequate angling catch rates. No change in stocking is recommended.

Hat Creek Lake #5

Two sinking-style gill nets were set in Hat Creek Lake #5 for a total of 34.9 h and caught eight WCT (combined CPUE = 0.2 fish/h; Table 3). Two anglers caught three WCT in 2.7 hours (combined CPUE = 1.1 fish/h; Table 3). Total length of WCT ranged from 309 to 385 mm with an average of 346 mm (± 8.5; n = 11; Figure 2). Average relative weight was 97 (range = 70 to 114) and appeared to decline sharply with length (Figure 3). Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. Hat Creek Lake #5 offers adequate angling catch rates of WCT in average to good body condition. The lake also harbors moderate to larger size classes of fish. No change in stocking is recommended.

Heart Lake

One sinking-style gill net was set in Heart Lake for 13.9 h and caught 20 WCT (CPUE = 1.4 fish/h; Table 3). Two anglers caught six WCT in 2.8 h (combined CPUE = 2.2 fish/h; Table 3). Total length of WCT ranged from 175 to 325 mm and averaged 237 mm (± 6.4; n = 26; Figure 2). Relative weights were approximately dispersed around 100 (mean W_r = 96, range = 65 to 136; Figure 2) and appeared to decline with length. No amphibians were observed during the VES. Heart Lake offers adequate angling catch rates, though body condition appeared to decline with body size. A reduction in stocking density of WCT from 739 fish/ha (*n* = 1,675) to 552 fish/ha (*n* = 1,250) is recommended to improve average body condition and size.

Merriam Lake

One floating- and one sinking-style gill net was set in Merriam Lake for 14.3 and 15.3 h, respectively. The floating-style gill net caught two TGT and one BKT (combined CPUE = 0.2 fish/h), and the sinking-style gill net caught 18 BKT and 8 TGT (combined CPUE = 1.7 fish/h; Table 3). One angler caught two BKT and two TGT in 1.0 h (combined CPUE = 4.0 fish/h; Table 3). Total length of BKT ranged from 198 to 260 mm with an average of 230 mm (± 3.8; n = 21; Figure 2) and TGT ranged from 220 to 298 mm and averaged 255 mm (± 7.9; n = 12; Figure 2). Relative weights were below 100 for all BKT (mean W_r = 83, range = 68 to 97; Figure 3) and were not calculated for TGT. No amphibians were observed during the VES. Body condition of BKT is below average and appears to decrease with size. The addition of catchable-sized TGT in 2022 was done to predate upon smaller size classes of BKT and increase population size structure and average body condition. No change in stocking is recommended until further surveys are conducted in Merriam Lake to monitor BKT relative abundance and size structure.

At certain flows, the Merriam Lake outlet shares a hydrologic connection to the upper West Fork Pahsimeroi River; which contains ESA-listed Bull Trout *Salvelinus confluentus.* Though downstream migration and subsequent colonization by BKT from Merriam Lake is unlikely, consideration should be given to piscicide treatment (e.g., rotenone) as an alternative method to eradicate BKT and renovate the fishery if the addition of larger size classes of TGT does not produce the desired result.

Reflection Lake

One floating- and one sinking-style gill net was set in Reflection Lake for 13.5 h each. The floating-style gill net caught 4 RBT × WCT (CPUE = 0.3 fish/h) and the sinking-style gill net caught two RBT, two WCT, and one RBT × WCT (combined CPUE = 0.4 fish/h; Table 3). Two anglers caught two RBT and one WCT in 4.5 h (combined CPUE = 0.7 fish/h; Table 3). Ttotal length of RBT × WCT ranged from 232 to 346 mm with an average of 270 mm (± 21.8; n = 5; Figure 2), RBT ranged from 232 to 341 mm and averaged 291 mm (± 22.4; n = 4; Figure 2), and WCT ranged from 294 to 345 mm and averaged 317 mm (± 14.9; n = 3; Figure 2). Relative weights were below 100 for all four fish, but higher for RBT (mean W_r = 96) than WCT (mean W_r = 78; Figure 3). No amphibians were observed during the VES. Reflection Lake offers diverse species opportunities and slightly lower than desirable angling catch rates. No change in stocking is recommended, but a follow up survey to monitor catch rates and species composition given the documentation of natural reproduction and natural-origin hybrid trout is recommended.

Sheepeater Lake

Two anglers caught 31 WCT in 5.0 h (combined CPUE = 6.2 fish/h; Table 3). Total length of WCT ranged from 185 to 335 mm with an average of 273 mm (± 7.3; n = 31; Figure 2). No amphibians were observed during the VES. Sheepeater Lake offers high angling catch rates of fish in multiple size classes. Though weights were not recorded, anecdotally, fish were in average to good body condition. No change in stocking is recommended.

Skyhigh Lake

One floating- and one sinking-style gill net was set in Skyhigh Lake for 14.0 h each. The floating-style gill net caught nine WCT (CPUE = 0.6 fish/h) and the sinking-style gill net caught 35 WCT (CPUE = 2.5 fish/h; Table 3). Two anglers caught nine WCT and two RBT × WCT in 2.0 h (combined CPUE = 5.5 fish/h; Table 3). Total length of WCT ranged from 94 to 305 mm with an average of 205 mm (± 7.2; n = 53; Figure 2) and RBT × WCT ranged from 181 to 282 mm and averaged 232 mm (± 50.5; n = 2; Figure 2). Relative weights were highly variable, particularly for smaller individuals, but generally below 100 (mean W_r = 82, range = 44 to 129; Figure 3). One Columbia spotted frog adult was observed during the amphibian VES. Skyhigh Lake offers high angling catch rates, yet individuals are generally of smaller size classes. Additionally, body condition appeared to decline with body size. A reduction in stocking density of WCT from 249 fish/ha (*n* = 675) to 187 fish/ha (*n* = 500) is recommended to improve size structure of the fishery.

Turquoise Lake

One floating-style gill net was set in Turquoise Lake for 13.8 h and caught three WCT (CPUE = 0.2 fish/h; Table 3), though one fish escaped prior to measurements being taken. Two anglers caught 10 WCT in 4.6 h (combined CPUE = 2.2 fish/h; Table 3). Total length of WCT ranged from 228 to 390 mm with an average of 282 mm (± 15.8; n = 12; Figure 2). Relative weights of the two WCT were 56 and 74 (Figure 3). No amphibians were observed during the VES. Though relative weights were below average, sample size was very limited. Turquoise Lake offers adequate angling catch rates, and WCT up to larger size classes. No change in stocking is recommended.

Twin Cove Lake

One floating- and one sinking-style gill net was set in Twin Cove Lake for 14.8 and 14.9 h, respectively. The floating-style gill net caught one RBT and one WCT (combined CPUE = 0.1 fish/h) and the sinking-style gill net caught 15 RBT, one WCT, and one RBT × WCT (combined CPUE = 1.1 fish/h; Table 3). Two anglers caught seven RBT and one RBT × WCT in 2.5 hours (combined CPUE = 3.2 fish/h; Table 3). Total length of RBT ranged from 175 to 365 mm and averaged 303 mm (± 9.9; n = 23; Figure 2). Total lengths for RBT × WCT were 220 and 230 mm, and 239 and 310 mm for WCT. Relative weights were nearly 100 for both WCT (mean W_r = 101), but generally below 100 for RBT (mean W_r = 87, range = 58 to 105; Figure 3). One Columbia spotted frog adult was observed during the amphibian VES. Twin Cove Lake offers diverse species opportunities and desirable angling catch rates, though body condition of RBT appeared to decline with size. A slight reduction in stocking density of RBT from 317 fish/ha (*n* = 1,000) to 253 fish/ha (*n* = 800) is recommended to improve average body condition while maintaining adequate catch rates.

U P Lake

Two anglers caught 2 WCT in 2.5 h (combined CPUE = 0.8 fish/h; Table 3), though one fish escaped before measurements could be recorded. Total length of the WCT collected was 287 mm (Figure 2). Adult and juvenile Columbia spotted frogs as well as two juvenile long-toed salamanders were observed during the amphibian VES. While U P Lake produced a low angling catch rate at the time of the survey, environmental conditions during the survey were undesirable, as angling was conducted shortly after a significant wildfire event. Future surveys are recommended to monitor fish growth and overall fishery quality given the wildfire disturbance to the surrounding area within the catchment. No change in stocking is currently recommended, though if catch rates remain low during the next survey, consider increasing stocking density.

Welcome Lake

Four anglers caught 44 WCT in 4.7 h (combined CPUE = 9.4 fish/h; Table 3). Total length of WCT ranged from 136 to 260 mm with an average of 191 mm (± 3.5; n = 44; Figure 2). Columbia spotted frog adults, juveniles, and larvae were observed during the amphibian VES. Though Welcome Lake is largely comprised of small size class WCT, higher stocking densities are still recommended due to ease of access and high angling use of the lake. However, a reduction from 738 fish/ha (*n* = 1,225) to 517 fish/ha (*n* = 600) is recommended to improve size structure while still offering higher catch rates.

Wilson Lake

Two anglers caught 6 WCT in 2.0 h (combined CPUE = 3.0 fish/h; Table 3). Total length of WCT ranged from 147 to 280 mm with an average of 234 mm (± 21.1; n = 6; Figure 2). No amphibians were observed during the VES. While Wilson Lake offers adequate angling catch rates, a decrease in stocking density from 419 fish/ha (*n* = 1,000) to 314 fish/ha (*n* = 750) is recommended to improve the size structure of WCT.

MANAGEMENT RECOMMENDATIONS

1. Review and implement annual changes in stocking recommendations for each lake.

2. Monitor the BKT population in Merriam Lake to determine whether the addition of catchable-sized TGT reduced their abundance and improved the overall size structure of the fishery.

3. Monitor U P Lake to assess if the fishery will continue to provide high quality angling opportunities post-wildfire under the current stocking regiment.

4. Develop a regional HML sampling plan to reassess lakes where fish stocking changes have been made.

Table 1. High mountain lakes stocked in the Salmon Region in 2022 (n = 55). Species stocked include Westslope Cutthroat Trout (WCT), Rainbow Trout (RBT), Arctic Grayling (GRA), Golden Trout (GNT), and tiger trout (TGT). Lake names in bold font indicate lakes stocked via backpack.

Lake name	LLID	Date stocked	Species	Size	Number stocked
Airplane Lake	1145991451563	9/1/2022	WCT	Fry (0-3 inches)	1,004
Basin Lake	1138550448415	8/31/2022	WCT	Fry (0-3 inches)	1,147
Bear Valley Lake #1	1138702448026	8/31/2022	WCT	Fry (0-3 inches)	1,505
Bear Valley Lake #1	1138702448026	8/31/2022	GRA	Fry (0-3 inches)	467
Birdbill Lake	1145875451504	9/1/2022	WCT	Fry (0-3 inches)	502
Bronco Lake	1146536454675	9/25/2022	WCT	Fry (0-3 inches)	299
Buck Lake	1145954450977	9/1/2022	RBT	Fry (0-3 inches)	512
Cabin Creek Lake #3	1149032444206	8/31/2022	WCT	Fry (0-3 inches)	116
Cabin Creek Lake #4	1148916444210	8/31/2022	WCT	Fry (0-3 inches)	600
Cabin Creek Lake #7	1148889444145	8/31/2022	WCT	Fry (0-3 inches)	305
Cabin Creek Peak Lake #01	1149156444024	8/31/2022	WCT	Fry (0-3 inches)	251
Crater Lake	1146082441415	9/1/2022	GNT	Fry (0-3 inches)	702
Devils Lake	1135400446019	8/31/2022	WCT	Fry (0-3 inches)	358
Doe Lake	1145991450982	9/1/2022	RBT	Fry (0-3 inches)	512
Finger Lake #3	1151499444898	8/31/2022	WCT	Fry (0-3 inches)	475
Glacier Lake	1145853451684	9/1/2022	GNT	Fry (0-3 inches)	277
Golden Trout Lake	1145218451119	9/1/2022	GNT	Fry (0-3 inches)	960
Gooseneck Lake	1145820451649	9/1/2022	GNT	Fry (0-3 inches)	203
Harbor Lake	1145917451426	9/1/2022	WCT	Fry (0-3 inches)	3,011
Hat Creek Lake #01	1142029448744	8/31/2022	GRA	Fry (0-3 inches)	259
Hat Creek Lake #02	1142104448747	8/31/2022	GRA	Fry (0-3 inches)	518
Hat Creek Lake #03	1142044448775	8/31/2022	RBT	Fry (0-3 inches)	995
Hat Creek Lake #04	1142040448793	8/31/2022	RBT	Fry (0-3 inches)	299

Table 1. (continued)

Lake name	LLID	Date stocked	Species	Size	Number stocked
Heart Lake	1145949451353	9/1/2022	WCT	Fry (0-3 inches)	1,684
Helen Lake	1145824455387	9/25/2022	WCT	Fry (0-3 inches)	484
Knapp Lake #14	1149411444341	8/31/2022	GRA	Fry (0-3 inches)	259
Knapp Lake #7	1149238444228	8/31/2022	WCT	Fry (0-3 inches)	197
Lola Lake #2	1152248443910	8/31/2022	WCT	Fry (0-3 inches)	502
Lola Lake #3	1152402443907	8/31/2022	WCT	Fry (0-3 inches)	502
Loon Creek Lake #11	1149496444671	8/31/2022	WCT	Fry (0-3 inches)	376
Loon Creek Lake #13	1149456444909	8/31/2022	WCT	Fry (0-3 inches)	224
Loon Creek Lake #3	1149282444426	8/31/2022	WCT	Fry (0-3 inches)	152
Lost Packer Lake	1147777454716	9/25/2022	RBT	Fry (0-3 inches)	1,017
McNutt Lake	1138488448272	8/31/2022	WCT	Fry (0-3 inches)	421
Merriam Lake	1137549441153	9/16/2022	TGT	Catchable (12-14 inches)	400
North Fork East Fork Reynolds Lake #2	1145482455479	9/25/2022	WCT	Fry (0-3 inches)	475
North Fork East Fork Reynolds Lake #4	1145447455576	9/25/2022	WCT	Fry (0-3 inches)	554
Paragon Lake	1146198450829	9/1/2022	WCT	Fry (0-3 inches)	278
Pass Lake	1137575440901	9/25/2022	GNT	Fry (0-3 inches)	441
Patterson Creek Lake #1	1136694445994	8/31/2022	WCT	Fry (0-3 inches)	152
Patterson Creek Lake #3	1136538446355	8/31/2022	WCT	Fry (0-3 inches)	134
Quake Lake	1139380443899	10/13/2022	RBT	Fry (0-3 inches)	298
Ramshorn Lake	1146133450851	9/1/2022	WCT	Fry (0-3 inches)	358
Reflection Lake	1146043451058	9/1/2022	RBT	Fry (0-3 inches)	1,010
Rocky Lake	1151353444863	8/31/2022	WCT	Fry (0-3 inches)	968
Sheepeater Lake	1146037451501	9/1/2022	WCT	Fry (0-3 inches)	323
Skyhigh Lake	1146087451196	9/1/2022	WCT	Fry (0-3 inches)	672
Spruce Gulch Lake	1144515446044	8/31/2022	WCT	Fry (0-3 inches)	1,451

Table 1. (continued)

Lake name	LLID	Date stocked	Species	Size	Number stocked
Tango Lake #4	1148984444467	8/31/2022	WCT	Fry (0-3 inches)	672
Tango Lake #6	1148967444401	8/31/2022	WCT	Fry (0-3 inches)	914
Turquoise Lake	1146131451117	9/1/2022	WCT	Fry (0-3 inches)	278
Twin Cove Lake	1146045451006	9/1/2022	RBT	Fry (0-3 inches)	1,010
U P Lake	1140147452354	9/25/2022	WCT	Fry (0-3 inches)	500
Welcome Lake	1145911451288	9/1/2022	WCT	Fry (0-3 inches)	1,219
Wilson Lake	1145865451439	9/1/2022	WCT	Fry (0-3 inches)	1,004

Table 2. High mountain lakes surveyed in 2022 (n = 23), including lake number (LLID), elevation (m), surface area (ha), trail and cross-country (XC) hiking distance (km), number of campsites, and estimated level of human use.

Lake name	LLID	Elevation (m)	Area (ha)	Trail distance (km)	XC distance (km)	Number of campsites	Human use
Airplane Lake	1145991451560	2562	6.3	14.0	0.0	4	Moderate
Birdbill Lake	1145875451500	2644	1.2	12.9	0.0	2	Low
Buck Lake	1145954450980	2462	1.2	20.9	0.0	1	Low
Crater Lake	1145787451630	2655	3.7	14.8	0.0	1	Low
Doe Lake	1145991450980	2463	1.3	19.3	0.0	0	Low
Glacier Lake	1145853451680	2726	3.4	15.6	1.0	0	Low
Gooseneck Lake	1145949451350	2667	2.3	14.8	0.5	1	Low
Harbor Lake	1145917451430	2721	8.2	10.0	0.3	3	Moderate
Hat Creek Lake #1	1142029448744	2670	1.2	7.5	0.0	3	Moderate
Hat Creek Lake #2	1145104448750	2716	1.8	7.2	0.4	1	Low
Hat Creek Lake #3	1142044448780	2692	2.1	7.2	0.0	3	High
Hat Creek Lake #4	1142040448790	2691	1.2	7.4	0.2	0	Moderate
Hat Creek Lake #5	1142101448782	2722	4.8	6.9	0.3	4	Moderate
Heart Lake	1145949451350	2632	2.3	12.9	0.0	1	Moderate
Merriam Lake	1137549441153	2921	3.0	3.5	0.0	3	Moderate
Reflection Lake	1146043451060	2473	2.5	17.7	0.0	2	Low
Sheepeater Lake	1146037451500	2645	2.4	15.4	1.8	0	Low
Skyhigh Lake	1146087451200	2633	2.7	16.1	0.8	1	Low
Turquoise Lake	1146131451120	2626	2.2	14.5	1.6	1	Low
Twin Cove Lake	1146045451010	2551	3.2	17.7	0.8	0	Low
U P Lake	1140147452354	2456	2.4	0.0	0.8	2	Moderate
Welcome Lake	1145911451290	2541	1.7	11.3	0.0	6	High
Wilson Lake	1145865451440	2715	2.4	9.7	0.0	2	High

Table 3. Fishery characteristics of high mountain lakes surveyed in 2022 (n = 23), including stocking information, fish species present in survey (WCT = Westslope Cutthroat Trout; RBT = Rainbow Trout; RBT x WCT = Rainbow Trout/Westslope Cutthroat Trout hybrid; GNT = Golden Trout; GRA = Arctic Grayling; BKT = Brook Trout; BB = Tiger Trout), total number of fish collected, angling and/or gillnet CPUE (S = sinking gillnet; F = floating gillnet), evidence of natural reproduction (Y = Yes; N = No; IN = Inconclusive) , spawning suitability of lake, and presence/absence of amphibians (CSF = Columbia Spotted Frog; WT = Western Toad; UNK = unknown). Year last stocked refers to at the time of the survey, so dates listed do not reflect stocking events that occurred in 2022 after surveys were conducted. Refer to Table 1 for a complete list of lakes stocked in 2022.

Lake name	Year last stocked	Species last stocked	Fish species present	Number caught	Angling CPUE (fish/h)	Gill netting CPUE (fish/h)	Natural reproduction	Spawning suitability	Amphibians present
Airplane Lake	2019	WCT	RBT, WCT, RBT x WCT, GNT	31	2.9	1.5 (S)	Y	Poor	CSF
Birdbill Lake	2019	WCT	WCT	13	2.9	-	Y	Fair	CSF
Buck Lake	2019	RBT	RBT	12	0.2	0.5 (S), 0.2 (F)	N	Poor	CSF
Crater Lake	2019	GNT	GNT	24	0.0	1.7 (S)	N	Fair	None
Doe Lake	2019	RBT	RBT	3	0.3	0.1 (S), 0.1 (F)	N	Poor	CSF
Glacier Lake	2019	GNT	GNT	7	0.0	0.5 (S)	N	Good	LTS
Gooseneck Lake	2019	GNT	GNT	1	0.0	0.1 (F)	N	Poor	None
Harbor Lake	2019	WCT	WCT	48	6.0	1.8 (S), 1.0 (F)	N	Good	None

Table 3. (continued)

Lake name	Year last stocked	Species last stocked	Fish species present	Number caught	Angling CPUE (fish/h)	Gill netting CPUE (fish/h)	Natural reproduction	Spawning suitability	Amphibians present
Hat Creek Lake #1	2019	GRA	WCT	10	1.5	0.4 (S)	Y	Poor	CSF
Hat Creek Lake #2	2019	GRA	GRA	6	1.0	0.3 (S)	N	Poor	CSF
Hat Creek Lake #3	2019	RBT	WCT, RBT	19	1.3	0.5 (F)	IN	Poor	CSF
Hat Creek Lake #4	2019	RBT	RBT	12	1.7	0.1 (F)	N	Poor	CSF
Hat Creek Lake #5	2013	WCT	WCT	11	1.1	0.2 (S)	N	Poor	CSF
Heart Lake	2019	WCT	WCT	26	2.2	1.4 (S)	N	Poor	CSF
Merriam Lake	2014	BB	BKT, BB	33	4.0	1.7 (S), 0.2 (F)	Y	Good	None
Reflection Lake	2019	RBT	WCT, RBT, RBT x WCT	12	0.7	0.4 (S), 0.3 (F)	Y	Poor	None
Sheepeater Lake	2019	WCT	WCT	30	6.0	-	N	Poor	None
Skyhigh Lake	2019	WCT	WCT x RBT, WCT	55	5.5	2.5 (S), 0.6 (F)	Y	Fair	None
Turquoise Lake	2019	WCT	WCT	13	2.2	0.2 (F)	N	Poor	CSF
Twin Cove Lake	2019	RBT	RBT, WCT, RBT x WCT	27	3.2	1.1 (S), 0.1 (F)	Y	Fair	None
U P Lake	2019	WCT	WCT	2	0.8	-	N	Poor	CSF
Welcome Lake	2019	WCT	WCT	44	9.4	-	Y	Good	CSF, LTS
Wilson Lake	2019	WCT	WCT	6	3.0	-	N	Poor	CSF, WT

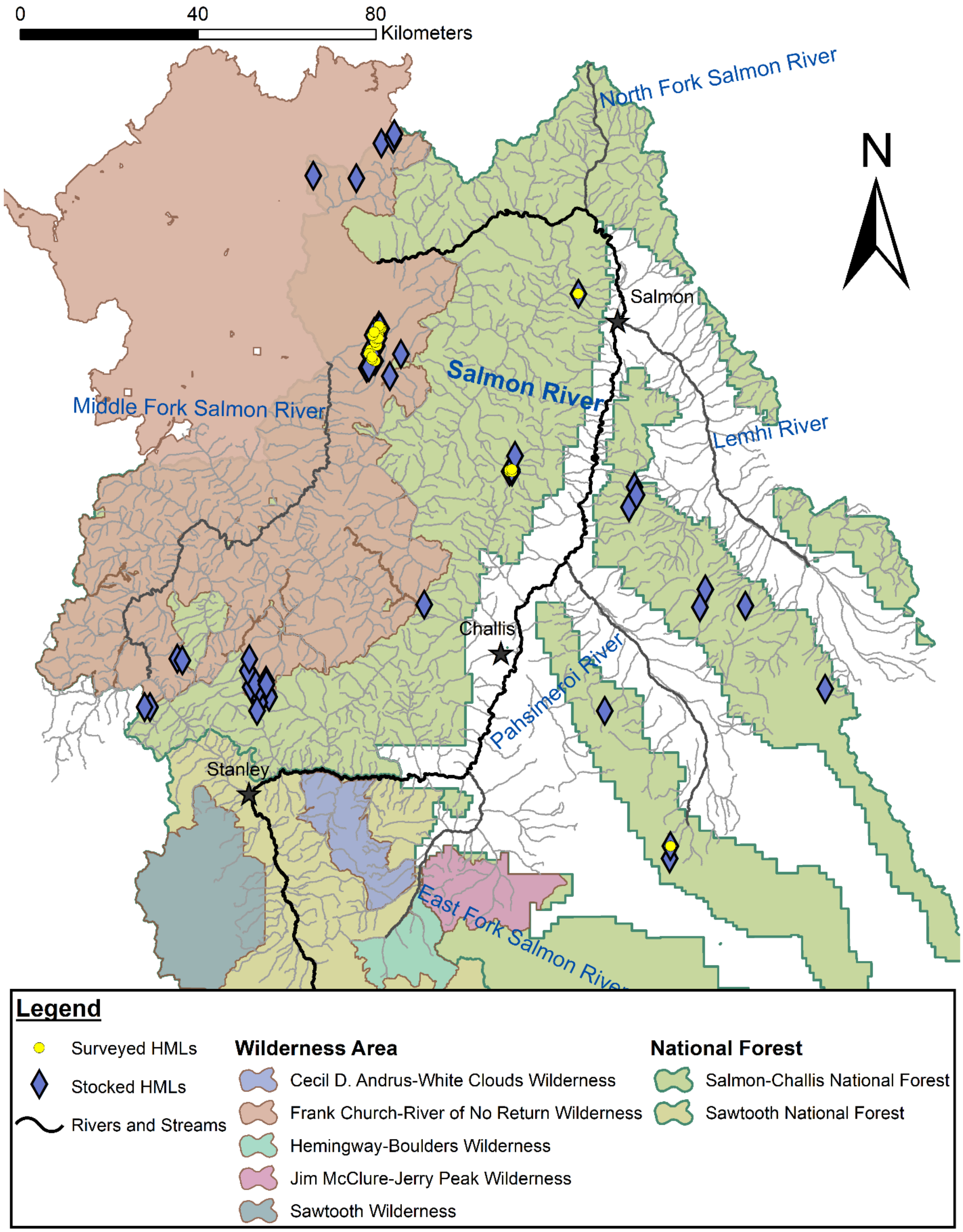


Figure 1. Spatial locations of stocked (blue diamonds; n = 55) and surveyed (yellow circles; n = 23) high mountain lakes in the Salmon Region in 2022.

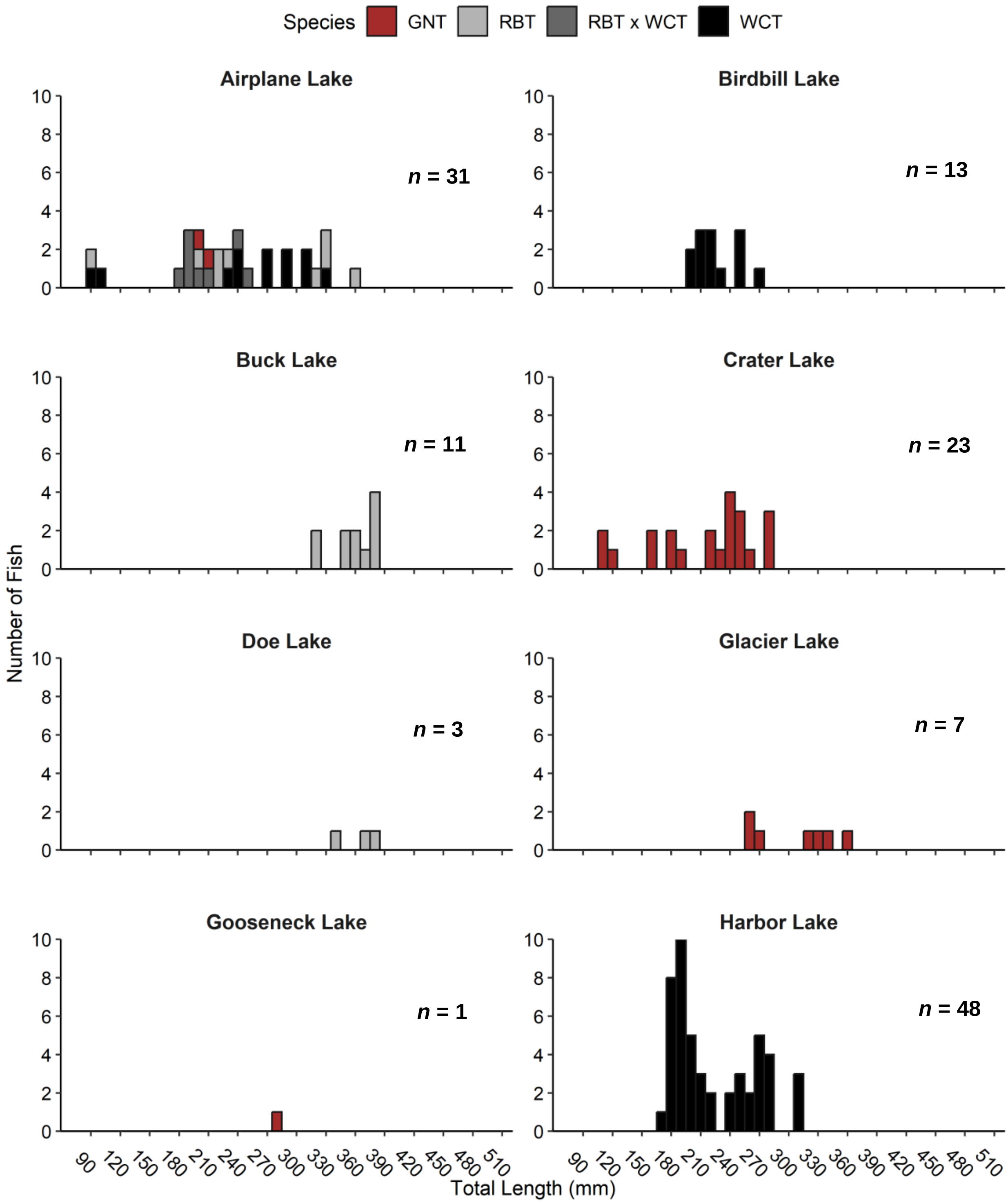


Figure 2. Length-frequency histograms of fish collected in high mountain lake surveys in the Salmon Region in 2022.

Figure 2. (continued)

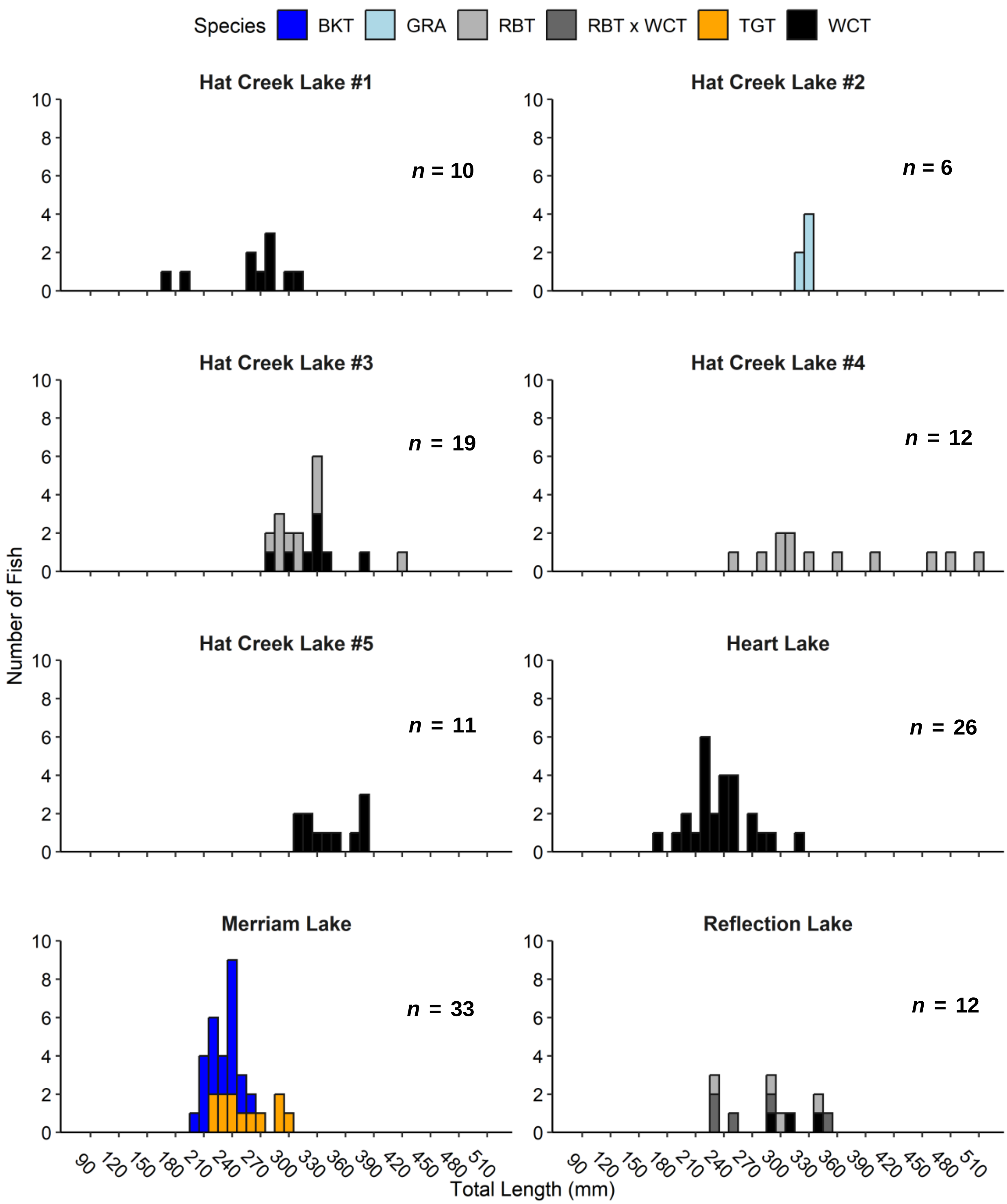
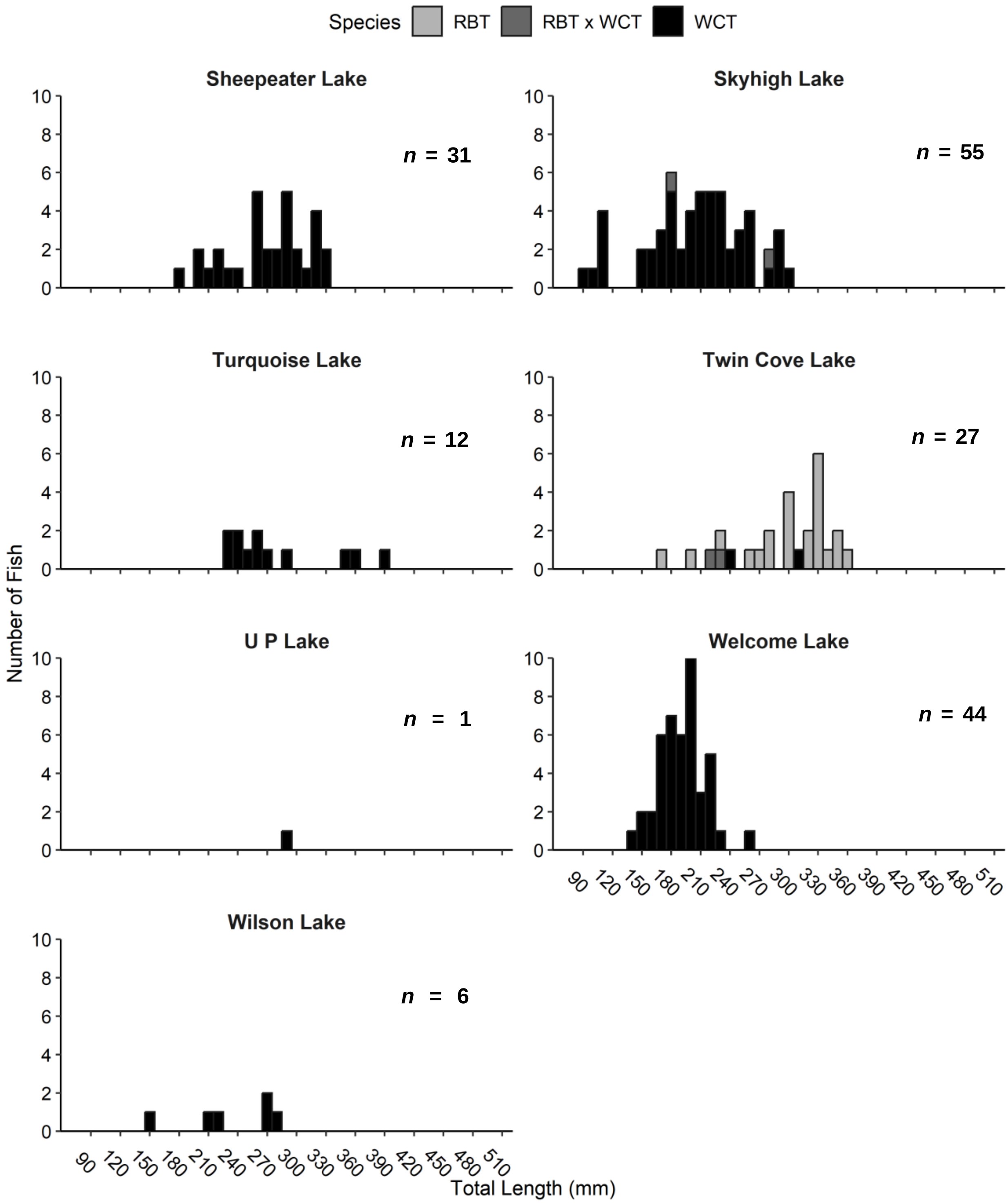


Figure 2. (continued)



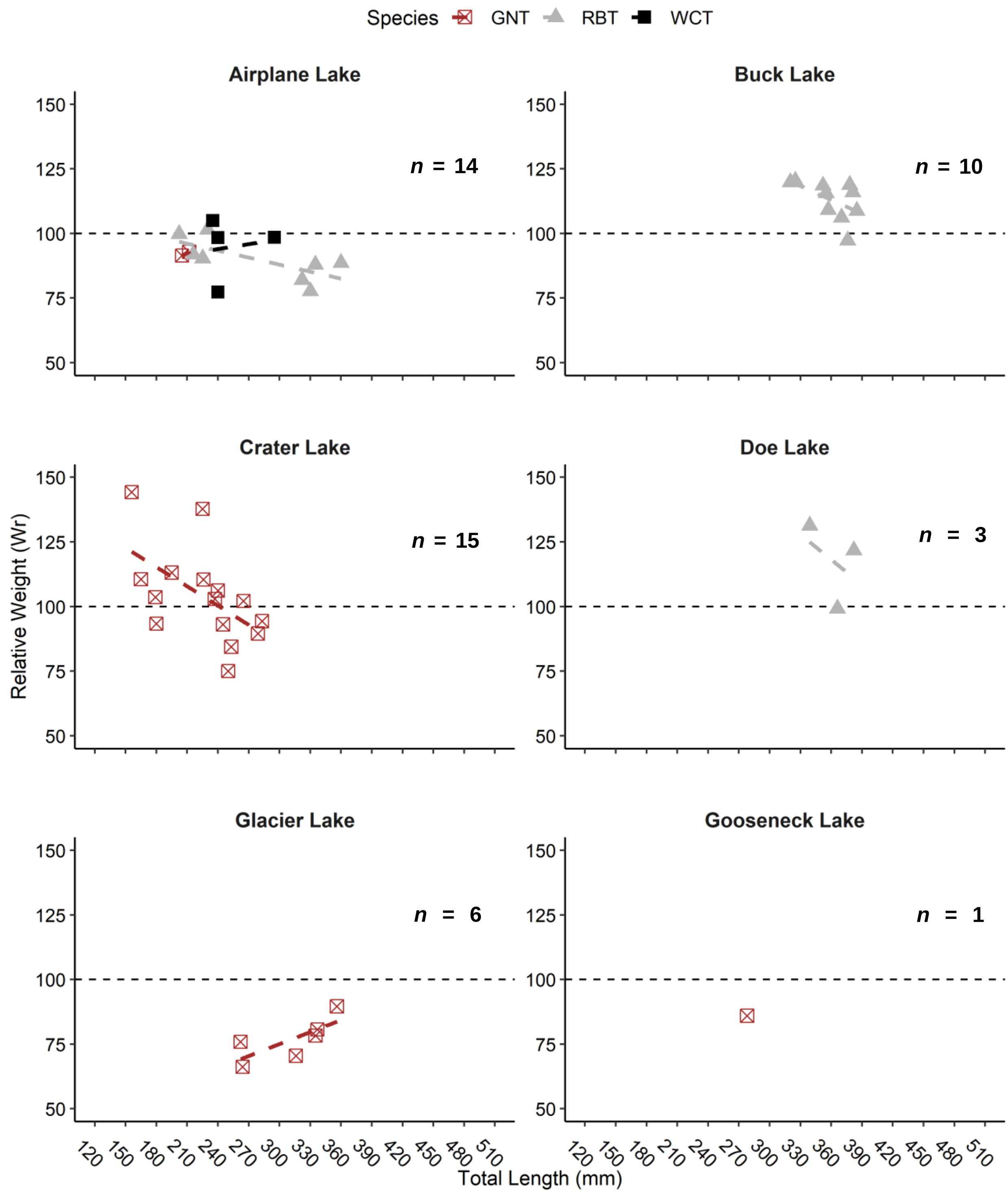


Figure 3. Relative weights (W_r) of fish collected during high mountain lake surveys in the Salmon Region in 2022. *One suspect datapoint was excluded from Hat Creek Lake #1.

Figure 3. (continued)

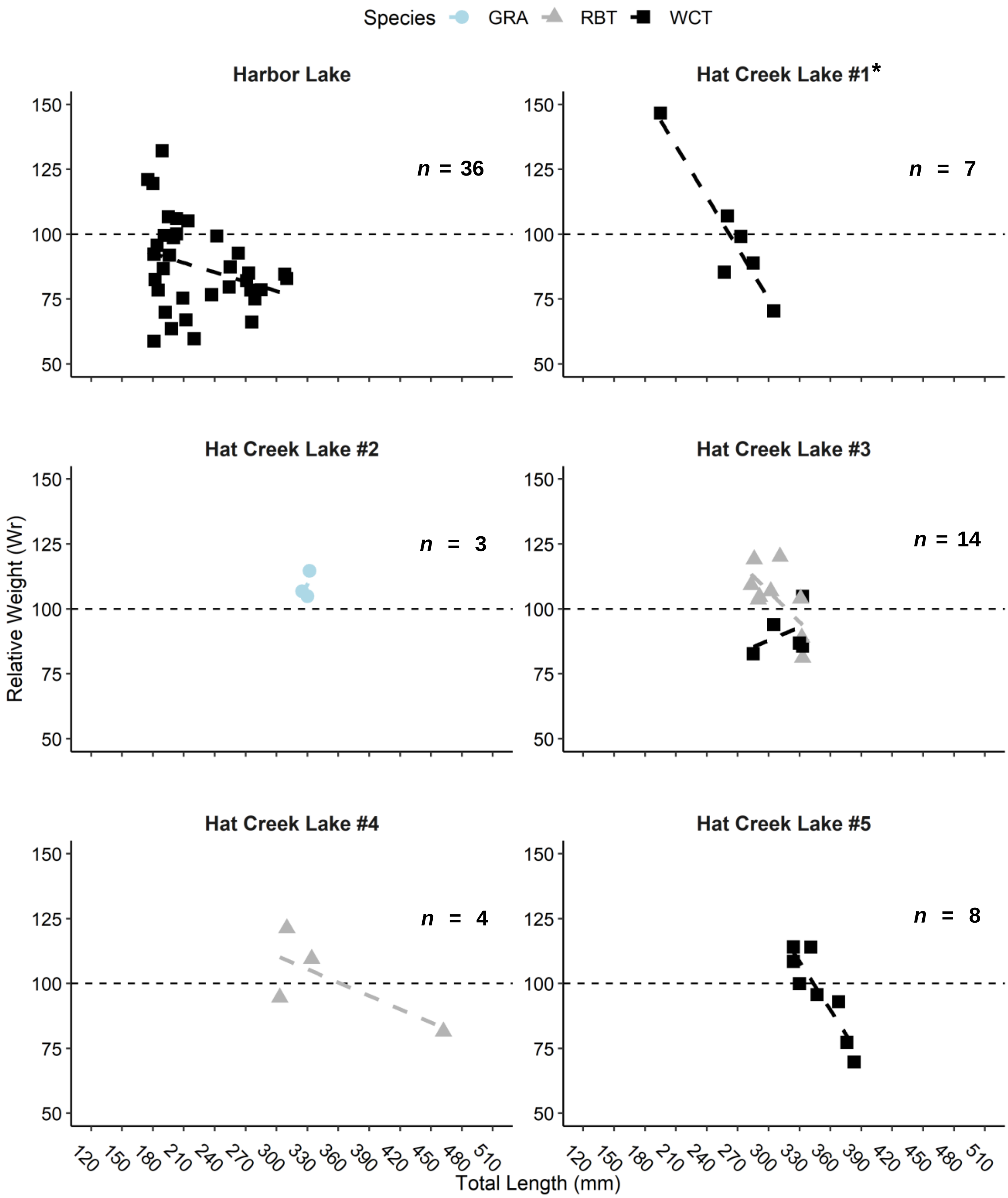
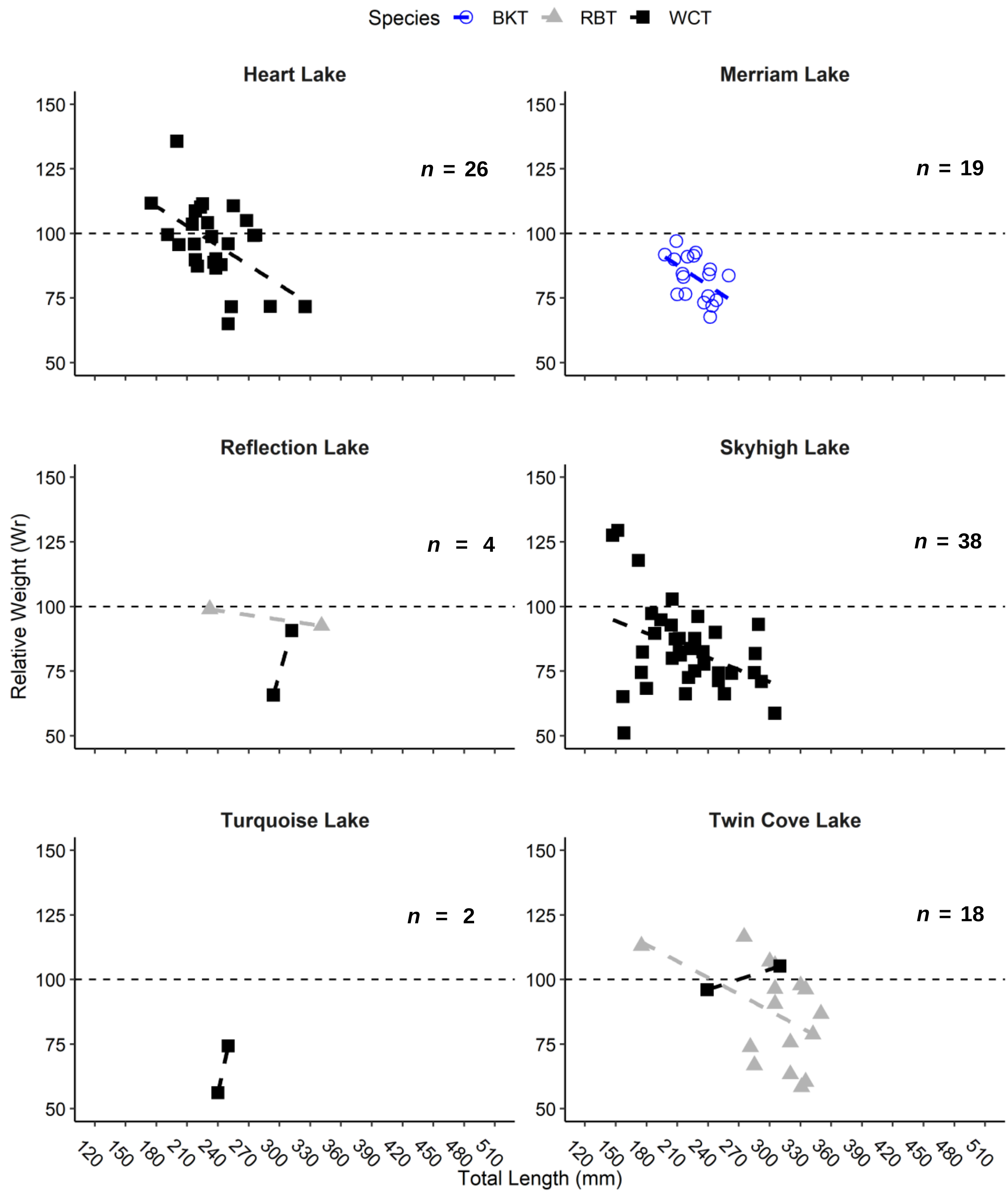


Figure 3. (continued)



LOWLAND LAKES AND RESERVOIRS: REMOVAL OF LAKE TROUT FROM STANLEY LAKE

ABSTRACT

In 2022, regional fisheries staff conducted the third consecutive year of wild-origin fertile Lake Trout *Salvelinus namaycush* removals from Stanley Lake followed by stocking of sterile (triploid) Lake Trout. A total of 75,073 m of gill net was deployed over 20 days across three netting periods from May to October. Gill net catch was comprised of 354 hatchery Lake Trout, 289 wild Lake Trout, 888 kokanee *Oncorhynchus nerka*, 598 Rainbow Trout *O. mykiss*, 465 Brook Trout *S. fontinalis*, 13 Westslope Cutthroat Trout *O. clarkii lewisi*, and 2 Bull Trout *S. confluentus*. Total lengths of hatchery Lake Trout ranged from 199 to 417 mm and averaged 333 mm (SE = 1.6) while wild Lake Trout total lengths ranged from 162 to 1,150 mm and averaged 279 mm (± 7.8). Lengths varied among non-target species (i.e., non-Lake Trout), with Rainbow Trout being the largest on average (331 mm, ± 1.4) and kokanee being the smallest (206 mm, ± 0.8). Average total lengths were similar among Brook Trout (247 ± 1.8), Westslope Cutthroat Trout (260 mm, ± 18.5), and Bull Trout (259 mm, ± 24.0; Table 2). Wild Lake Trout CPUE (fish/m) in 2022 was approximately half (0.004 fish/m) of the CPUE observed in 2020 (0.007 fish/m) when removals began. Additionally, CPUE was lower for all mesh sizes in 2022 than 2020, and relatively consistent with 2021. Gill net catch in 2022 was primarily comprised of smaller size class wild Lake Trout, with 89% of fish being < 400 mm TL. Wild-origin Lake Trout relative weight ranged from 31.8 to 118.6, averaged 85.6 (SE = 1.2), and appeared to increase with total length. To date, the number of wild LKT removed from Stanley Lake to date has exceeded the 2012 population estimate; however, proportional removal targets have not been achieved in all length bins, necessitating additional removal efforts.

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INTRODUCTION

In 2022, IDFG fisheries staff conducted the third consecutive year of Lake Trout *Salvelinus namaycush* (LKT) removal efforts. Removal of LKT began in June of 2020, following the formulation of the Stanley Lake Fisheries Management Plan (IDFG 2018). The management plan was developed by IDFG staff as well as the Stanley Lake Advisory Committee. The advisory committee was comprised of anglers and other parties interested in the future of the Stanley Lake fishery and native fish conservation within the upper Salmon River basin. The plan proposed a management strategy of mechanical removal of fertile LKT (wild-origin or wild LKT hereafter) via gillnetting over a three-year period to minimize threats of non-native LKT to Sockeye Salmon *Oncorhynchus nerka* and their recovery. However, to maintain LKT angling opportunity in Stanley Lake, IDFG committed to annual stocking of catchable-sized (~300 mm) sterile (triploid) LKT (hatchery LKT hereafter) with additional plans to eventually transplant quality to trophy-sized sterile LKT into Stanley Lake. Since LKT are a long-lived species and a main objective of the Stanley Lake Fisheries Management Plan was to reduce the potential for LKT to establish in other Sawtooth Valley lakes, all hatchery LKT were implanted with passive integrated transponder (PIT) tags. This allows regional fisheries staff to monitor downstream escapement of hatchery LKT on PIT array infrastructure located downstream of the Stanley Lake outlet. The primary interrogation site for this objective is located on the lower portion of Valley Creek, a major tributary to the upper Salmon River. For additional context and in-depth summary of the fishery and formulation of the current management plan, refer to Kelly et al. (*in preparation*).

OBJECTIVES

- Assess the number of Lake Trout removed relative to the 2012 population estimate and removal targets.
- Monitor the size structure of wild LKT removed as well as the CPUE by year and mesh size.
- Monitor incidental mortalities of bycatch, particularly hatchery LKT, to inform future stocking events to maintain overall quality of the fishery.

STUDY AREA

Stanley Lake (WGS84 datum: 44.24371°N, 115.05653°W) is an oligotrophic lake located in the upper Salmon River basin, near Stanley, Idaho. Stanley Lake is 71.3 ha in size, 1,990 m in elevation, has an average depth of 13 m, and a maximum depth of 27.5 m. The lake's primary inflow and outflow is Stanley Lake Creek. Historically, fish species composition in Stanley Lake was primarily non-sport fish such as suckers *Catastomus spp*., Northern Pikeminnow *Ptychocheilus oregonensis*, and shiners (likely Redside Shiner *Richardsonius balteatus*; Rodeheffer 1935). Currently, the lake is a popular fishery that contains a variety of game fish species such as LKT (wild and hatchery), Rainbow Trout *Oncorhynchus mykiss* (RBT), kokanee *O. nerka* (KOK), Brook Trout *Salvelinus fontinalis* (BKT), Westslope Cutthroat Trout *O. clarkii lewisi* (WCT), and Bull Trout *S. confluentus* (BLT).

METHODS

Gillnetting

Gillnetting on Stanley Lake in 2022 was conducted by Hickey Bros. Research LLC (Bailey's Harbor, WI) and IDFG fisheries staff in efforts to remove wild-origin LKT. Nets were primarily single-panel construction (i.e., one mesh size per net) sinking nets 1.8 to 6.1 m deep X 91.4 m long. Net mesh sizes ranged from 38 to 114 mm (stretch measure) and webbing material was either "coarse" or "fine" diameter monofilament nylon. Three floating nets were also used that were 9.1 m deep X 91.4 m long with 76 mm mesh (stretch measure). Sinking nets were typically tied together along the float and lead lines to form a "gang" and set in a serpentine pattern throughout all navigable portions of the lake; dictated by boat size. The three floating nets were tied together to form one gang ~270 m in length and set independently from sinking nets. The floating net gang was suspended throughout the water column to depths ranging from 3 to 20 m below the surface. All nets were generally set in the afternoon or evening and retrieved the following morning.

Hickey Bros. Research LLC conducted ten days of gillnetting from June 6 to June 16, 2022 and 6 days from September 11 to September 17, 2022, deploying 45,263 m and 27,158 m of net, respectively. Regional fisheries staff conducted 4 days of gillnetting from October 17 – 21 , 2022 deploying 2,653 m of net.

Lake Trout Stocking

Stocking of 476 triploid LKT (~300 mm TL) occurred on October 28, 2022. Triploidy was verified for all fish prior to stocking at the Eagle Fish Health and Genetics Lab (Eagle, ID). All stocked LKT were tagged in the body cavity with PIT tags to track any potential downstream escapement from Stanley Lake. Hatchery LKT were also adipose fin clipped for easy differentiation from wild-origin fish.

Data Collection and Analysis

All LKT captured during netting were measured for total length (TL; mm), weight (g), and, when possible, sexed (wild-origin fish only). Sex was determined by direct observation of gametes. A fin clip was collected and archived for future genetics work. Otoliths were removed in the field, cleaned, and stored dry in vials. All fish carcasses were returned to Stanley Lake to retain nutrients in the lake. Non-target catches were enumerated, and a subset were measured for length and weight. Net type (sinking or floating), mesh size, and webbing material (coarse or fine) was recorded for each fish captured, including non-target species.

Relative abundance of fish was indexed for each species as CPUE where the number of individuals caught within a specified netting period (e.g., 2022) was divided by the total meters of gill net deployed within that netting period (fish/m).

Removal efficiency was estimated by comparing wild LKT catch relative to the 2012 population estimate stratified into 200-mm length bins (i.e., 200-400 mm, 401-600 mm, 601-800 mm, >800 mm). Percentage of catch obtained for each length bin was estimated by dividing catch in each length bin by the point estimate of the population estimate for that length bin.

Relative weight (W_r) was calculated for all LKT greater than 280 mm TL (Blackwell et al. 2000). Standard weights (W_s) were first calculated using the equation:

$$Log_{10}(W_s) = a + b * Log_{10}(\text{total length (mm)})$$

where a = the intercept value (-5.681) and b = slope (3.246). The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$W_r = \left(\frac{\text{weight (g)}}{W_s}\right) * 100$$

Relative weights were then compared across all gill net surveys (2020 to 2022) to evaluate changes in average body condition.

RESULTS

In 2022, the total catch consisted of 354 hatchery LKT, 289 wild LKT, 888 KOK, 598 RBT, 465 BKT, 13 WCT, and two BLT (Table 4). Of the 354 hatchery LKT collected, 5.6% were recaptures (*n* = 20) and 75.7% (*n* = 268) were incidental mortalities. Total lengths (± SE) of hatchery LKT ranged from 199 to 417 mm and averaged 333 mm (± 1.6; Table 5). Total length varied among non-target species, with KOK being the smallest on average (206 mm, ± 0.8) and RBT being the largest (331 mm, ± 1.4; Table 5). Mean total lengths were relatively consistent across BKT (247 mm, ± 1.8), WCT (260 mm, ± 18.5), and BLT (259 mm, ± 24.0; Table 5).

Total meters of net deployed in 2022 was similar to that of 2020 (*n* = 77,084 m), though overall CPUE (fish/m) of wild LKT in 2022 was approximately half (CPUE = 0.004 fish/m) of the CPUE observed in 2020 (CPUE = 0.007; Table 5). Additionally, mesh-specific CPUE was lower for all mesh sizes in 2022 than 2020, and relatively consistent with 2021 (Table 5). Wild LKT CPUE was highest in the 38 mm mesh for all three years of removal efforts (Table 5).

A wide size range of wild LKT were captured and removed in 2022 (Table 4; Figure 4). Mean TL of wild LKT was 279 mm (± 7.8) and ranged from 162 to 1,150 mm (Table 4). Catch was largely concentrated among smaller size classes of fish with 89% of wild LKT being < 400 mm (Figure 4). Combined with previous removal efforts in 2020 and 2021, the number of wild LKT removed from Stanley Lake to date has exceeded the 2012 population estimate (± 95% CI) of 548 fish (318-1,014). Yet, divided into proportional population estimates by length bin, removal numbers are higher than the estimate in smaller size classes (TL < 400 mm) and lower that the estimate for larger size classes (401 – 600 mm; Figure 5). In particular, removal of wild LKT in the 200 to 400 mm length bin is 361% (*n* = 673) of the estimate (*n* = 186; 108-345) while removal in the 401 to 600 mm length bin is 36% (*n* = 57) of the estimate (*n* = 159; 92-294; Figure 5).

Wild LKT relative weights ranged from 32 to 119 and averaged (± SE) 86 (± 1.2) in 2022. Similar to previous years, relative weight appeared to increase with TL (Figure 6). The average relative weight of wild LKT captured and removed in 2021 (85 ± 1.1; *n* = 98) and 2022 (86 ± 1.2; *n* = 92) was lower than 2020 (91 ± 0.8; *n* = 256). Additionally, average total length of individuals included in relative weight calculations in 2020 (663 mm ± 13.1) was 192% and 179% larger than fish from 2021 (345 mm ± 10.8) and 2022 (370 mm ± 9.3), respectively.

In 2022, none of the hatchery LKT released in October 2022 were detected on the Valley Creek array. Throughout the entire year, five hatchery LKT were detected, three of which were stocked in September 2020, and two stocked in November 2021.

DISCUSSION

Annual gill net catch and average TL of wild LKT removed has decreased over the three-year removal period. In 2022, deploying approximately the same amount of net to that of 2020 resulted in only 51% of the number of wild LKT captured in 2020. Additionally, the average total length of wild LKT removed in 2022 was 35% lower than fish removed in 2020. Decreases in CPUE of larger mesh sizes have been observed accordingly, although 24 mature LKT (based on presence of mature gonads) were caught in both 2021 and 2022 compared to 236 mature LKT removed in 2020. Results observed in 2022 combined with the proportional population estimates of larger size classes from 2012 suggest that CPUE and average TL of the catch will continue to decline in subsequent netting efforts. Although, disproportionately higher catch of smaller size classes will likely continue as fish < 200 mm TL not included in the original estimate recruit to the gear. Yet, deploying larger mesh sizes to continue targeting larger LKT is still worthwhile in efforts to achieve removal objectives in concordance with the population estimate.

Throughout all removal efforts since 2020, gill net catch of LKT in the 400-600 mm size class has been low relative to other size classes. To date only 36% of the overall population estimate for that size class has been removed. Interestingly, net selectivity estimates from 2020 indicated that the gill nets with mesh sizes used currently should effectively capture LKT of that size (Kelly et al. *in preparation*). Historically, gill net surveys on Stanley Lake timed around ice-off (typically occurring in late April or early May) were successful in catching LKT in this size class (Kelly et al. *in preparation*). For example, 44% (n = 32 of 72) of LKT captured in May 2019 were between 400 and 600 mm TL. Nets used in that survey consisted of mesh panels of 38, 51, and 64 mm (stretch measure). Thus, scheduling future gillnetting events around ice-off with nets of similar mesh sizes may increase catch rates of LKT in the 400-600 mm size class; albeit logistically challenging due to access to the lake at that time of year. Nevertheless, continued removal effort is recommended in order to achieve removal targets for wild LKT across all length bins based on 2012 proportional population estimates.

Relative weights of wild LKT removed from Stanley Lake were generally below 100. The slightly positive relationship observed with total length may indicate that there is a growth bottleneck at smaller size classes. While mechanisms to explain this potential bottleneck and overall lower body condition have not been evaluated, these results suggest that LKT may experience density dependence at smaller size classes. This should be considered when determining stocking density of sterile LKT to enhance fishing opportunity at Stanley Lake, given that hatchery LKT are currently stocked at approximately 300 mm TL. Additionally, preferentially selecting individuals of larger size classes for sterile LKT transplantation will not only augment fishing opportunity lost by wild LKT removals but may also allow for transplanted individuals to have a competitive advantage and exhibit higher body condition metrics once introduced.

MANAGEMENT RECOMMENDATIONS

- Continue implementing the Stanley Lake Fishery Management Plan.

- Continue removing wild LKT in 2023 to achieve removal objectives in all length bins based on 2012 population estimate.

- Develop long-term monitoring plan for LKT and other sportfish species in Stanley Lake.

- Monitor downstream escapement of hatchery LKT via PIT arrays within the upper Salmon River basin.

- Work with Bear Lake stakeholder groups to facilitate transfer of quality- to trophy-sized individuals to augment LKT fishing opportunity in Stanley Lake while hatchery fish grow.

Table 4. Number of fish caught by species, meters of net deployed, CPUE (fish/m), average (± SE) total length (mm), and range of total lengths for fish collected via gill net on Stanley Lake in 2022 (LKT = Lake Trout, KOK = kokanee, RBT = Rainbow Trout, BKT = Brook Trout, WCT = Westslope Cutthroat Trout, and BLT = Bull Trout).

				Total length (mm)	
Species	Number caught	Net deployed (m)	CPUE (fish/m)	Mean (± SE)	Range (mm)
Hatchery LKT	354	75,073	0.005	333 (± 1.6)	199 – 417
Wild LKT	289	75,073	0.004	279 (± 7.8)	162 – 1,150
KOK	888	75,073	0.012	206 (± 0.8)	57 – 290
RBT	598	75,073	0.008	331 (± 1.4)	215 – 493
BKT	465	75,073	0.006	247 (± 1.8)	159 – 406
WCT	13	75,073	<0.001	260 (± 18.5)	175 – 395
BLT	2	75,073	<0.001	259 (± 24.0)	235 – 283

Table 5. Gillnetting effort (m) fished in 8 mesh sizes (mm, stretch measure) for Lake Trout in Stanley Lake from 2020 to 2022 (LKT = Lake Trout). Number of Lake Trout reported here refers to 'wild' or natural-origin fish (i.e., not stocked).

	Year								
	2020			2021			2022		
Mesh (mm)	Net deployed (m)	Number LKT caught	CPUE (fish/m)	Net deployed (m)	Number LKT caught	CPUE (fish/m)	Net deployed (m)	Number LKT caught	CPUE (fish/m)
38	5,669	214	0.038	5,883	79	0.013	9,327	174	0.019
51	17,191	118	0.007	6,706	80	0.012	13,716	56	0.004
64	14,448	42	0.003	6,706	15	0.002	10,973	15	0.001
76	11,521	33	0.003	8,230	5	0.001	13,167	17	0.001
89	5,764	28	0.005	4,663	2	<0.001	4,389	4	0.001
102	11,247	46	0.004	2,743	1	<0.001	5,122	5	0.001
114	11,247	82	0.007	5,486	6	0.001	13,990	17	0.001
127	0	-	-	2,743	3	0.001	4,389	1	<0.001
Total	77,084	563	0.007	43,160	191	0.004	75,073	289	0.004

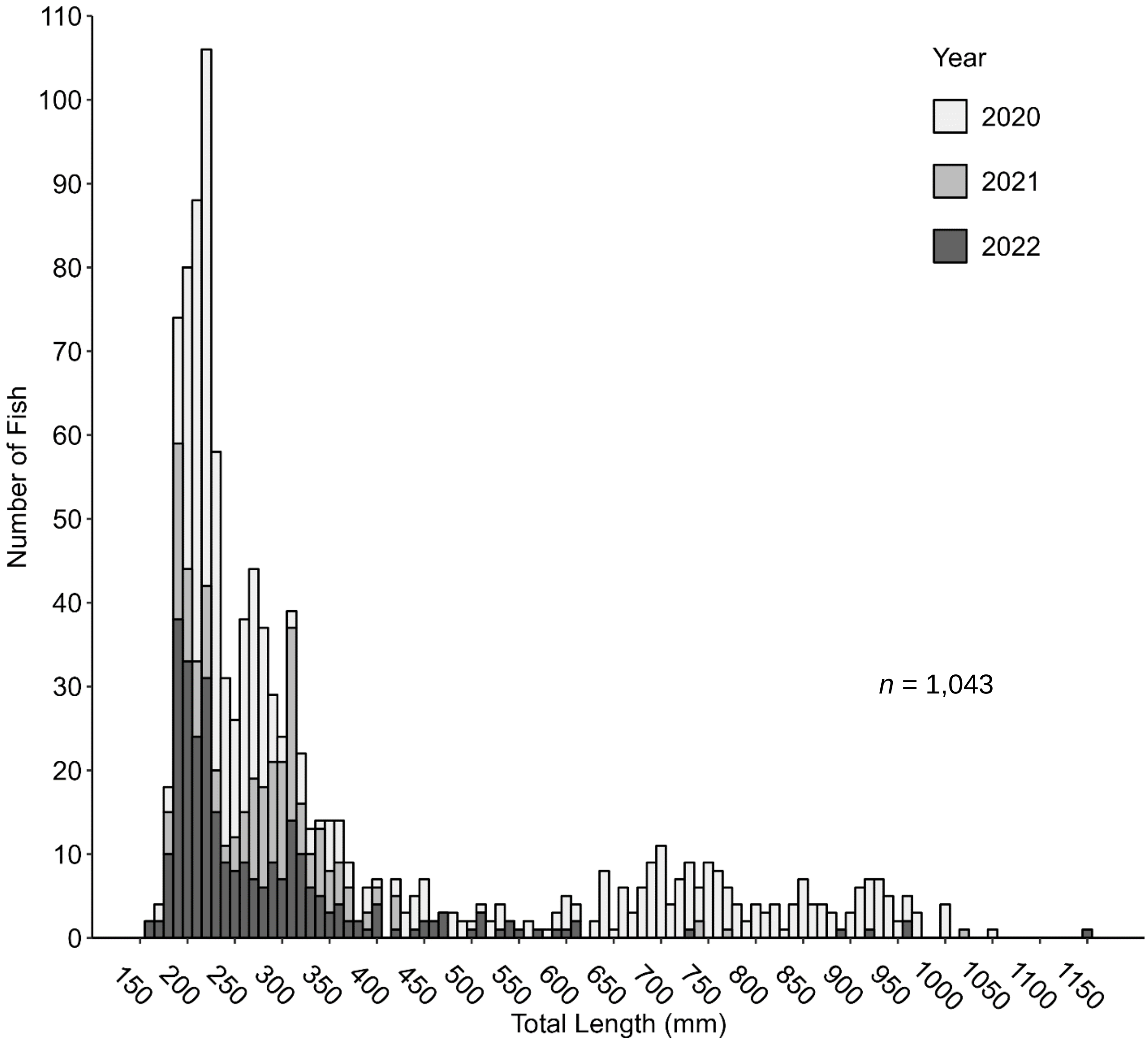

Figure 4. Length-frequency histogram of wild Lake Trout removed from Stanley Lake via gillnetting from 2020 to 2022.

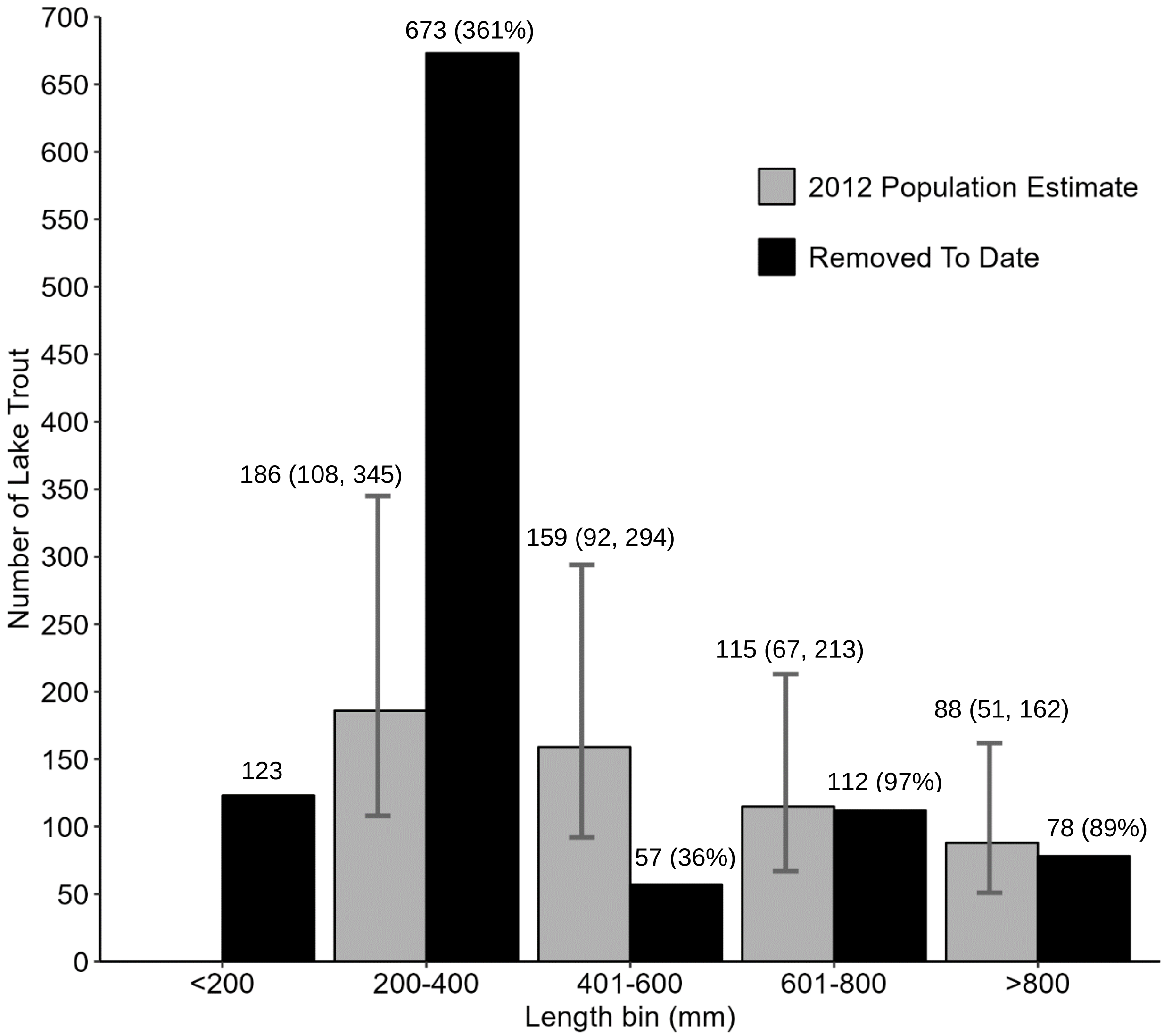

Figure 5. Bar chart showing the number of wild Lake Trout by length bin (TL; mm) removed from Stanley Lake via gillnetting from 2020 to 2022 (black bars) compared to the 2012 Lake Trout population estimate (gray bars). Gray error bars display the upper and lower 95% confidence limits of the 2012 population estimate for each length bin. Sample sizes of Lake Trout removed by length bin (% of population estimate in corresponding length bin), and population estimates (95% confidence interval) are displayed above each bar. The 2012 estimate did not include fish < 200 mm in total length.

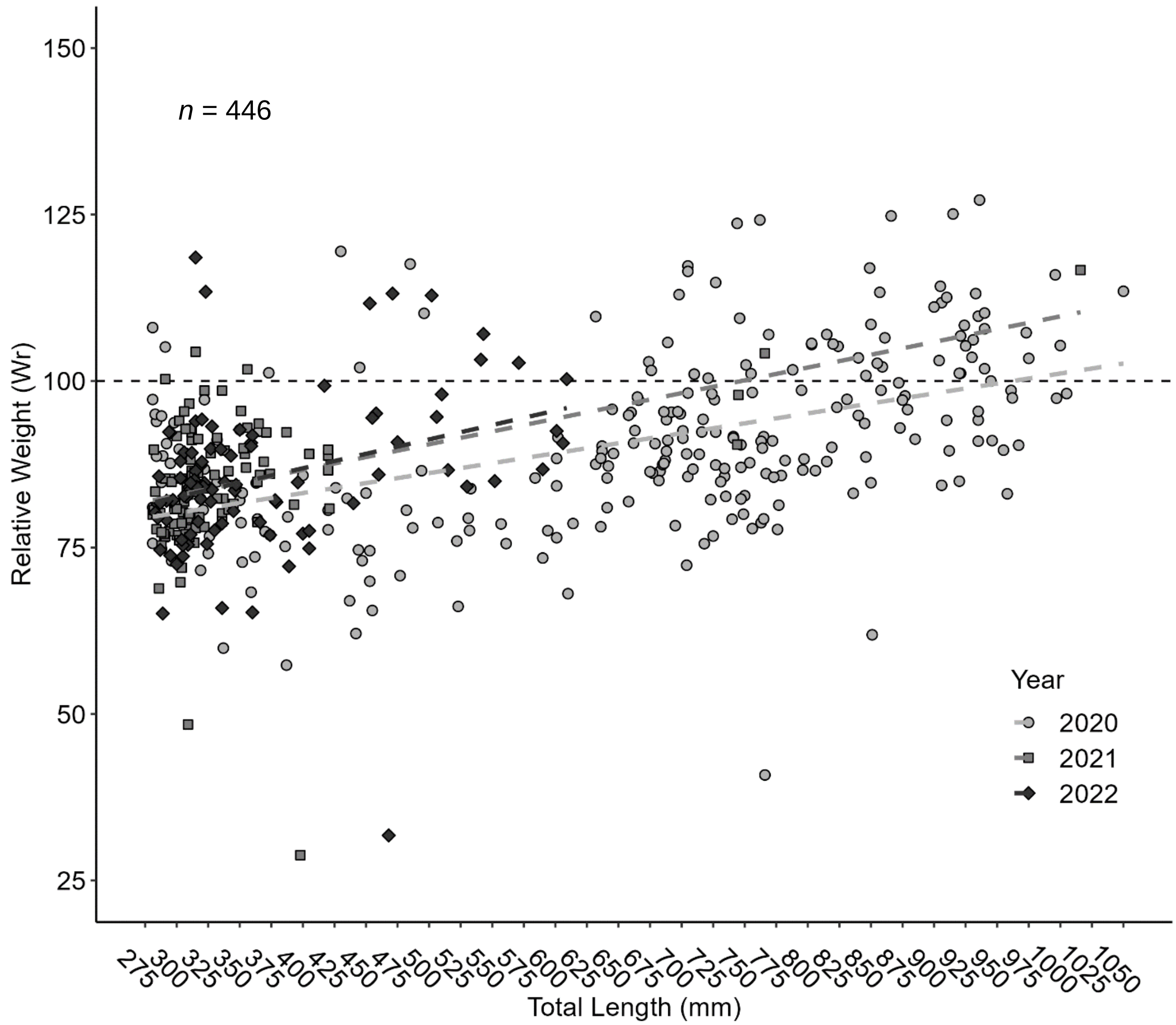

Figure 6. Relative weights (W_r) of wild Lake Trout removed from Stanley Lake via gillnetting from 2020 to 2022. Lake Trout are represented by light gray circles for 2020, gray squares for 2021, and dark gray diamonds for 2022.

SPRUCE GULCH LAKE

ABSTRACT

In 2022, regional fisheries staff conducted a standardized lowland lake gill net survey in Spruce Gulch Lake to monitor fish species composition, abundance, and size structure. Gill net catch consisted of 51 Brook Trout *Salvelinus fontinalis*, one Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, and one tiger muskellunge (Northern Pike *Esox lucius* × Muskellunge *E. masquinongy*; combined CPUE = 26.5 fish/net-night). Brook Trout CPUE was the highest observed value across eight surveys over 17 years (CPUE = 25.5 fish/net-night). The mean TL (± SE) of Brook Trout was 206 mm (± 5.4), and the proportion of fish ≥ 250 mm was 0.18 (n = 9). Brook Trout relative weights averaged 89.3 (SE = 1.6) and were not significantly different from pre-tiger muskellunge stocking data from 2005 (ANOVA: $P > 0.05$). Results from 2022 showed that Brook Trout CPUE and size structure are similar to those prior to tiger muskellunge introduction. Additionally, while Westslope Cutthroat Trout were present in the survey catch, recent stocking events have failed to establish a self-sustaining population or a fishing opportunity. Currently, the Brook Trout population in Spruce Gulch Lake exhibits signs of density dependence and overall poor size structure. Results from 2022 emphasize the need to improve fishery quality with management options ranging from piscicide followed by native salmonid stocking to routine gillnetting surveys to reduce BKT abundance and improve size structure.

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INTRODUCTION

Spruce Gulch Lake contains a naturally reproducing population of Brook Trout *Salvelinus fontinalis* (BKT) originating from stocking events in the 1930s and 1940s. Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* (WCT) were also stocked in Spruce Gulch Lake in 1948, 1959, and 1964, but never established a self-sustaining population. Survey data from 2005 indicated BKT were the only fish species in the lake. In 2007, tiger muskellunge (Northern Pike *Esox lucius* × Muskellunge *E. masquinongy*) were stocked (*n* = 439; ~317 mm TL) to evaluate their effectiveness as a tool to eliminate BKT (Koenig et al. 2015). Subsequent fish surveys showed that while tiger muskellunge introduction did not eliminate BKT, their abundance (CPUE; fish/net-night) was reduced by 94% (Koenig et al. 2015). Regional fisheries staff then proposed renewing WCT stockings to improve the fishery and establish WCT alongside a diminished BKT population (Messner et al. 2017). Further, the lake's perceived lack of public use, despite its ease of access with off-road vehicles, led to recommendations for improving the fishery. In 2016, Spruce Gulch Lake was added to the "C-rotation" for high mountain lake stocking, with a request of 1,450 WCT every three years. Since WCT were added to the stocking rotation, Spruce Gulch Lake has not been surveyed. To evaluate the success of recent WCT stockings and to continue monitoring BKT abundance, fisheries staff surveyed Spruce Gulch Lake in 2022.

OBJECTIVES

- Determine fish species composition, size structure, and relative abundance.
- Assess WCT presence, abundance, size structure, and evidence of natural reproduction to evaluate stocking success and current stocking density.
- Assess BKT abundance and size structure to compare with previous surveys and determine if tiger muskellunge introduction had lasting population effects.

STUDY AREA

Spruce Gulch Lake (WGS84 datum: 44.60435ºN, 114.45113ºW) is a mountain lake accessible by motorized trail near Challis, Idaho. The lake is 4.4 ha in size and located in the headwaters of the Challis Creek drainage (HUC5) at 2,699 m elevation. Subterranean flow from the lake's outlet drains into Bear Creek, a tributary to Challis Creek in the upper Salmon River basin, but both inlet and outlet flows are seasonally intermittent.

METHODS

One pair of standard lowland lake gill nets (one sinking and one floating; 46 m x 2 m, with six panels consisting of 19-, 25-, 32-, 38-, 51-, and 64-mm bar mesh) was set on September 8, 2022, and fished overnight. The following morning, fish caught in gill nets were tallied by species, measured to the nearest mm (TL), and weighed to the nearest gram (g).

Brook Trout relative abundance was indexed as CPUE (fish/net-night) by summing the number of fish caught in each gill net divided by the number of nights the net fished (net-nights). To compare numbers observed in 2022 with previous surveys (Koenig et al. 2015), CPUE was calculated cumulatively across nets and not reported on a per-net basis.

Length-frequency histograms were constructed for BKT caught by gill net in 2022, as well as in all previous gill net surveys conducted by IDFG fisheries staff on Spruce Gulch Lake (2005 to 2022). Brook Trout captured via gill net were also used to calculate the proportion of catch ≥ 250 mm for population size structure comparisons with previous years.

Relative weights (W_r) were calculated for fish caught in gill nets that met species-specific minimum length requirements (BKT ≥ 120 mm TL; WCT ≥ 130 mm TL; tiger muskellunge ≥ 240 mm TL). Standard weights (W_s) were first calculated using the equation:

$$Log_{10}(W_s) = a + b * Log_{10}(\text{total length (mm)})$$

where *a* = the intercept value and *b* = slope derived from Neumann et al. (2012). The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$W_r = \left(\frac{\text{weight (g)}}{W_s}\right) * 100$$

Relative weights of BKT were then compared across all gill net surveys (2005 to 2022) to evaluate changes in average body condition through time. Differences in annual mean relative weights were tested via one-way analysis of variance (ANOVA) and compared before and after tiger muskellunge introduction using a post-hoc test (Tukey’s honestly significant difference). *P*-values were considered significant at $\alpha < 0.05$.

RESULTS

In 2022, a total of 53 fish were caught via gill net consisting of 51 BKT, one WCT, and one tiger muskellunge (combined CPUE = 26.5 fish/net-night). Total length of the WCT captured was 232 mm and relative weight was 82. Total length of the tiger muskellunge was 819 mm and its weight was not recorded as it exceeded the upper limit of the scale used. Brook Trout CPUE was 25.5 fish/net-night, marking the highest recorded value compared to all previous gillnetting surveys (Table 6; Figure 7). Total lengths of BKT ranged from 140 to 265 mm and averaged 206 mm (± 5.4; Table 6; Figure 8). The proportion of BKT ≥ 250 mm was 0.18 (n = 9). Brook Trout relative weights were generally below 100 for all observed size classes (mean = 89; SE = 1.6; Figure 9) and did not differ significantly from pre-tiger muskellunge introduction survey data in 2005 (ANOVA: $P > 0.05$; Figure 10). Of all gill net surveys, relative weights were significantly higher in 2008, 2010, and 2015 (ANOVA: $P \leq 0.01$) than those observed in 2005 prior to tiger muskellunge stocking (Figure 10).

DISCUSSION

Results from the gill net catch in 2022 showed that BKT relative abundance (CPUE) and population size structure have reverted to similar conditions exhibited prior to tiger muskellunge introduction. Brook Trout CPUE (fish/net-night) in 2022 was the highest value recorded during the 17-year survey period and 1.6 times greater than that observed in the pre-stocking survey in 2005. Granted, surveys conducted from 2005 to 2012 only used floating style gill nets. Therefore, CPUE calculated from surveys conducted in 2015 and 2022 may have been biased higher due to potential increased catch efficiency of sinking style gill nets. Size structure of the BKT population in Spruce Gulch Lake in 2022 displayed notably consistent metrics of average body length, relative weight, and the proportion of the catch ≥ 250 mm to 2005. Currently, an average individual BKT in Spruce Gulch Lake is below quality length and standard weight compared to a representative lentic BKT. Overall, the current BKT population in Spruce Gulch Lake appears to exhibit density dependent signs of stunted maximum individual size and likely poor growth rates, however, more information about length-at-age for BKT is needed. Thus, collecting aging structures of BKT in subsequent gillnetting efforts is recommended.

Results from 2022 also revealed that recent WCT stockings failed to establish a fishing opportunity, nor a self-sustaining population. Although 2,951 WCT had been stocked in years leading up to the 2022 survey (2016 and 2019), only one WCT was observed in the gill net catch. While competition with BKT is the most likely factor affecting WCT establishment (Peterson et al. 2004; Meyer et al. 2022), predation by tiger muskellunge or BKT could have also significantly reduced WCT survival, particularly since they are stocked as fry (≥ 76 mm). Conversely, the tiger muskellunge captured in the gill net in 2022 may represent the last or one of the last few remaining in Spruce Gulch Lake, and the WCT stocked in the fall of 2022 may experience higher survival. Regardless, discontinuing stocking of fry stage WCT on the “C” rotation is recommended, especially until predator populations are eradicated.

Results from 2022 combined with previous surveys show that tiger muskellunge were an effective predator for controlling BKT abundance and size structure. Though BKT were not fully eradicated from the lake, survey data indicate that a secondary stocking four- or five-years post introduction (2011 or 2012) may have eliminated the remaining individuals. Given that BKT in Spruce Gulch Lake currently do not provide a high-quality fishery, management action should be taken to either improve BKT fishing opportunity or eradicate BKT and establish a native salmonid fishery. Potential options include 1) stock tiger muskellunge at a low density (e.g., 5 to 10 fish/ha) to reduce BKT abundance and increase average length and relative weight while providing a diverse fishing opportunity, 2) periodically conduct intensive gillnetting to reduce BKT abundance and increase average fish condition, or 3) utilize piscicide to eliminate BKT and then subsequently stock WCT or RBT. Stocking the lake post piscicide treatment with Golden Trout *O. mykiss aguabonita* or Arctic Grayling *Thymallus arcticus* would also offer a unique fishing opportunity that would be more accessible compared to other lakes throughout the region that require hiking to catch these species, granted these fish are not native to the Salmon River watershed. While establishing a fishery for a native species reduces the ecological consequences of potential downstream escapement and colonization, the Spruce Gulch outlet is effectively disconnected from Bear Creek and certain anglers favor niche fishing opportunities for unique species. Gauging anglers’ opinions on the Spruce Gulch Lake fishery could help guide future management direction.

MANAGEMENT RECOMMENDATIONS

1. Discontinue stocking of fry-stage Westslope Cutthroat Trout unless Brook Trout are extirpated from Spruce Gulch Lake.

2. Depending on public interest and angler desires, either maintain a high catch rate Brook Trout fishery (i.e., no change), reduce Brook Trout density to improve fishery size structure, or eliminate Brook Trout and establish a native (e.g., Westslope Cutthroat Trout) trout fishery.

Table 6. Relative abundance (CPUE; fish/net-night) and size structure (mean TL mm, mean relative weight W_r, and proportion of catch ≥ 250 mm) of Brook Trout caught in gill net surveys in Spruce Gulch Lake from 2005 to 2022.

	Relative abundance			Size structure		
Year	Gill net effort (net-nights)	Number caught	CPUE (fish/net-night)	Mean TL (mm; ± SE)	Mean W_r (± SE)	Proportion ≥ 250 mm TL
2005	4	63	15.8	207 (± 4.7)	87 (± 1.9)	0.10
2008	2	16	8.0	264 (± 5.3)	103 (± 3.0)	0.81
2009	2	13	6.5	309 (± 5.8)	95 (± 4.4)	1.00
2010	2	12	6.0	304 (± 9.5)	102 (± 3.4)	0.92
2011	2	2	1.0	320 (± 15.0)	99 (± 2.5)	1.00
2012	2	2	1.0	168 (± 2.5)	83 (± 1.9)	0.00
2015	2	7	3.5	231 (± 26.7)	108 (± 3.2)	0.57
2022	2	51	25.5	206 (± 5.4)	89 (± 1.6)	0.18

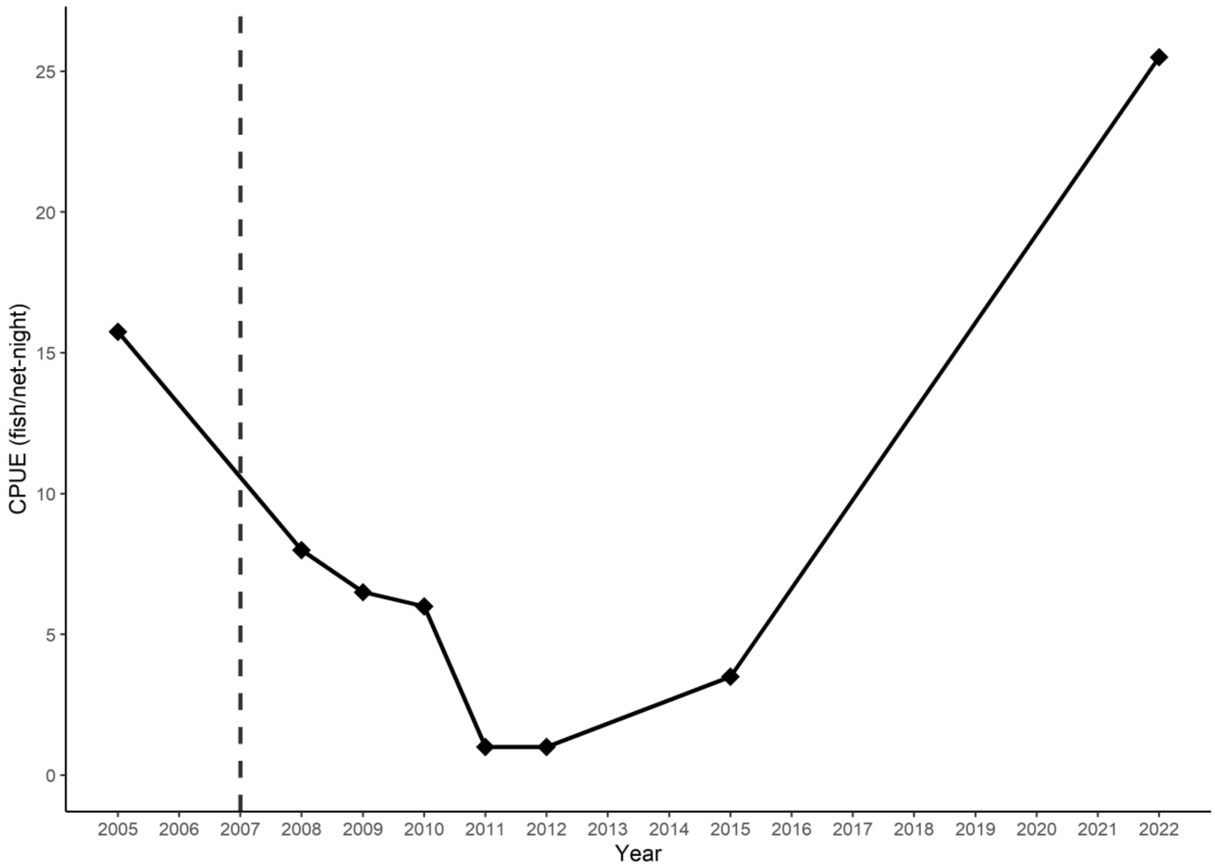

Figure 7. Gill net CPUE (fish/net-night) for Brook Trout caught in Spruce Gulch Lake from 2005 to 2022. Black diamonds indicate years when surveys were conducted, and the vertical dashed line denotes the introduction of tiger muskellunge in 2007.

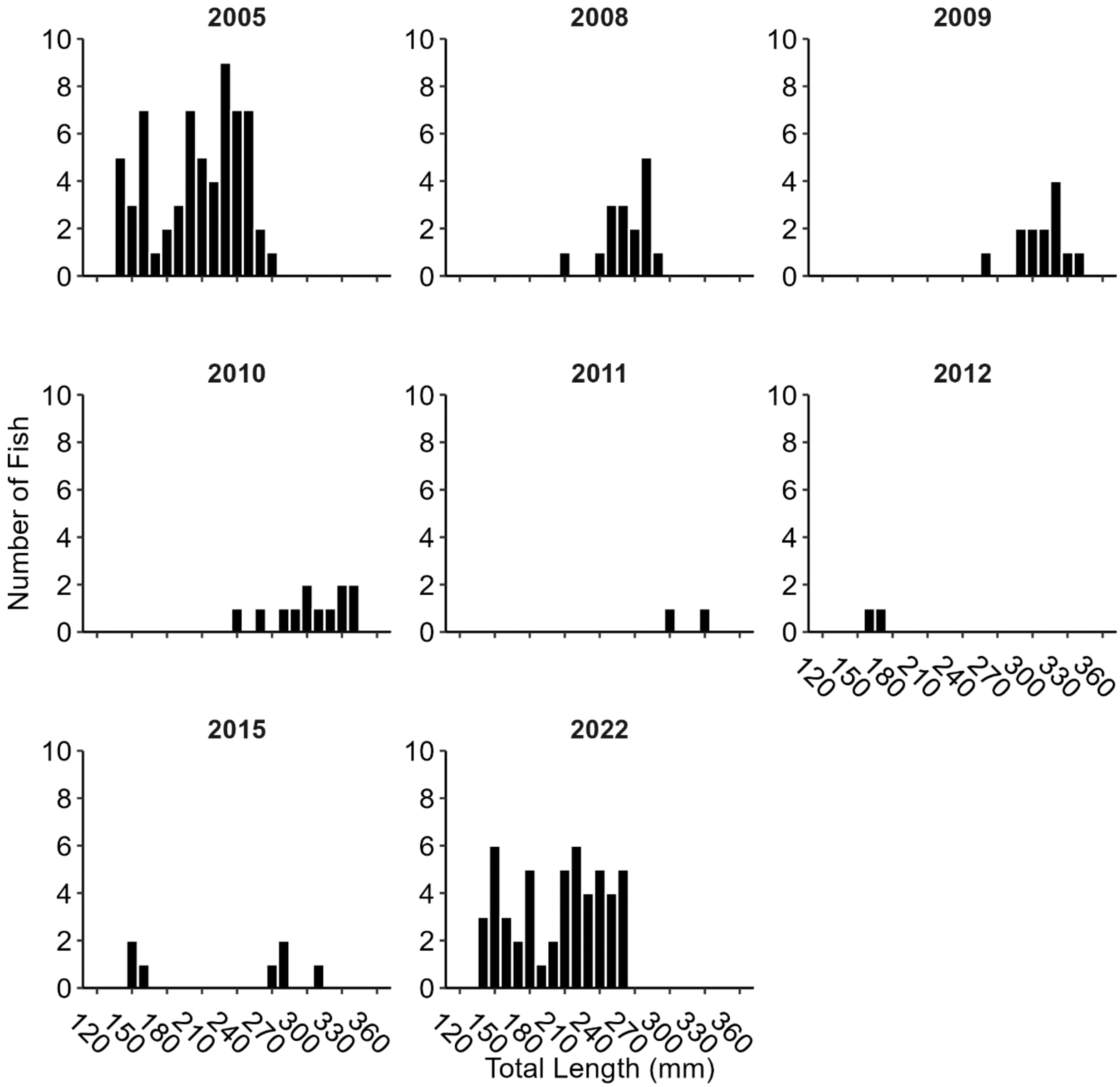

Figure 8. Length-frequency histograms for Brook Trout caught during gill net surveys in Spruce Gulch Lake from 2005 to 2022. Refer to Table 1 for sample sizes of each year.

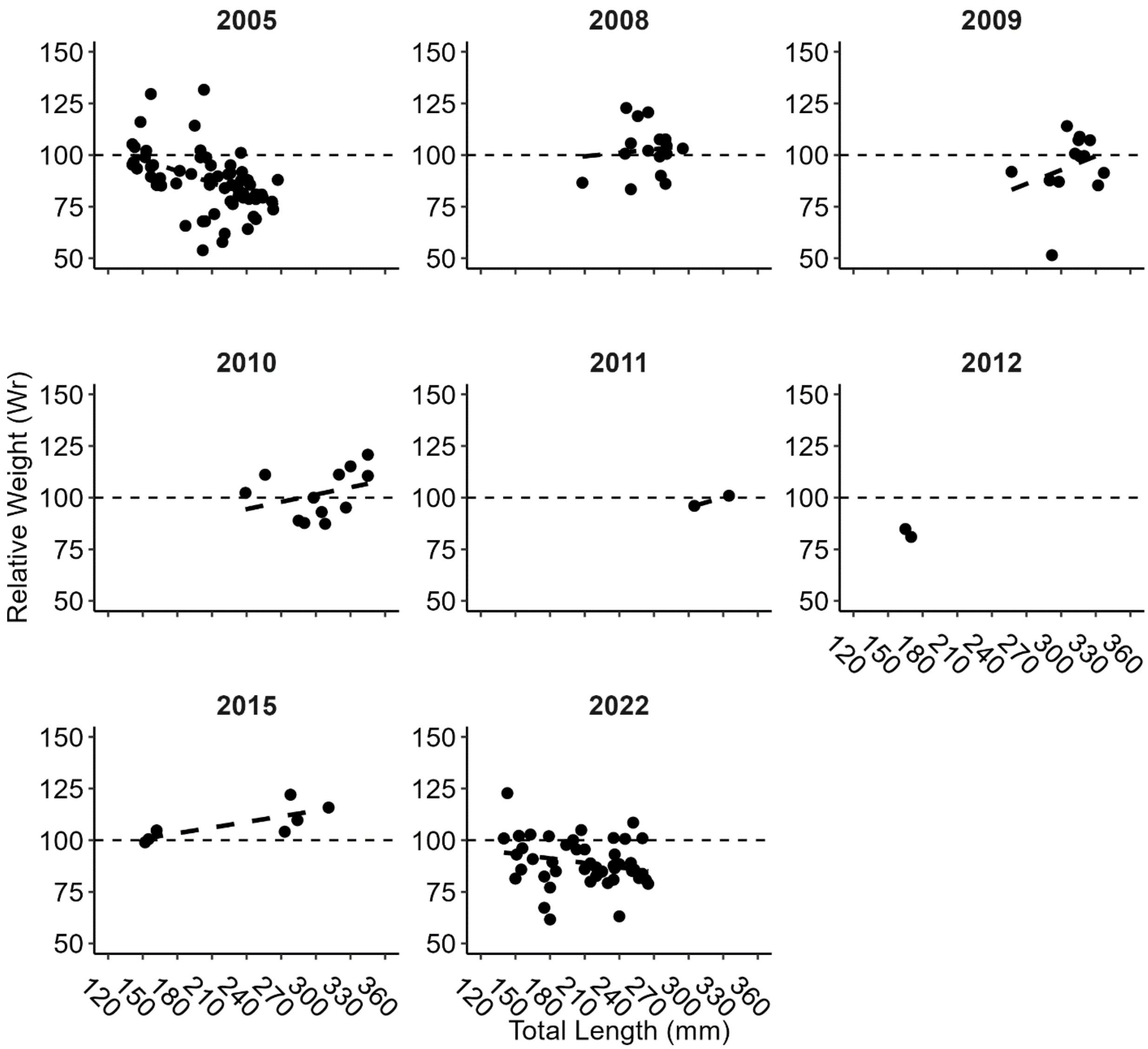

Figure 9. Relative weights (W_r) plotted against total length (TL; mm) for Brook Trout caught during gill net surveys in Spruce Gulch Lake from 2005 to 2022. Refer to Table 1 for sample sizes of each year.

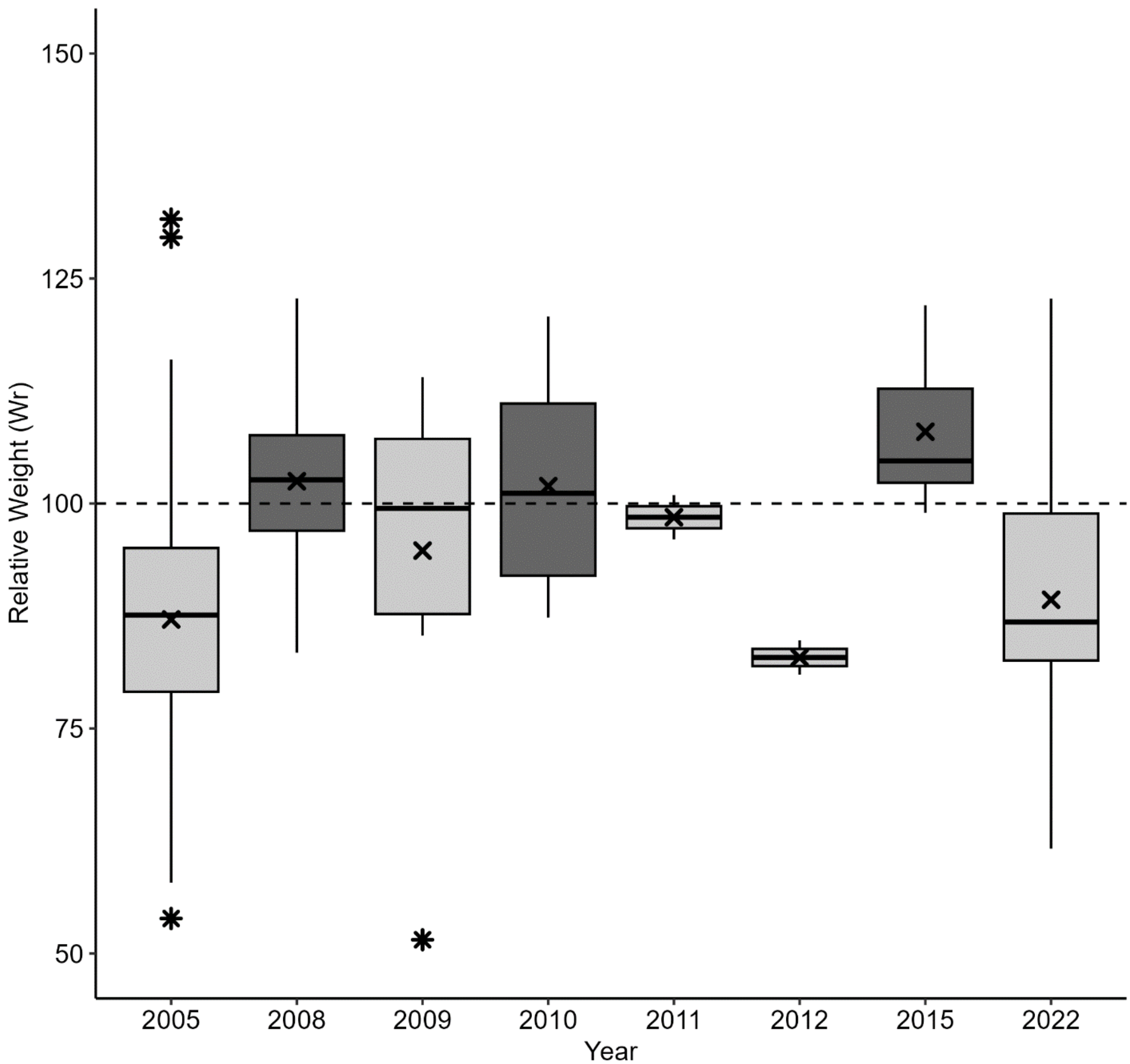

Figure 10. Boxplots displaying the relative weights (W_r) of Brook Trout caught during gill net surveys in Spruce Gulch Lake from 2005 to 2022. Mean values are depicted by “x” and outliers are denoted by asterisks. Dark gray boxes indicate years that mean relative weight differs significantly from pre-tiger muskellunge stocking data in 2005 (ANOVA, $\alpha = 0.05$). Refer to Table 1 for sample sizes of each year.

RIVERS AND STREAMS: MIDDLE FORK SALMON RIVER TREND MONITORING

ABSTRACT

During July 2022, IDFG staff snorkeled 36 trend transects in the Middle Fork Salmon River (MFSR) drainage to determine fish species composition, size, abundance, and density. Thirty-one main-stem MFSR transects, and five tributary transects were snorkeled. For main stem transects (n = 31), Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* had an overall mean density (± SE) of 1.30 fish/100 m^2 (± 0.68), Rainbow Trout/steelhead *O. mykiss* mean density was 0.82 fish/100 m^2 (± 0.23), and juvenile Chinook Salmon *O. tshawytscha* mean density was 0.56 fish/100 m^2 (± 0.17). In tributary transects (n = 10), Westslope Cutthroat Trout had an overall mean density of 0.60/100 m^2 (± 0.26), Rainbow Trout/steelhead mean density was 1.36 fish/100 m^2 (± 0.69), and juvenile Chinook Salmon mean density was 2.94 fish/100 m^2 (± 1.37).

In 2022, 56% (n = 125) of the 223 Westslope Cutthroat Trout observed during main stem snorkel surveys were greater than 300 mm TL, compared to 13% in 1971 (prior to catch-and-release regulations implemented in 1972). Thirty-one percent (31%) of Westslope Cutthroat Trout caught during hook-and-line surveys in 2022 were greater than 300 mm TL. The percentage of Westslope Cutthroat Trout caught > 300 mm has fluctuated from 25% in 2007 to 53% in 1987 but has remained higher in the years since catch-and-release regulations began (1972) than during the four years of data we have prior. Average catch rate during hook-and-line surveys has remained relatively stable over the last ten years (2.3 to 4.3 fish/h) but was the highest ever recorded in 2022 with 6.7 fish/h. Westslope Cutthroat Trout accounted for 58% of the total angler catch and Rainbow Trout/steelhead accounted for 38% in 2022. No White Sturgeon *Acipenser transmontanus* were caught during a novel sampling effort in the MFSR in 2022.

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INTRODUCTION

The earliest fishery study on the Middle Fork Salmon River (MFSR) was conducted in 1959 and 1960. This study evaluated the life history and seasonal movements of Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* (Mallet 1963). A study in 1971 established snorkeling transects to be surveyed periodically (Corley 1972). Further studies were established in 1971 to evaluate catch-and-release regulations put in place by the Idaho Department of Fish and Game (IDFG) in 1972 (Jeppson and Ball 1977, 1979). Our annual snorkel survey of the MFSR and its tributaries is now a continuation of a study started in 1985 to measure the densities of juvenile steelhead *O. mykiss,* Chinook Salmon *O. tshawytscha*, and Westslope Cutthroat Trout (Reingold and Davis 1987a, 1987b, 1988; Lukens and Davis 1989; Davis et al. 1992; Schrader and Lukens 1992; Liter and Lukens 1992). We also perform an annual hook-and-line survey to monitor trends of catch rates and size structure of fishes, as well as periodically collect hard structures for age and growth information. We have performed this survey annually since 2008, and it was previously performed sporadically from 1959 until 2008.

OBJECTIVES

- Monitor Rainbow Trout/steelhead, juvenile Chinook Salmon, and Westslope Cutthroat Trout densities within the MFSR and its tributaries to evaluate long-term trends in population status.
- Monitor angling catch rates and size structure, particularly for Westslope Cutthroat Trout, to evaluate long-term trends relating to angler satisfaction.

STUDY AREA

The Middle Fork of the Salmon River is part of the Wild and Scenic Rivers System and flows through the Frank Church River of No Return Wilderness in central Idaho. The MFSR originates at the confluence of Bear Valley and Marsh creeks near Cape Horn Mountain and flows 171 km to its confluence with the Salmon River, 92 km downstream from Salmon, Idaho (Figure 11). The MFSR is a major recreational river offering a wide variety of outdoor and back-country experiences. The MFSR offers fantastic fishing opportunities in the mainstem river and tributaries for Westslope Cutthroat Trout. Additionally, the MFSR provides opportunity to catch Bull Trout *Salvelinus confluentus* and other popular sportfish. The number of people floating the river has increased substantially in the past 5 decades, from 625 in 1962 to 11,844 in 2022 although this number has remained relatively constant since approximately 1973 when a lottery permit season was implemented.

METHODS

Main-stem and Tributary Snorkeling Transects

To monitor fish populations throughout the MFSR drainage, a total of 44 snorkel survey transects have been established and regularly surveyed since 1986. Six snorkel transects on the main-stem MFSR were established prior to 1985 and are defined as historical (Corley) transects. Traditional transects were established after 1985 and consist of 28 main stem transects and 10 tributary transects. MFSR snorkeling transects were sampled using techniques described by Thurow (1982). Snorkeling was conducted by two snorkelers floating downstream with the current, remaining as motionless as possible, along both sides of the river margin using the corridor method. All main-stem MFSR snorkeling transects and one tributary transect (i.e., Loon L1-Bridge) were sampled using the corridor method. All other tributary transects were snorkeled using the entire width survey method (Thurow 1982) in which snorkelers move upstream in a meandering pattern. All species observed were documented, and length and abundance were estimated for all salmonids. The area surveyed for corridor sites was estimated by multiplying the length of the snorkeled transect by the visible corridor (i.e. visibility) and then multiplied by the number of snorkelers at each site (e.g., 111 m length x 2.2 m visibility x 2 snorkelers = 488.4 m^2). Visibility was measured at each site by suspending a sighting object (i.e., a sandal) in the water column and allowing the snorkeler to drift downriver until the object was no longer identifiable. The snorkeler then moved upriver until the object reappeared clearly. The measured distance (m) between the object and the observer's facemask was used as an index for visibility. Fish densities were calculated by dividing estimated abundance by the area of the site and then multiplying by 100 (e.g., (4 fish / 488 m^2) x 100 = 0.82 fish/100 m^2).

Hook-and-line Sampling

The main objective of hook-and-line sampling is to evaluate trends in catch rates and size of fishes caught in the recreational fishery. Surveyors used typical fly-fishing techniques to gather catch rate and creel size information on 152.5 km of the main-stem MFSR from Boundary Creek to the confluence with the Salmon River in 2022. The exact amount of time fished, gear type used, total length and species of their catch was recorded. These data were added to an existing trend dataset that has been sporadically maintained since 1959, and consistently maintained since 2008.

In recent years, several outfitters, IDFG staff, and the public have reported sightings of White Sturgeon *Acipenser transmontanus* in the MFSR. Therefore, in addition to typical angling efforts conducted on the MFSR in 2022, we attempted to sample White Sturgeon to collect baseline information regarding relative abundance, distribution, size and age, genetics, and movement (based on PIT tags). White Sturgeon sampling was conducted with two heavy action fishing rods and heavy monofilament line, with tackle consisting of a circle hook baited with dead fish. Sampling for White Sturgeon was conducted every day of the trip at approximately 27 locations (Table 10). At each sampling location, two rods were fished for approximately 20 minutes (i.e., 40 total minutes).

RESULTS AND DISCUSSION

Main-stem and Tributary Snorkeling Transects

A total of 36 transects were snorkeled during July 13 to 19, 2022 including 5 MFSR historical (Corley) transects, 26 traditional main-stem transects, and 5 traditional tributary transects. Relatively high water prohibited some snorkel sites from being surveyed both in the main stem (n = 3) and in tributaries (n = 5). Mean densities (± SE) at traditional main-stem sites in 2022 were 1.12 fish/100 m^2 (± 0.25) for Westslope Cutthroat Trout, 0.86 fish/100 m^2 (± 0.42) for Rainbow Trout/steelhead, 0.60 fish/100 m^2 (± 0.33) for Chinook Salmon parr, 0.02 fish/100 m^2 (± 0.01) for Bull Trout, and 2.06 fish/100 m^2 (± 0.77) for Mountain Whitefish *Prosopium williamsoni* (Table 7; Figure 12). Mean fish densities at historical main-stem (Corley) sites snorkeled in 2022 were 2.11 fish/100 m^2 (± 1.11) for Cutthroat Trout, 0.12 fish/100 m^2 (± 0.05) for Rainbow Trout/steelhead, 0.00 fish/100 m^2 (± 0.0) for Chinook Salmon parr, 0.03 fish/100 m^2 for Bull Trout, and 1.26 fish/100 m^2 (± 0.55) for Mountain Whitefish (Table 7). In the five traditional tributary transects, we snorkeled in 2022, densities averaged 0.60 fish/100 m^2 (± 0.26) for Westslope Cutthroat Trout, 1.36 fish/100 m^2 (± 0.69) for Rainbow Trout/steelhead, 2.94 fish/100 m^2 (± 1.37) for Chinook Salmon parr, 0.06 fish/100 m^2 (± 0.06) for Bull Trout, and 0.38 fish/100 m^2 (± 0.13) for Mountain Whitefish (Table 7; Figure 12).

Since 1986 when the first snorkel surveys were completed at MFSR traditional sites, the percent of WCT greater than 300 mm has varied from 13 – 60% with an average of 32% during the same time period. In 2022, 56% (*n* = 125) of the 223 Cutthroat Trout observed during snorkeling were estimated to be greater than 300 mm TL in traditional main-stem MFSR transects, which was the third highest value since 1971 (Figure 16).

Snorkel densities in 2022 for anadromous parr in traditional main-stem transects were relatively low, which is to be expected considering the recent period of relatively low spawner escapement in the basin (Poole et al. 2021). This is evident in mean densities for Chinook Salmon parr across all main-stem traditional sites in 2022 (0.60 ± 0.33) when compared with the long-term average density (i.e., 1986 – 2022; 2.3 ± 0.32). Rainbow Trout/steelhead density was also slightly lower across all main-stem traditional sites in 2022 (0.86 ± 0.42) than the long-term average density (i.e., 1986 – 2022; 0.87 ± 0.09; Table 7). Additionally, WCT density was lower across all main-stem traditional sites in 2022 (1.12 ± 0.25) than the long-term average density (i.e., 1986-2022; 1.52 ± 0.09). In general, densities of Westslope Cutthroat Trout are higher in the upper and middle sections of the Middle Fork Salmon River, declining farther downstream (Figure 13). This trend is observed in both snorkel and hook-and-line surveys (Figure 13, Figure 19). Furthermore, Westslope Cutthroat Trout density in tributary sites (0.6 ± 0.26) was lower than the long-term average (1985 – 2022 = 1.79 ± 0.27; Table 7, Figure 14). It is possible that a positive relationship exists between water discharge in the main-stem MFSR and abundance of salmonids observed in main-stem snorkel surveys (Figure 17). For example, 2021 was a relatively low water year and this may help to explain the low densities of fishes observed in mainstem snorkel sites that year (Figure 17). On the contrary, 2022 was a relatively high-water year (Figure 15) and the inverse relationship was observed (Figure 17). Because of the increase in fish densities in tributaries in 2021 and the decrease observed in 2022, it is possible that salmonids are seeking refuge in tributaries during low water years in the mainstem MFSR.

Hook-and-line Sampling

During hook-and-line surveys, 439 fish from the main-stem MFSR where caught in 2022 (Table 8). Westslope Cutthroat Trout accounted for 58% of our total catch (*n* = 276) whereas Rainbow Trout/steelhead accounted for 38% (*n* = 151; Table 9). Mountain Whitefish, Northern Pikeminnow *Ptychochelius oregonensis*, suckers (various spp), Redside Shiners *Richardsonius balteatus*, Bull Trout, Brook Trout *S. fontinalis*, Chinook Salmon smolts, and trout hybrids accounted for the remaining 4% (Table 9). Catch per unit effort (CPUE) has fluctuated between 2.3 and 5.8 fish/h since 2008 (mean = 3.9 fish/h) when we began recording angling effort times and 2022 was the highest CPUE ever recorded with 6.7 fish/h (Table 8, Figure 18).

It is worth noting that average water temperatures in 2022 were relatively similar (16.1° C ± 0.29) when compared with prior temperature data (1989-2022; mean = 16.7° C ± 0.24) collected during snorkel surveys. Although water temperatures were similar to other years, discharge was relatively high at 1,538 cubic feet per second (cfs) when compared with the 10-year average (1134 ± 107). Water temperatures increased moving downstream, while angler CPUE decreased. For example, CPUE was 10.8 fish/h on the first day of the trip and water temperature was 14.5° C. Conversely, CPUE was 3.5 fish/h on the last day and water temperature was 17.8° C. This relationship has been observed in previous year’s surveys as catch rates generally decline farther downstream in the MFSR as water temperature generally increases and observed snorkel densities decrease (Figure 19). High water temperatures may negatively influence catch rates of WCT (Figure 22). This highlights the importance of documenting environmental variables such as water temperature during these surveys to better understand variability in catch rates. Our ability to detect dramatic shifts in species composition and fish abundance in the MFSR will increase as we continue to collect these data.

Prior to catch-and-release fishing regulations going into effect in 1972, the proportion of Westslope Cutthroat Trout sampled by hook-and-line anglers greater than 300 mm TL averaged approximately 20%. Since the regulation change, this proportion has fluctuated annually, ranging from a low of 25% in 2007 to a high of 53% in 1987 (mean = 38%; Figure 20). In 2022, the proportion of Westslope Cutthroat Trout larger than 300 mm TL caught by project anglers was 31% (*n* = 69; Figure 20). The relative increase in proportion of larger Westslope Cutthroat Trout caught since catch-and-release regulations went into place in 1972 is likely due to decreased total annual mortality (particularly harvest mortality). Annual fluctuation of this value could be partially attributed to differences in angler skill level, gear type, sample timing, river discharge, and water clarity. However, this value has remained relatively stable since 2010 (Figure 20). The overall size structure of Westslope Cutthroat Trout is balanced with peaks observed at 200-240 mm length bins (Figure 21). We will continue to monitor trends in the size structure of WCT in the MFSR to evaluate whether density dependence mechanisms may be influencing growth of WCT.

No White Sturgeon were captured in 2022 on the MFSR. There were two sampling locations (Funston and Wall Creek) in which the bait was taken, but no fish were hooked. The results of our attempted sturgeon sampling provide further evidence that sturgeon abundance is likely relatively low despite occasional sightings. Although no White Sturgeon were sampled in 2022, we recommend this effort is repeated every few years if time allows.

Lamprey Sampling

Lamprey surveys were not conducted on the Middle Fork Salmon in 2022. Lamprey distribution in the MFSR appears to be relatively constant. However, it is important to continue to monitor Lamprey size structure, although it might be acceptable to move to a five-year sampling regime.

MANAGEMENT RECOMMENDATIONS

1. Continue annual monitoring of Westslope Cutthroat Trout, Rainbow Trout/Steelhead, and juvenile Chinook Salmon in all 28 main-stem sites, 10 tributary sites, and 6 historical main-stem MFSR sites by snorkeling near the second week of July.

2. Continue annual monitoring of hook-and-line catch rates (fish/h) and fish size structure on the Middle Fork Salmon River to assess trends and to provide up-to-date information for anglers, guides, and outfitters.

3. Conduct age and growth analysis of WCT in MFSR for 3 consecutive years once every 10 years.

4. Continue monitoring of Lamprey in the MFSR every 5 years to monitor long-term changes in distribution, abundance, and size structure.

5. Create a sampling protocol to quantify the area surveyed in Lamprey monitoring to better evaluate changes in abundance over time.

6. Conduct fine-scale water temperature monitoring to assess changes in catch rates associated with changes in water temperature at the time of catch.

7. Continue to hook-and-line sample for White Sturgeon every few years to establish a baseline to monitor trends in abundance, distribution, size and age, genetics, and movement.

Table 7. Densities of salmonids observed during snorkel surveys in the MFSR drainage in 2022 (fish/100m^2). Bold text indicates the highest density observed for each species in historical, traditional, and tributary snorkel sites. Sites are listed from upstream to downstream within each category.

Site	Cutthroat Trout	Rainbow Trout/ steelhead	Chinook Salmon Parr	Bull Trout	Whitefish	Brook Trout	Fry
Historical main-stem sites (Corley)							
Little Creek GS	2.45	0.16	0.00	**0.16**	**3.43**	0.00	0.00
Mahoney	**6.32**	**0.26**	0.00	0.00	0.79	0.00	0.00
White Creek PB	0.29	0.04	0.00	0.00	0.46	0.00	0.00
Bernard Airstrip	0.66	0.13	0.00	0.00	0.79	0.00	0.00
Hancock Pool	--	--	--	--	--	--	--
Cliffside Pool	0.83	0.00	0.00	0.00	0.83	0.00	0.00
Mean	2.11	0.12	0.00	0.03	1.26	0.00	0.00
SE	1.11	0.05	0.00	0.03	0.55	0.00	0.00
Traditional main-stem sites							
Boundary	1.42	7.72	4.73	0.00	6.78	0.00	0.00
Gardell's	0.89	1.49	0.20	0.10	1.29	0.00	0.00
Velvet	**5.31**	**8.20**	**7.24**	0.00	2.90	0.00	0.00
Elkhorn	0.00	0.35	0.00	0.00	0.18	0.00	0.00
Sheepeater	0.67	1.11	0.00	0.00	0.45	0.00	0.00
Greyhound	0.42	0.42	0.00	0.00	0.42	0.00	0.00
Rapid R	2.82	0.70	0.00	0.14	1.41	0.00	0.00
Indian	3.27	0.38	0.67	0.00	1.44	0.00	0.00
Pungo	2.51	0.59	0.00	0.00	0.30	0.00	0.00
Marble Pool	1.41	0.00	0.00	0.00	0.79	0.00	0.00
Ski Jump	--	--	--	--	--	--	--
Lower Jackass	1.58	0.34	2.25	0.00	1.58	0.00	**0.11**
Cougar	0.00	0.00	0.00	0.00	0.26	0.00	0.00
Whitey Cox	2.01	0.11	0.00	0.00	0.89	0.00	0.00
Rock Island	0.28	0.00	0.09	0.00	0.37	0.00	0.00
Hospital Pool	0.82	0.00	0.00	0.16	0.49	0.00	0.00
Hospital Run	1.05	0.00	0.42	**0.21**	0.42	0.00	0.00
Tappan Pool	0.64	0.00	0.00	0.00	0.36	0.00	0.00
Flying B	0.18	0.00	0.00	0.00	**17.72**	0.00	0.00
Airstrip	0.12	0.84	0.12	0.00	0.00	0.00	0.00
Survey	0.00	0.00	0.00	0.00	0.71	0.00	0.00
Big Cr PB	0.10	0.10	0.00	0.00	10.71	0.00	0.00
Love Bar	0.13	0.00	0.00	0.00	0.13	0.00	0.00
Ship Island	NA	NA	NA	NA	NA	NA	NA

Table 7. (continued)

Site	Cutthroat Trout	Rainbow Trout/ steelhead	Chinook Salmon Parr	Bull Trout	Whitefish	Brook Trout	Fry
Little Ouzel	0.15	0.00	0.00	0.00	0.15	0.00	0.00
Otter Bar	2.05	0.00	0.00	0.00	0.96	0.00	0.00
Goat Pool	0.56	0.00	0.00	0.00	1.49	0.00	0.00
Goat Run	0.82	0.00	0.00	0.00	1.43	0.00	0.00
Mean	1.12	0.86	0.60	0.02	2.06	0.00	0.00
SE	0.25	0.42	0.33	0.01	0.77	0.00	0.00
Traditional tributary sites							
Big Creek L1	--	--	--	--	--	--	--
Indian LOWER	0.66	1.15	0.00	0.00	0.33	**1.00**	0.00
Indian UPPER	0.00	0.00	3.41	0.00	0.45	0.00	0.00
Loon L1-Bridge	--	--	--	--	--	--	--
Loon L-2 Run	--	--	--	--	--	--	--
Camas L1	--	--	--	--	--	--	--
Camas UPPER	--	--	--	--	--	--	--
Marble Lower	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pistol L1	**1.22**	**3.65**	**7.31**	0.00	**0.81**	0.00	0.00
Pistol L2	1.14	1.99	3.98	**0.28**	0.28	0.00	0
Mean	0.60	1.36	2.94	0.06	0.38	0.20	0.00
SE	0.26	0.69	1.37	0.06	0.13	0.20	0.00

Table 8. Summary of fish caught and catch-per-unit-effort (CPUE; fish/h) during angling surveys on the main stem MFSR, 1959 to 2022.

	WCT	RBT/ STHD	BLT	MWF	WCTx RBT	BLTx BKT	CHN	BKT	NPM	SUC	RSS	Total number of fish	Total effort (h)	CPUE
1959	143	112	11	0	0	0	0	0	0	0	0	266	UNK	n/a
1960	484	103	94	0	0	0	0	0	0	0	0	681	UNK	n/a
1969[a]	166	-	-	-	-	-	-	-	-	-	-	166	UNK	n/a
1975	158	109	11	4	0	0	0	0	0	0	0	282	57.5	4.9
1976	75	14	2	2	0	0	0	0	0	0	0	93	UNK	n/a
1978	160	91	0	13	0	0	0	0	0	0	0	264	86.0	3.1
1979	139	112	0	0	0	0	0	0	0	0	0	251	UNK	n/a
1990	735	339	2	0	0	0	0	0	0	0	0	1076	UNK	n/a
1991	42	54	0	0	3	0	0	0	0	0	0	99	UNK	n/a
1992	42	53	0	1	0	0	0	0	0	2	0	98	UNK	n/a
1993	242	66	0	0	6	0	0	0	0	0	0	314	UNK	n/a
1999	182	132	0	0	8	0	0	0	0	0	0	322	UNK	n/a
2003	167	91	0	0	0	0	1	0	0	0	1	260	UNK	n/a
2004	243	184	1	0	0	0	1	0	1	0	0	430	UNK	n/a
2005	226	157	7	2	4	0	0	0	5	0	0	401	UNK	n/a
2007	264	253	2	6	1	0	0	0	16	0	0	542	UNK	n/a
2008	64	90	0	0	1	0	0	0	0	0	0	155	26.9	5.8
2009	340	230	2	4	8	0	0	1	14	0	2	601	166.0	3.6
2010	174	115	8	21	3	0	2	2	0	0	0	325	116.2	2.8
2011	109	47	0	6	0	0	0	0	0	0	0	162	42.0	3.9
2012	299	206	11	14	4	0	0	0	5	1	1	541	145.9	3.7
2013	200	195	1	6	1	1	3	0	9	0	0	416	102.0	4.1
2014	167	137	3	7	1	1	0	0	6	3	2	327	98.7	3.3
2015	214	179	3	12	10	0	29	0	8	0	0	455	104.9	4.3
2016	270	192	0	2	11	0	0	0	9	0	2	486	156.5	3.1
2017	247	99	1	1	4	0	6	0	5	0	1	364	105.2	3.5

Table 8. (continued)

	WCT	RBT/ STHD	BLT	MWF	WCTx RBT	BLTx BKT	CHN	BKT	NPM	SUC	RSS	Total number of fish	Total effort (h)	CPUE
2018	116	93	1	1	3	0	0	0	1	0	0	215	61.3	3.5
2019	324	131	1	0	8	0	0	1	2	0	0	467	203.1	2.3
2021	253	170	2	7	5	2	3	1	11	0	0	454	110.3	4.1
2022	276	151	0	0	10	0	1	0	1	0	0	439	61.9	6.7

[a] Only WCT enumerated
WCT=Westslope Cutthroat Trout, RBT/STHD=Rainbow Trout/Steelhead, BUT=Bull Trout, MWF=Mountain Whitefish, CHN=Chinook Salmon, BKT= Brook Trout, NPM=Northern Pikeminnow, SUC = Sucker spp., RSS=Redside Shiner.

Table 9. Percentage (%) of each salmonid species represented in total catch during angling surveys on the mainstem MFSR, 1959 to 2022. Only WCT were enumerated in 1969, therefore it was omitted from this table, and no surveys were conducted in 2020 due to Covid-19.

Year	WCT	RBT/STHD	BLT	MWF	WCTxRBT	BKT	BLTxBKT
1959	54	42	4	0	0	0	0
1960	71	15	14	0	0	0	0
1975	56	39	4	1	0	0	0
1976	81	15	2	2	0	0	0
1978	61	34	0	5	0	0	0
1979	55	45	0	0	0	0	0
1990	68	32	0	0	0	0	0
1991	42	55	0	0	3	0	0
1992	43	54	0	1	0	0	0
1993	77	21	0	0	2	0	0
1999	57	41	0	0	2	0	0
2003	64	35	0	0	0	0	0
2004	57	43	0	0	0	0	0
2005	56	39	2	0	1	0	0
2007	49	47	0	1	0	0	0
2008	41	58	0	0	1	0	0
2009	57	38	0	1	1	0	0
2010	54	35	2	6	1	0	1
2011	67	29	0	4	0	0	0
2012	55	38	2	3	1	0	0
2013	48	47	0	1	0	0	1
2014	51	42	1	2	0	0	0
2015	47	39	1	3	2	0	6
2016	56	40	0	0	2	0	0
2017	68	27	0	0	1	0	0
2018	54	43	0	0	1	0	0
2019	69	28	0	0	2	<1	0
2021	56	37	<1	2	1	<1	0
2022	63	34	0	0	2	0	0
mean	58	38	1	1	1	0	0

*Note: column headers were incorrect in 2014-2016 annual reports. They are presented correctly here.
WCT=Westslope Cutthroat Trout, RBT/STHD=Rainbow Trout/steelhead, BLT=Bull Trout, MWF=Mountain Whitefish, BKT= Brook Trout.

Table 10. Names and locations of sites sampled for White Sturgeon on the Middle Fork Salmon River in 2022.

Site Name	Latitude	Longitude
Dolly Lake	44.694654	-115.146844
Pistol Creek	44.723176	-115.149295
Marble Run	44.743247	-115.021823
Lower Jackass	44.722587	-114.961754
Mahoney Pool	44.751213	-114.916618
Pine Flat	44.759052	-114.897433
Whitey Cox	44.783717	-114.855739
White Creek Pack Bridge	44.800388	-114.835733
Heifer Creek	44.821102	-114.803788
Cave Camp/Hospital Pool	44.836030	-114.792021
Tappan Pool	44.879073	-114.748747
Cove Creek	44.879087	-114.738918
Pool Camp	44.903994	-114.728263
Funston	44.909207	-114.732701
Cold Spring Creek	44.999065	-114.729072
Jack Creek Canyon	45.012254	-114.726652
Below Rattlesnake	45.053240	-114.724634
Survey Camp	45.056724	-114.723508
Woolard Camp	45.058184	-114.725099
Cutthroat Cove	45.105817	-114.730980
Elk Bar	45.114291	-114.725722
Wall Creek	45.128615	-114.727565
Otter Bar	45.238729	-114.662500
Reese Creek	45.248656	-114.659510
Nolan Creek	45.258312	-114.649012
Hancock Pool	45.261074	-114.643201
House of Rocks	45.275434	-114.622236

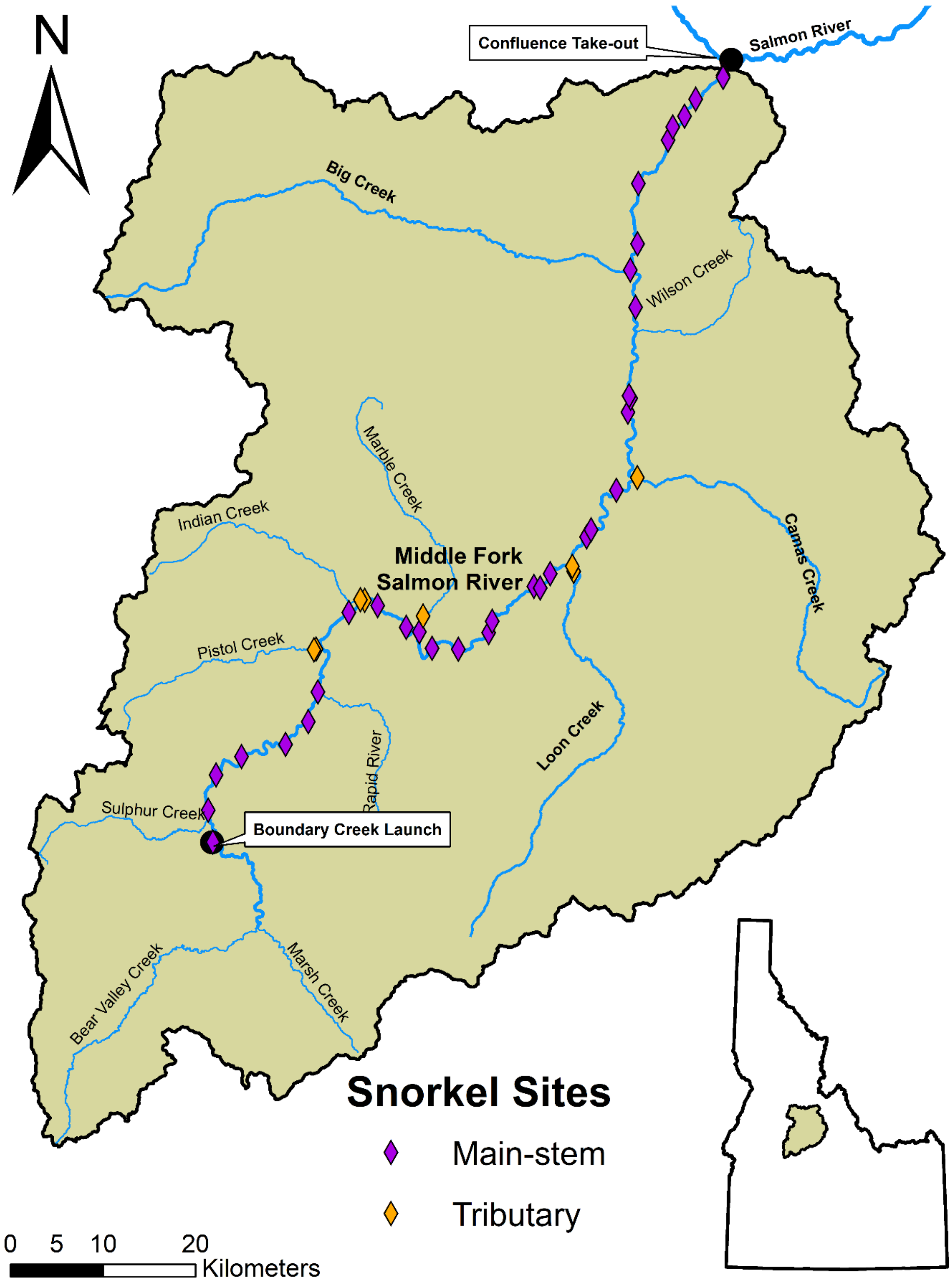

Figure 11. Map of the Middle Fork Salmon River and its major tributaries. Purple diamonds display main-stem snorkel sites while orange diamonds display sites done in tributaries. Refer to Table 7 for a list of all sites.

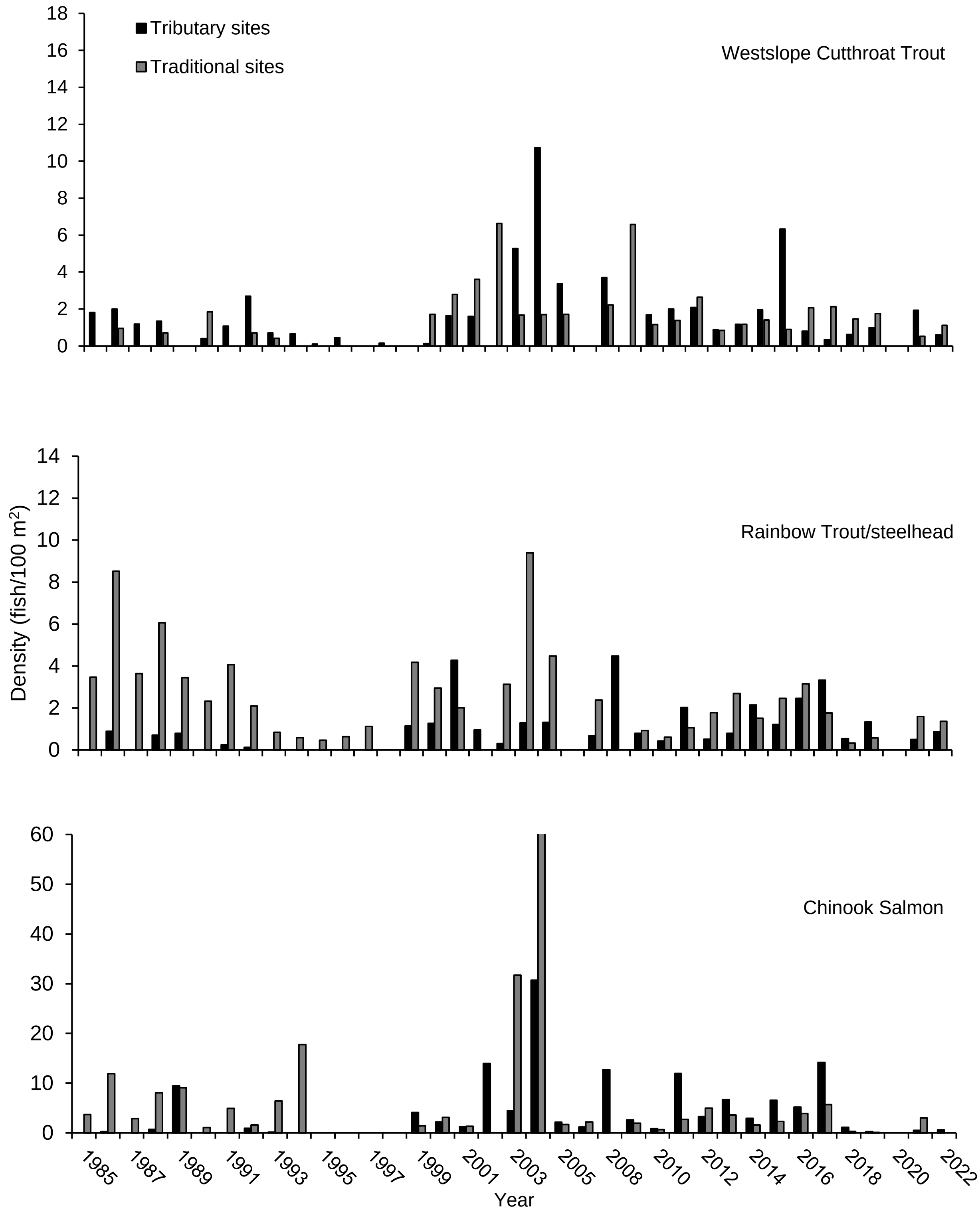

Figure 12. Average density of salmonids (Westslope Cutthroat Trout [top], Rainbow Trout/steelhead [middle], Chinook Salmon [bottom]) observed during snorkel surveys at MFSR main-stem sites and tributary sites from 1985-2022. Due to Covid-19, no surveys were conducted in 2020. Note differences in scale (y axis) for each figure.

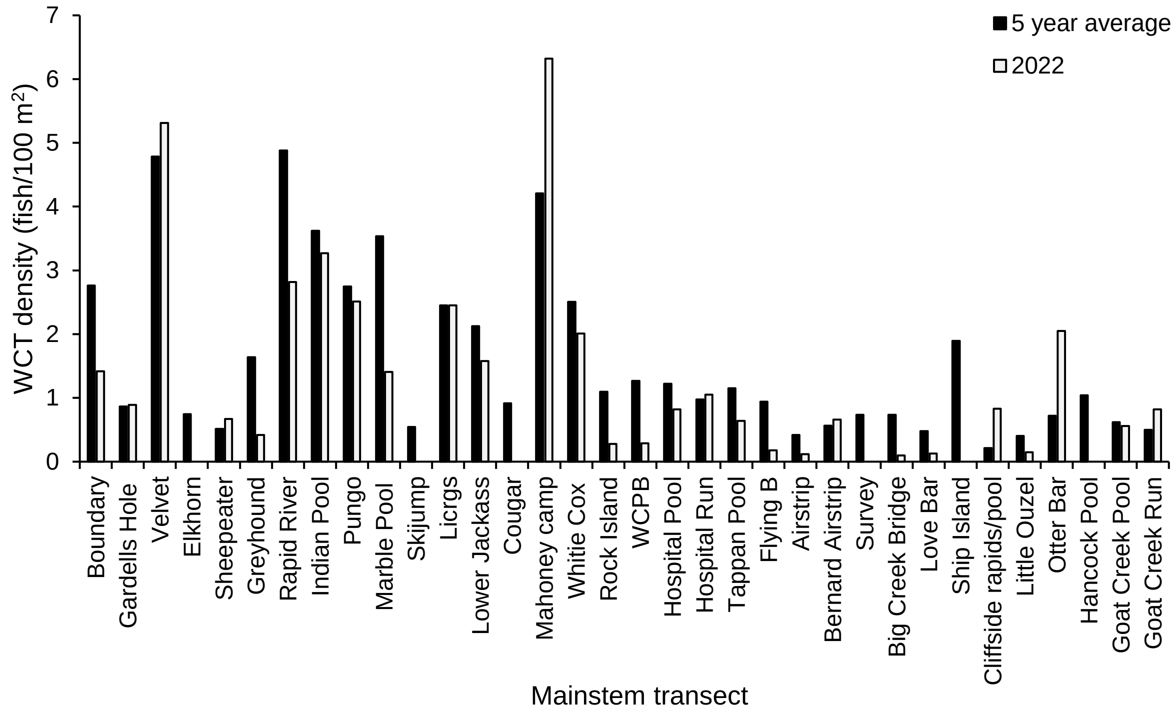

Figure 13. Densities of Westslope Cutthroat Trout (WCT) by site in the mainstem MFSR, 2022 compared with 5-year average (excluding 2020, due to Covid-19 when no surveys were conducted). Sites are arranged in order from upstream (Boundary site) to downstream (Goat Creek Run).

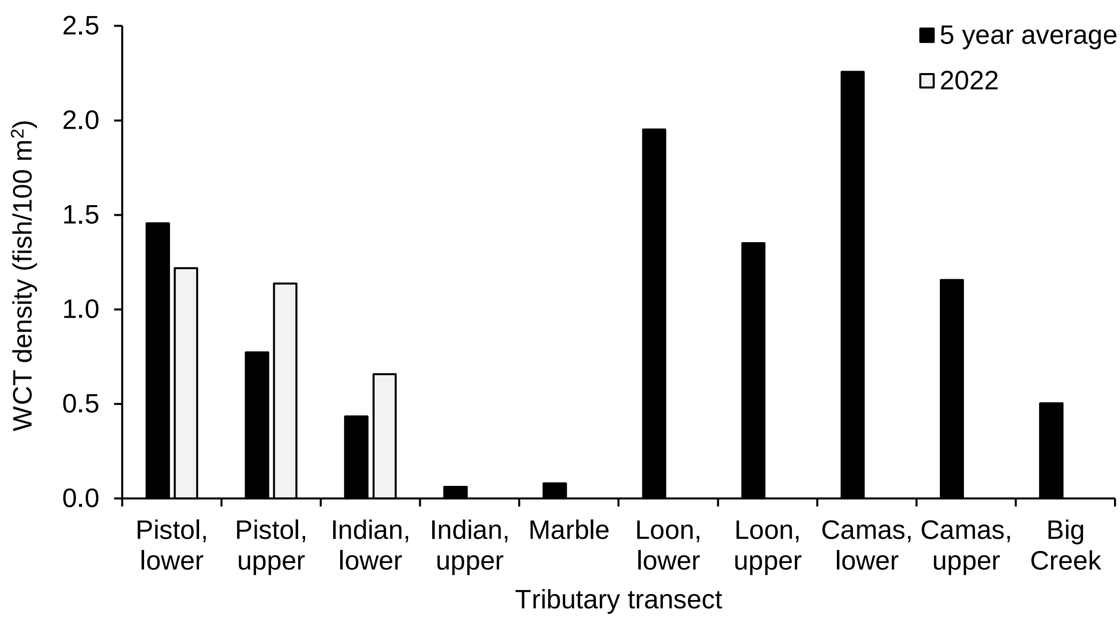

Figure 14. Densities of WCT by site in tributaries of the MFSR, 2022 compared with 5-year average (excluding 2020, due to Covid-19 when no surveys were conducted).

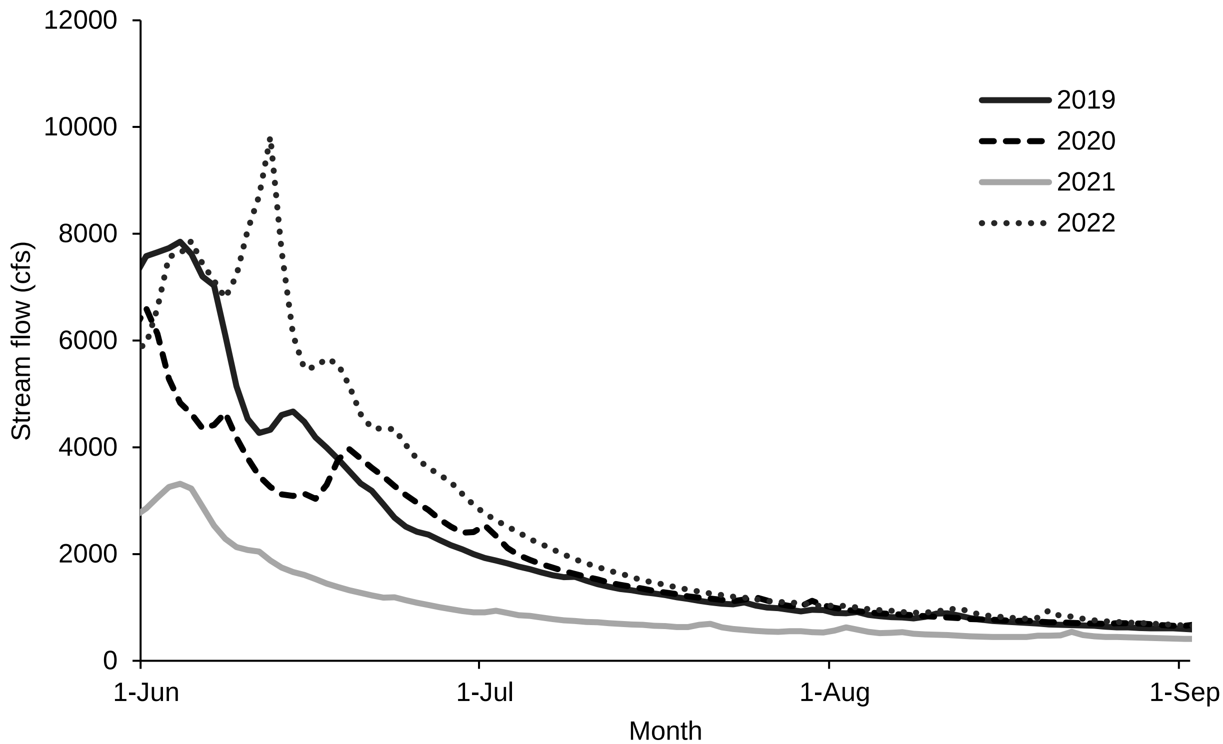

Figure 15. Daily discharge (cfs) for the Middle Fork Salmon River at Middle Fork Lodge (km 53 from Boundary Creek put-in), 2019 – 2022. Note that 2022 was a relatively high-water year during the annual sampling period.

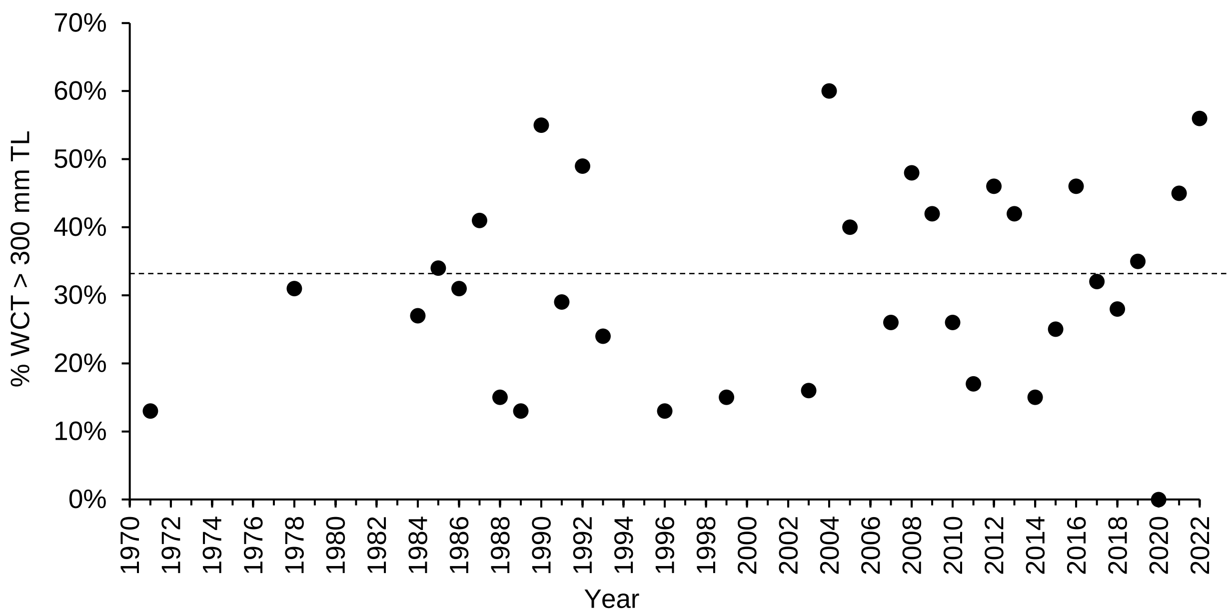

Figure 16. Percentage of Westslope Cutthroat Trout greater than 300 mm TL observed during snorkel surveys in the main stem MFSR, 1971 to 2022. Due to Covid-19, no surveys were conducted in 2020. Dashed line represents the average (32%) during the same time period.

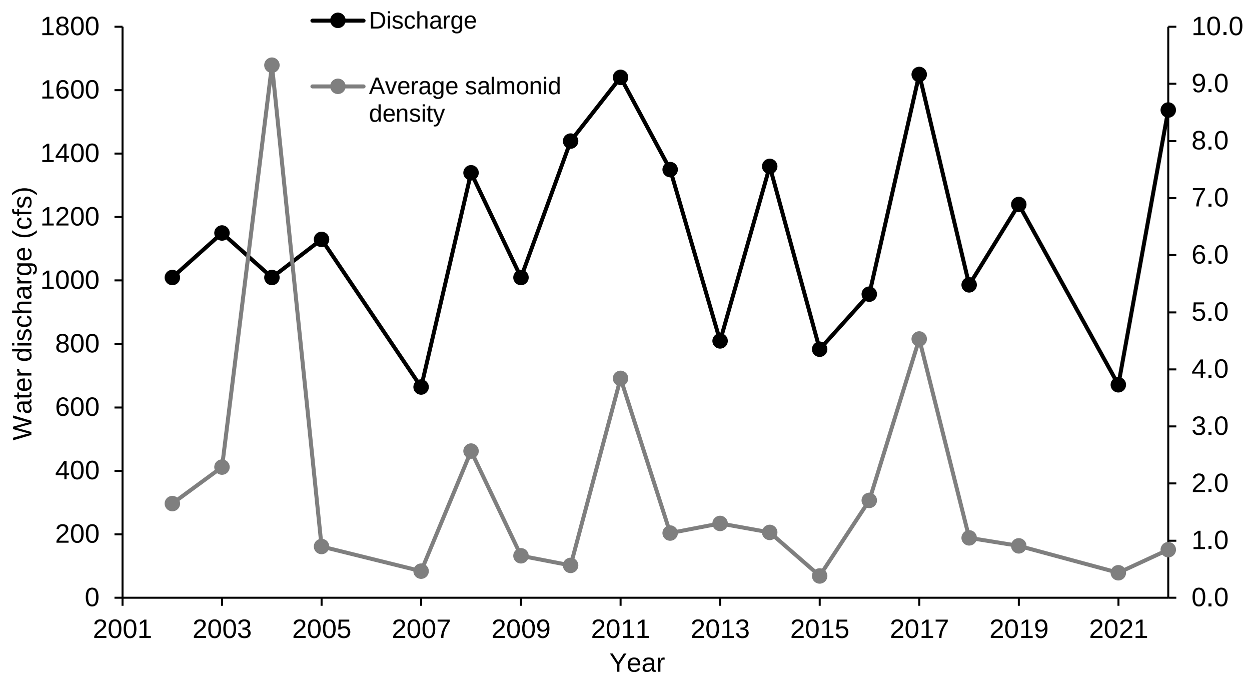

Figure 17. The black line represents average salmonid (i.e., Westslope Cutthroat Trout, Rainbow Trout/steelhead, Chinook Salmon parr) density in main-stem Middle Fork Salmon River snorkel surveys in 2022, and the grey line represents water discharge (cfs) from the Middle Fork Salmon River at Middle Fork Lodge (km 53 from Boundary Creek put-in) on the first day of each annual float trip from 2002-2022. Due to Covid-19, no surveys were conducted in 2020.

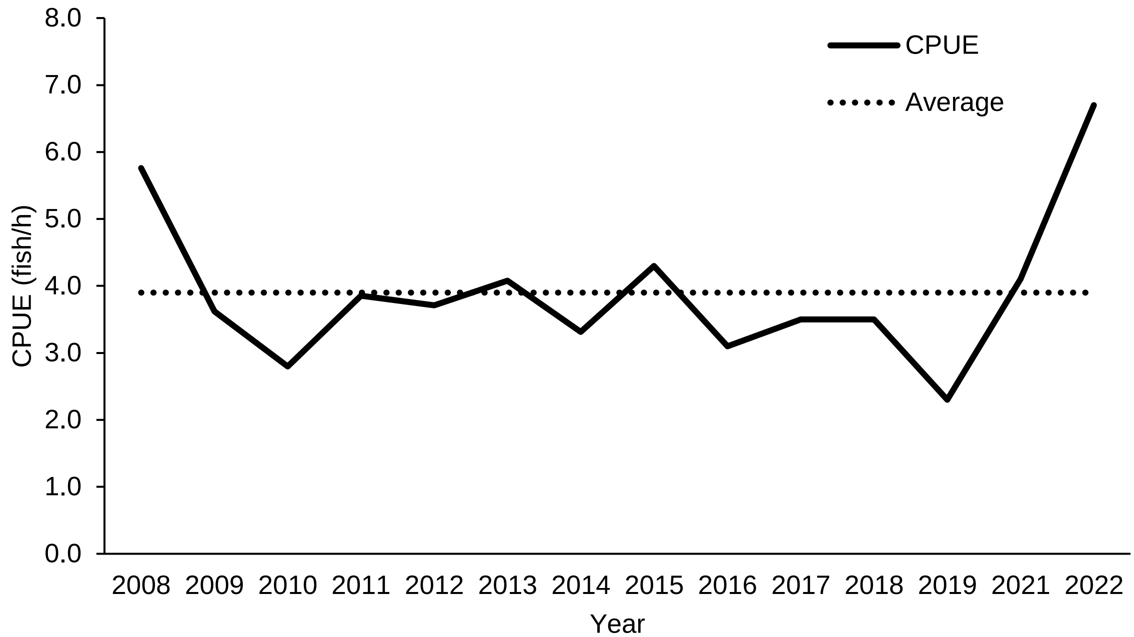

Figure 18. Catch per unit effort (CPUE; number of fish caught per angler hour) estimated from hook and line sampling on the Middle Fork of the Salmon River between 2008 and 2022. The dotted line represents the mean (3.9 fish per angler hour) CPUE estimated over this time period. Due to Covid-19, no surveys were conducted in 2020.

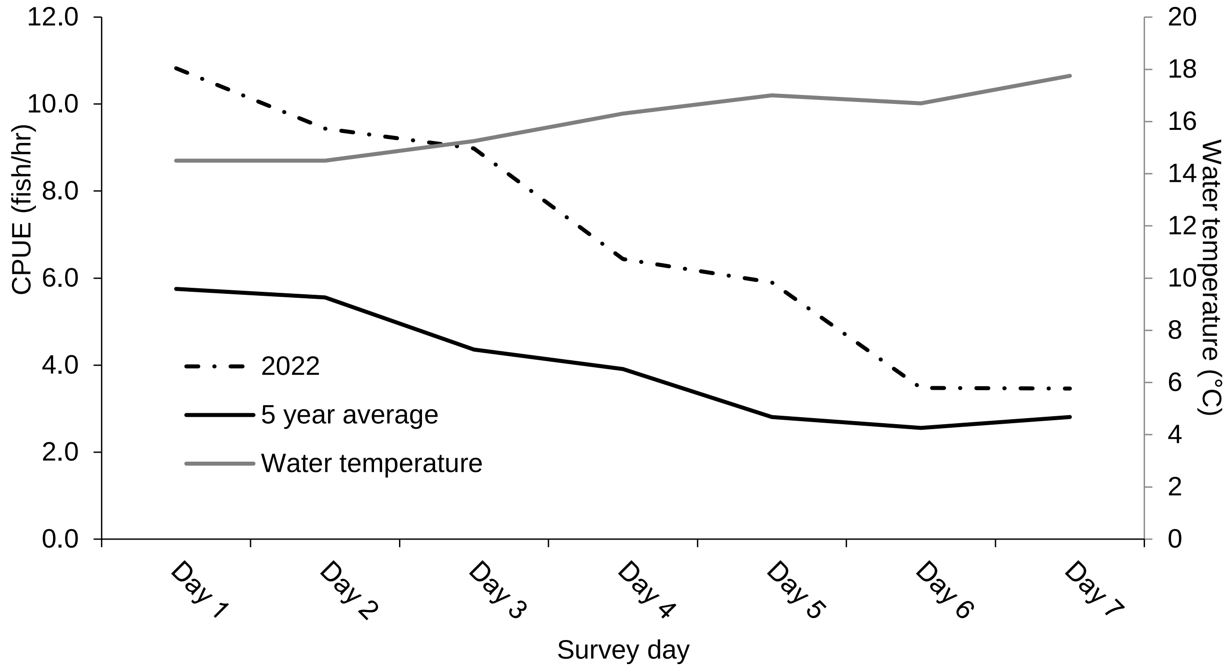

Figure 19. Daily catch per unit effort (CPUE; number of fish caught per angler hour) during angling surveys on the main stem MFSR. The solid line represents the average from surveys during 2017-2022 and the dashed line is the CPUE from 2022. Due to Covid-19, no surveys were conducted in 2020.

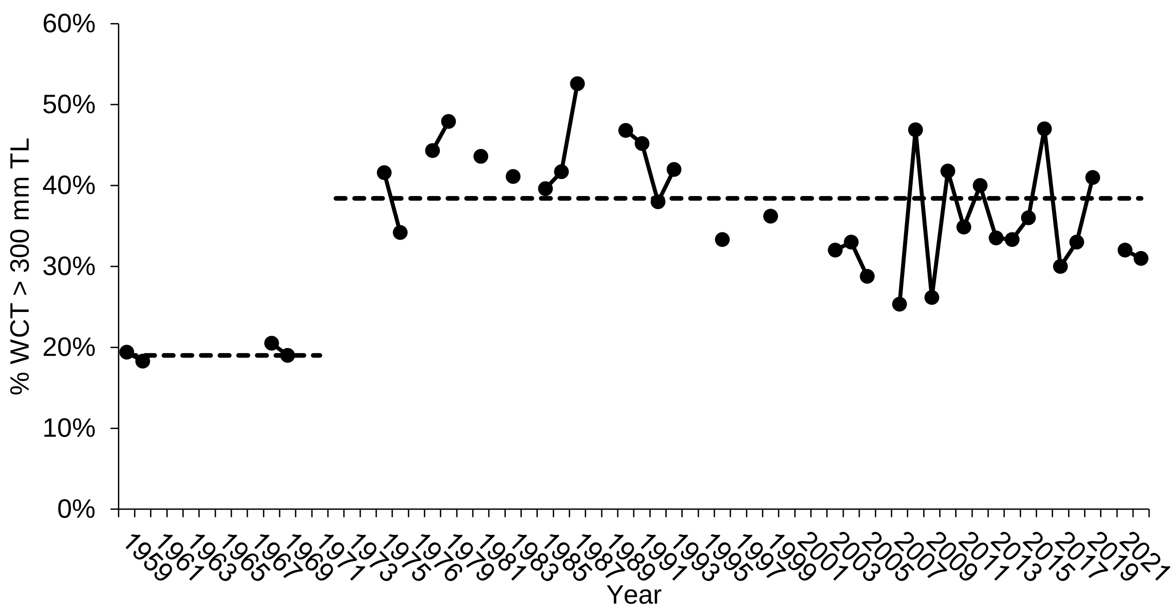

Figure 20. Percentage of Westslope Cutthroat Trout greater than 300 mm TL caught during angling surveys on the Middle Fork Salmon River, 1959 to 2022. The two dashed lines represent average proportions prior to 1972 (during harvest; 19%) and post-1972 (catch-and-release only; 38%). Due to Covid-19, no surveys were conducted in 2020.

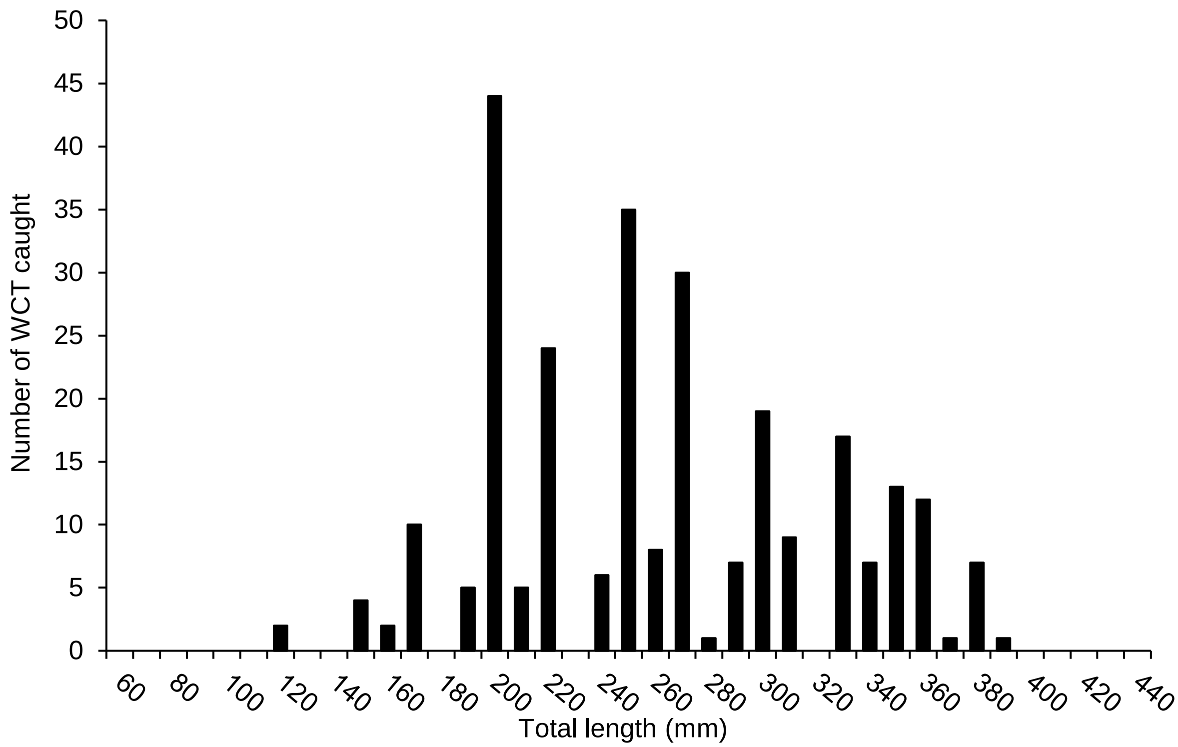

Figure 21. Length-frequency histogram of Westslope Cutthroat Trout (n = 269 fish) caught during angling surveys in 2022 on the Middle Fork Salmon River.

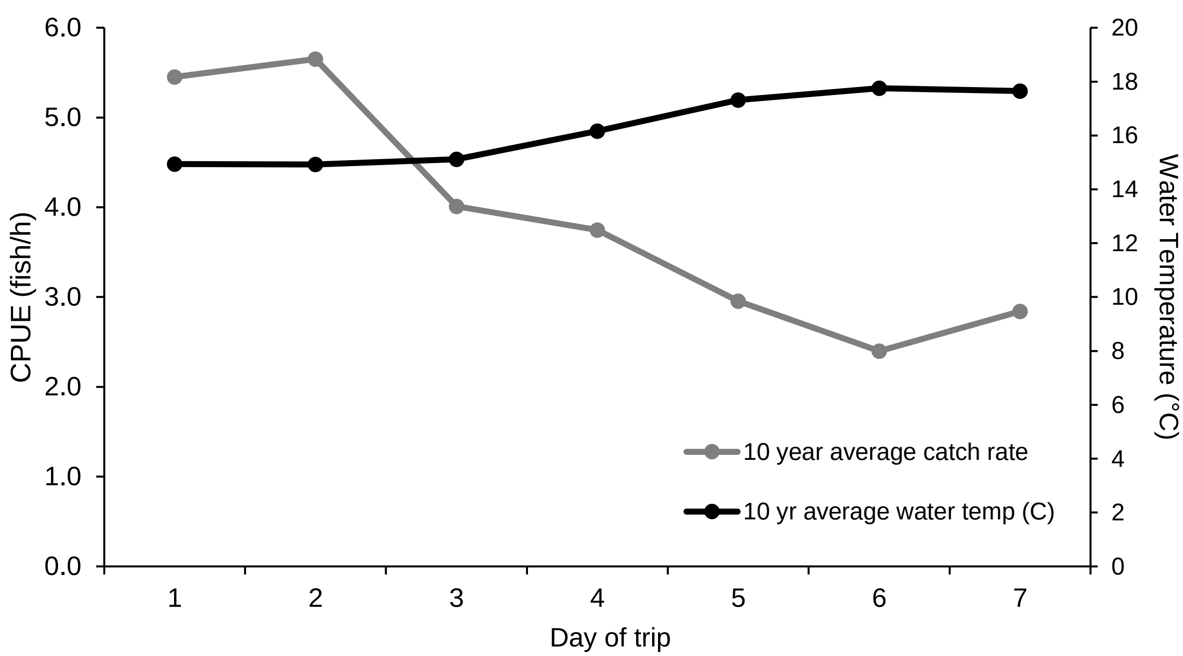

Figure 22. Ten-year average catch per unit effort (CPUE; number of fish caught per angler hour; black line and dots) and water temperature (°C; gray line and dots) on day 1 through 7 of the annual MFSR float trip. Due to Covid-19, no surveys were conducted in 2020.

MIDDLE FORK SALMON RIVER THERMAL REFUGIA STUDY

ABSTRACT

In July 2022, regional fisheries staff evaluated whether salmonid densities differed in the main-stem Middle Fork Salmon River (MFSR) above and below tributaries mouths (i.e., plumes) to understand the importance of cold-water input as thermal refugia for fishes. A total of 20 sites were surveyed in 2022, with salmonids present at 18 of them. Of the sites where salmonids were present, 12 (67%) contained higher salmonid densities in the plumes than in the mainstem immediately adjacent upstream of the tributary confluence. Plumes averaged 2.4°C (SE = 0.4) cooler than the main-stem MFSR. In general, we observed larger Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* using plume habitat over those observed in adjacent main-stem MFSR habitat. Identifying and understanding the importance of cold-water input as potential refugia for salmonids during higher summer water temperatures may help direct future habitat restoration efforts aimed at stream connectivity.

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INTRODUCTION

In the Upper Salmon River sub-basin, most tributary streams provide cold-water input to larger, warmer main-stem rivers during the summer months. Cold water pockets can develop where colder tributaries and warmer main-stem rivers converge. These cold-water pockets may be important for salmonid persistence and survival in larger main-stem rivers, particularly when water temperatures increase during the summer months. Elevated stream temperatures during summer months can negatively affect metabolic rates and sometimes cause direct mortality to salmonids (Brett 1979). Ebersole et al. (2001) found that 10 - 40% of Rainbow Trout *Oncorhynchus mykiss* sampled in their study reaches in the Snake River drainage were congregated in small pockets of colder water during warm summer months, where tributaries converge with the main stem. These "thermal plumes" when used by fish to avoid undesirable thermal conditions are known as "thermal refugia". Stevens and DuPont (2011) also observed Westslope Cutthroat Trout *O. clarkii lewisi*, Rainbow Trout, and Mountain Whitefish *Prosopium williamsoni* utilizing cold water side channels in northern Idaho with fish greater than 300 mm TL using these habitats at greater rates as temperature in the main river increased, and as the temperature of the main river and side channels diverged. However, many tributaries in the Upper Salmon River basin are impacted by water withdrawals, thus limiting the cold-water inputs available to main-stem rivers. We continued a study from 2012, 2013, 2014, and 2021 that investigated the importance of thermal refugia in an intact wilderness river system, the Middle Fork Salmon River (MFSR). This study aimed to determine if salmonid densities differed significantly above and below tributary confluences (i.e., main stem vs. plumes).

OBJECTIVES

Evaluate the importance of thermal refugia in tributary plumes for salmonids in the main-stem Middle Fork Salmon River.

STUDY AREA AND METHODS

From July 14 to 19, 2022, we surveyed 20 tributary plume sites along the wilderness section of the Middle Fork Salmon River (MFSR) via snorkeling to evaluate salmonid utilization of plume habitats. The MFSR was divided into three strata for this study: Upper, Middle, and Lower (Figure 23). The Upper strata extended from Sulphur Creek downstream to Pungo Creek, the Middle strata included those tributaries from Little Soldier Creek to Big Bear Creek, and the Lower strata encompassed selected tributaries from Sheep Creek to Goat Creek. In 2022, five sites were identified in the Upper strata, six sites in the Middle strata, and nine sites in the Lower (Figure 23). Each survey site consisted of a 30-m reach above each tributary (termed "above plume") and a 30-m reach below each tributary (termed the "plume"). One snorkeler counted fish while moving downstream in each reach, approximately 1 m out from the bank. All salmonids were identified to species, counted, and their total length was estimated to the nearest 25-mm length group. Chinook Salmon*O. tshawytscha* parr were assigned an age (i.e., age-0 or age-1) based on total length. Non-salmonids were noted if present. Visibility was estimated at each site by suspending a sighting object in the water column and allowing the snorkeler to drift downriver until the object was unidentifiable. Water temperature was measured with a hand-held thermometer at each site to determine thermal differences between the plume and the main-stem river. We recorded temperature above the tributary confluence, in the tributary itself, and at 1, 10, 20, and 30m below the tributary confluence, within 1 m of the bank.

We used paired *t*-tests to detect significant differences in salmonid densities above and below tributary mouths (α = 0.05). We used the same tests to determine whether the temperature difference between the main-stem river and the thermal plumes at each site and within each strata were significantly different. Paired *t*-tests were also used to determine whether there were significant differences in the mean TL of Westslope Cutthroat Trout observed in plumes and the main-stem MFSR.

RESULTS AND DISCUSSION

Snorkelers observed a total of 172 fish at the 20 study sites in 2022, of which 50.6% (*n* = 87) were Westslope Cutthroat Trout, 28.5% (*n* = 49) were Rainbow Trout/steelhead, 15.7% (*n* = 27) were Mountain Whitefish, 4.6% (*n* = 8) were Chinook Salmon parr (*O. tshawytscha)*, and 0.6% (n = 1) were trout fry (various spp.). Suckers *Catastomus* spp. were noted, but these species were not enumerated at six sites.

Salmonids were observed in 18 of the 20 sites surveyed (Table 11). Salmonid densities in tributary plumes were greater than in the main-stem river above the plumes in 67% (*n* = 12) of the 18 tributary sites where salmonids were observed (Table 12; Figure 24). Paired *t*-test results indicated that the difference was not statistically significant across the entire river reach (df = 19, *p* = 0.18). When broken out into the upper, middle, and lower strata, no strata had statistically significant differences in salmonid densities (*p = 0.47, p = 0.72, p = 0.19*, respectively; Figure 24). Although we did not observe significant differences, average salmonid densities were higher in plumes across all strata. The average salmonid density above plumes was 0.79 fish/100 m^2 (± 0.44) in the upper strata, 3.74 fish/100 m^2 (± 0.73) in the middle, and 4.08 fish/100 m^2 (± 0.92) in the lower strata. In the plume, the average salmonid density in the upper strata was 2.41 fish/100 m^2 (± 2.41), 5.61 fish/100 m^2 (± 1.72) in the middle, and 7.59 fish/100 m^2 (± 2.68).

We also compared the difference in size between Westslope Cutthroat Trout observed in the plumes and the mainstem immediately upstream of tributary mouths. The mean TL of Westslope Cutthroat Trout observed in the mainstem was 229 mm (*n* = 18); in the plumes, the mean Westslope Cutthroat Trout TL was 244 mm (*n* = 69). Results of the *t*-test indicate that this mean size difference was not significant (*p* = 0.33, *df* = 28). In previous years of the study, the utilization of cool water plume habitat by larger fish was similar to observations made by Stevens and Dupont (2011), where Westslope Cutthroat Trout greater than 300 mm TL selected for cold water side channel habitats as the difference in temperature increased between the refugia and the main-stem. In 2022, we did not see a strong relationship between fish size and plume use. This was likely related to higher stream flows (and cooler temperatures) in the main-stem river, reducing the need for thermal refugia in plumes.

On average, water temperature in tributary plumes was 2.4°C (SE = 0.4) cooler than the main-stem MFSR above the plumes, with a range from 1.0 °C warmer to 5.3 °C colder (Table 13; Figure 25). Paired *t*-test results indicated that the difference was statistically significant across the entire river reach (*p*<0.01, *df* = 18). We removed Loon Creek from this analysis due to missing main-stem temperature data. When broken out by strata, water temperature in tributary plumes was significantly lower than main-stem river temperatures above the plumes in the upper and lower strata (*p* <0.01, df = 4, and *p* <0.01, df = 8, respectively). Water temperatures in middle strata plumes were all less than or equal to main-stem MFSR temperatures, but the differences were not statistically significant (*p* = 0.18, df = 4). Temperature differences between the plume and main-stem MFSR were most pronounced in the lower strata (*diff* = -1.8, -2.1, -2.9, respectively; Table 13, Figure 26).

During the week our survey, discharge of\ the MFSR averaged about 81 m^3/s, roughly 25% more than the five-year mean discharge of 63 m^3/s for the same period (Figure 27). Unlike 2021, where the Salmon Region was characterized by prolonged drought, and near historic low stream discharge, 2022 was defined by above average discharge driven by precipitation throughout the spring into July. The 2022 sampling suggested salmonids still used plumes, but at a lower frequency that during low water years when thermal conditions in the main-stem MFSR would be more stressful During the survey period, the average daytime highs were 34ºC.

This study highlights the variability of stream temperature and habitat use over multiple years. While we did see some differences in stream temperatures between plumes and the main stem, we did not see salmonids consistently using plumes in 2022. Temperature differences and habitat use in 2021 were more pronounced and showed the significant importance of thermal refugia in extreme drought years (Kelly et al. *in review*). In 2022, flows in the MFSR were roughly 25% higher than the mean discharge for much of the summer (Figure 27), which may have affected our results. Higher flows in the MFSR in 2022 likely represented higher flows within the tributaries we surveyed for this study. The increased mainstem and tributary flows likely maintained thermal connectivity allowing fish to utilize the water outside of the plumes. Previous years in this study where low flow and high temperatures most likely exacerbated the temperature difference between main-stem and tributary habitats and led to higher densities and larger fish utilizing plumes (Kelly et al. *in review*). Although we saw higher fish densities utilizing the plume on average, this could be related to the increased stream flow contributing to increased plume habitat. Continued monitoring of tributary plumes in the MFSR during different water conditions and Chinook Salmon brood year strengths may elicit the relationship of plume habitat utilization for these species of greatest conservation concern. Identifying and understanding the importance of thermal plumes as refugia for salmonids in a wilderness system like the MFSR can help resource managers understand the importance of reconnecting tributaries to main-stem rivers in more altered systems, where flows have been dramatically decreased or disconnected due to anthropogenic effects. Future monitoring results may help guide restoration actions aimed at improving connectivity and maintaining thermal refugia.

MANAGEMENT RECOMMENDATIONS

1. Continue using the Middle Fork Salmon River system as a guide to understand how biological organisms and processes should function under ideal conditions.

2. Continue studying plume habitat use by threatened salmonids during variable flow and temperature regimes through time.

Table 11. Numbers of fish observed during snorkeling in tributary plumes and above plume sites in the main-stem Middle Fork Salmon River, 2022. Tributaries are listed in sequence as encountered downriver of Boundary Creek. Shading represents strata breaks for Upper, Middle, and Lower.

		Westslope Cutthroat Trout total length (mm)			Rainbow Trout/steelhead total length (mm)			Other species[c]				
Tributary	Strata	<300	>300	Total	<300	>300	Total	CK Juv	Trout Fry	MWF	SUC	Total fish
Deer Horn	Plume	0	0	0	0	0	0	0	0	1	0	1
Deer Horn	Above plume	0	0	0	0	0	0	0	0	0	0	0
Elkhorn	Plume	8	4	12	3	0	7	0	0	2	0	21
Elkhorn	Above plume	0	0	0	7	0	3	0	0	0	0	3
Garden	Plume	0	0	0	0	0	0	0	0	0	0	0
Garden	Above plume	0	0	0	1	0	1	0	0	0	0	1
Indian	Plume	0	0	0	0	0	0	0	0	0	0	0
Indian	Above plume	1	0	1	0	0	0	0	0	0	0	1
Pungo	Plume	0	0	0	0	0	0	0	0	0	0	0
Pungo	Above plume	0	0	0	0	0	0	0	0	0	0	0
Little Loon	Plume	3	2	5	0	0	0	0	0	0	0	5
Little Loon	Above plume	2	0	2	3	0	3	0	0	1	0	6
Little Soldier	Plume	1	0	1	0	0	0	0	0	0	0	1
Little Soldier	Above plume	0	1	4	3	0	3	2	0	0	P	9
Marble	Plume	0	0	0	0	0	0	0	0	4	0	4
Marble	Above plume	0	0	0	0	0	0	0	0	0	0	0
Camas	Plume	0	1	1	0	0	0	0	0	3	0	4
Camas	Above plume	1	1	2	0	0	0	0	1	0	0	3
Loon	Plume	1	1	2	0	0	0	0	0	0	P	2
Loon	Above plume	0	0	0	0	0	0	0	0	0	0	0
Pine	Plume	2	0	2	0	0	0	0	0	0	0	2
Pine	Above plume	1	0	1	1	0	1	2	0	1	0	5
Soldier	Plume	12	5	17	5	0	5	2	0	0	P	24
Soldier	Above plume	0	0	0	6	0	6	2	0	0	0	8

[a] Mussels observed.
[b] Adult Chinook Salmon observed.
[c] Other Species: CK=Chinook Salmon, MWF=Mountain Whitefish, SUC=Sucker *spp*.

Table 11. (continued)

Tributary	Strata	Westslope Cutthroat Trout total length (mm)			Rainbow Trout/steelhead total length (mm)			Other species[c]				
		<300	>300	Total	<300	>300	Total	CK Juv	Trout Fry	MWF	SUC	Total fish
Wilson	Plume	3	3	6	0	1	1	0	0	1	0	8
Wilson	Above plume	0	1	1	0	0	0	0	0	0	0	1
Bobtail	Plume	0	1	1	1	0	1	0	0	2	0	4[a]
Bobtail	Above plume	1	0	1	1	0	1	0	0	0	0	2
Golden	Plume	3	0	3	3	0	3	0	0	0	0	6
Golden	Above plume	0	0	0	2	0	2	0	0	0	0	2
Papoose	Plume	0	5	5	1	0	1	0	0	3	P	9
Papoose	Above plume	0	2	2	0	0	0	0	0	2	0	4
Ship Island	Plume	2	1	3	0	0	0	0	0	0	0	3[a]
Ship Island	Above plume	0	0	0	0	0	0	0	0	0	0	0
Goat	Plume	3	1	4	0	0	0	0	0	2	P	6
Goat	Above plume	2	0	2	1	0	1	0	0	0	0	3
Roaring	Plume	3	0	3	2	0	2	0	0	1	0	6
Roaring	Above plume	0	0	0	5	0	5	0	0	2	0	7
Stoddard	Plume	4	0	4	1	0	1	0	0	0	0	5
Stoddard	Above plume	2	0	2	2	0	2	0	0	2	P	6[a]

Mussels observed.
[b] Adult Chinook Salmon observed.
[c] Other Species: CK=Chinook Salmon, MWF=Mountain Whitefish, SUC=Sucker *spp*.

Table 12. Salmonid densities per 100 m^2 in snorkeling surveys of tributary within and above tributary plumes in the main-stem Middle Fork Salmon River, 2022. Shading represents strata breaks of upper, middle, and lower river sections.

		Species and densities in plume[a]						Species and densities above plume[a]					
Tributary	River km[b]	WCT	RBT/SH	CK	BLT	MWF	Total	WCT	RBT/SH	CK	BLT	MWF	Total
Elkhorn	139.2	6.9	4.0	0.0	0.0	1.2	12.1	0.0	2.4	0.0	0.0	0.0	2.4
Deer Horn	136.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Garden	114.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.8
Indian	109.6	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.8
Pungo	107.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Soldier	101.9	0.5	0.0	0.0	0.0	0.0	0.5	3.5	2.6	1.8	0.0	0.8	7.9
Marble	100.5	0.0	0.0	0.0	0.0	2.9	2.9	0.0	0.0	0.0	0.0	0.0	0.0
Little Loon	88.8	5.2	0.0	0.0	0.0	0.0	5.2	1.7	2.5	0.0	0.0	0.8	5.0
Pine	81.9	1.7	0.0	0.0	0.0	0.0	1.7	0.8	0.8	1.6	0.0	0.8	4.0
Loon	72.8	1.9	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0
Camas	56.3	0.9	0.0	0.0	0.0	2.8	3.7	1.7	0.0	0.8	0.0	0.0	2.5
Soldier	37.6	20.2	6.0	2.4	0.0	0.0	28.6	0.0	5.3	1.8	0.0	0.0	7.1
Wilson	37.1	5.0	0.8	0.0	0.0	0.8	6.6	1.1	0.0	0.0	0.0	0.0	1.1
Bobtail	31.2	1.0	1.0	0.0	0.0	2.0	4.0	1.2	1.2	0.0	0.0	0.0	2.4
Golden	21.8	2.9	2.9	0.0	0.0	0.0	5.8	0.0	2.4	0.0	0.0	0.0	2.4
Papoose	19.0	4.2	0.8	0.0	0.0	2.5	7.5	2.2	0.0	0.0	0.0	2.2	4.4
Ship Island	18.9	2.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Stoddard	9.8	2.5	0.6	0.0	0.0	0.0	3.1	2.2	2.2	0.0	0.0	2.2	6.6
Roaring	6.2	2.5	1.7	0.0	0.0	0.8	5.0	0.0	5.6	0.0	0.0	2.2	7.8
Goat	2.1	3.5	0.0	0.0	0.0	1.8	5.3	3.3	1.7	0.0	0.0	0.0	5.0

[a] Species: WCT = Westslope Cutthroat Trout, RBT/SH = Rainbow Trout/steelhead, CK=Chinook Salmon, BLT=Bull Trout, MWF=Mountain Whitefish
[b] River km readings begin at 0 km at the mouth of Middle Fork Salmon River and increase moving upstream

Table 13. Mean water temperatures in the Middle Fork Salmon River above tributary plume sites and degree difference in plumes, and visibility measurements inside and outside the plume at 20 snorkeling sites surveyed in 2022. Shading represents strata breaks of upper, middle, and lower river sections.

	Water temperature (ºC)		Visibility (m)	
Tributary	Above plume	Temperature difference in plume	MFSR	Plume
Elkhorn	13.5	-2.5	2.1	2.9
Deer Horn	14.0	+0.5	2.2	2.5
Garden	14.5	-2.5	2.2	1.6
Indian	16.0	-2.0	2.0	1.9
Pungo	17.0	-2.5	2.2	2.2
Little Soldier	16.0	+1.0	1.9	3.2
Marble	18.0	+1.0	1.2	2.3
Little Loon	16.0	-5.0	2.0	1.6
Pine	20.0	-4.0	2.1	2.0
Loon*	-	-	2.1	1.8
Camas	17.5	-3.5	2.0	1.8
Soldier	19.0	-4.0	1.9	1.4
Wilson	12.0	0.0	1.5	2.0
Bobtail	16.5	-2.0	1.4	1.7
Golden	19.0	-2.0	1.4	1.7
Papoose	19.0	-0.5	1.5	2.0
Ship Island	19.4	-2.7	1.5	NA
Stoddard	17.0	-2.0	1.5	2.7
Roaring	17.3	-5.3	1.5	2.0
Goat	18.0	-2.5	1.0	1.9

* - No mainstem temperature recorded at Loon Creek.

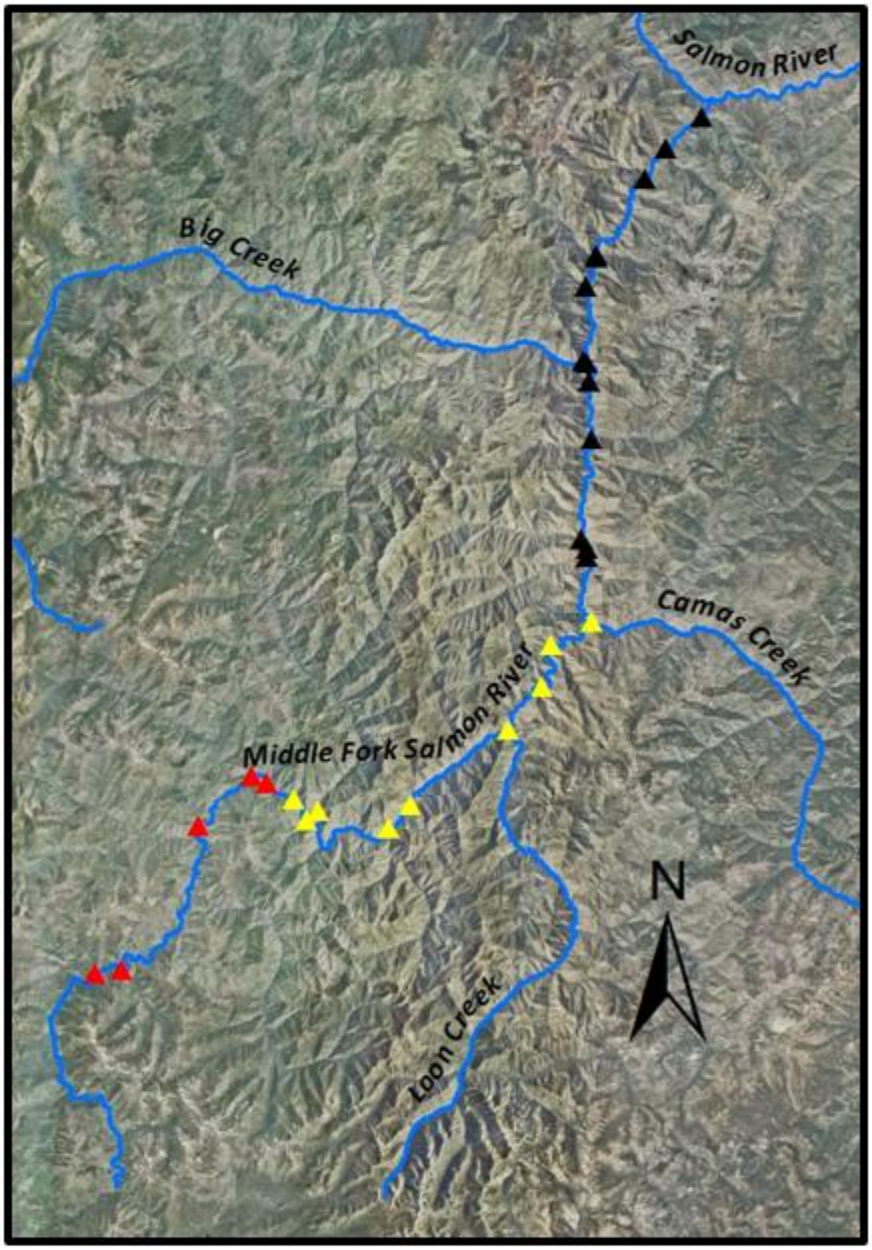

Figure 23. Map of approximate plume site locations surveyed in 2022. Five sites were surveyed in the Upper Strata (denoted by red triangles), six sites in the Middle Strata (denoted by yellow triangles), and nine sites in the Lower Strata (denoted by black triangles).

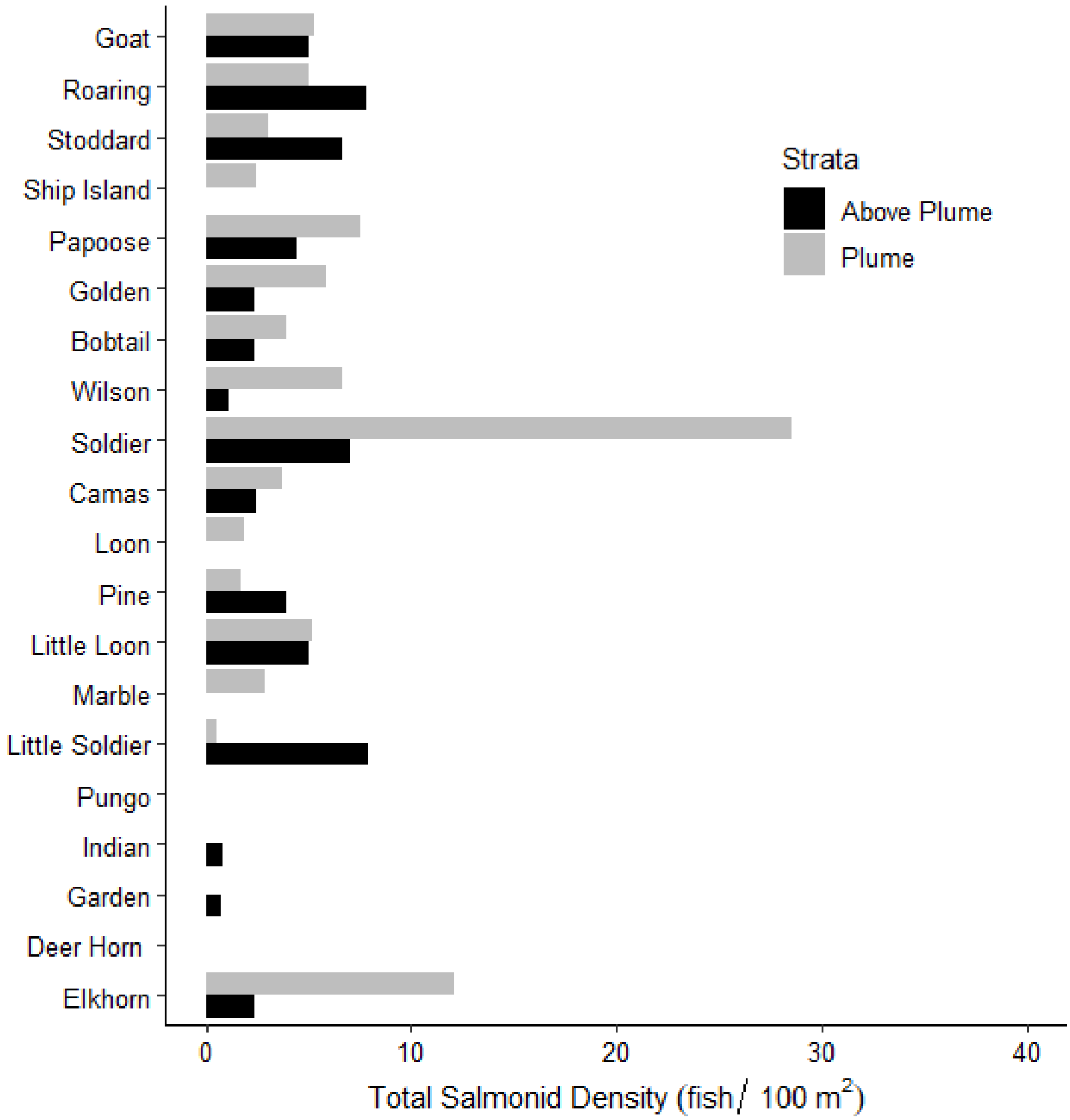

Figure 24. Densities of salmonids (fish/100m^2) in the main-stem Middle Fork Salmon River above tributary plumes (black bars) and in within plumes (gray bars) observed via snorkeling in 2022, starting from the lowest downriver site at Goat Creek (near the mouth of the Middle Fork) to the highest upriver site at Elkhorn Creek (near Boundary Creek).

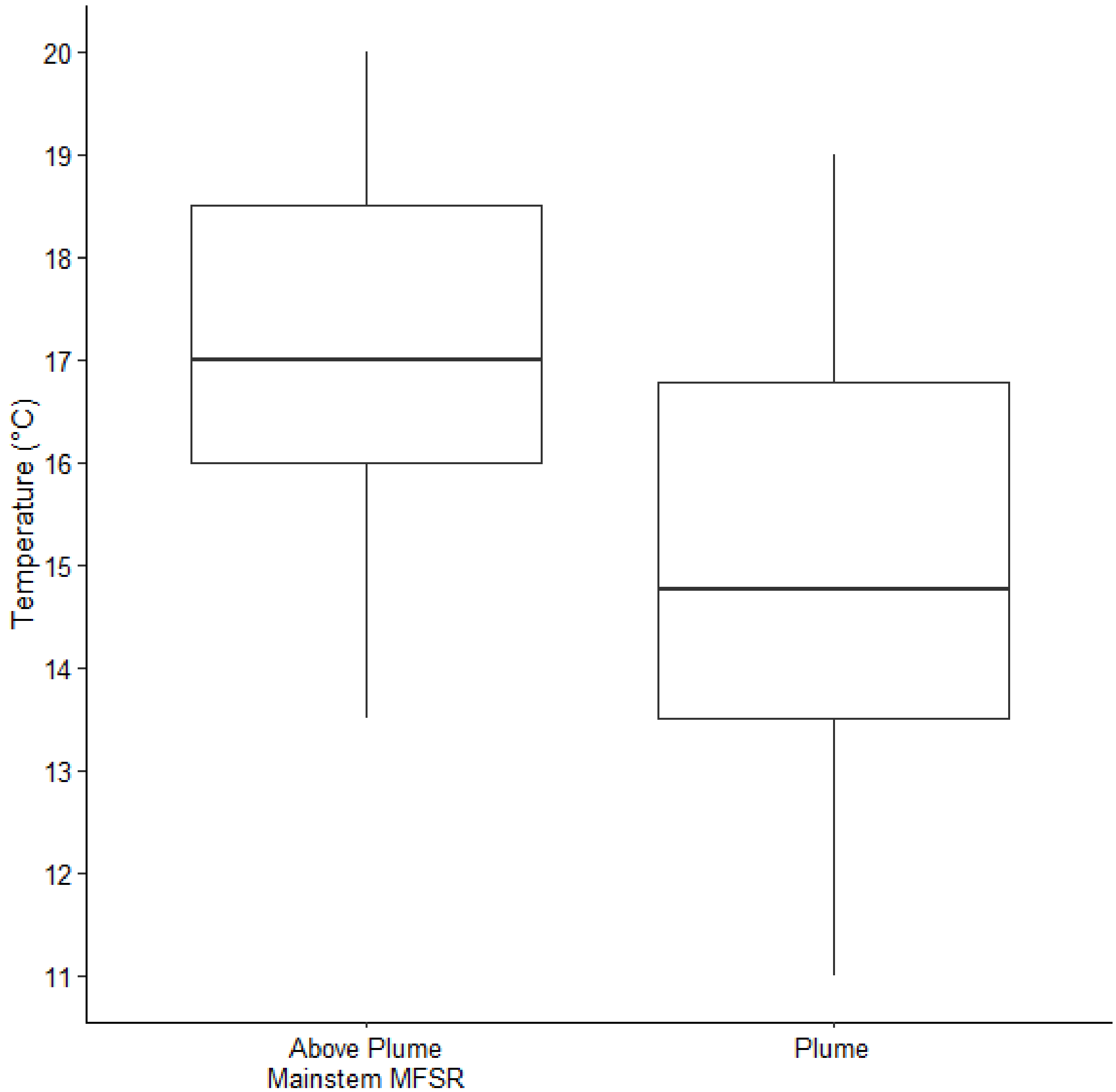

Figure 25. Boxplots of water temperatures (°C) above plume (e.g. main stem) and within plume habitats surveyed in the Middle Fork Salmon River in July 2022.

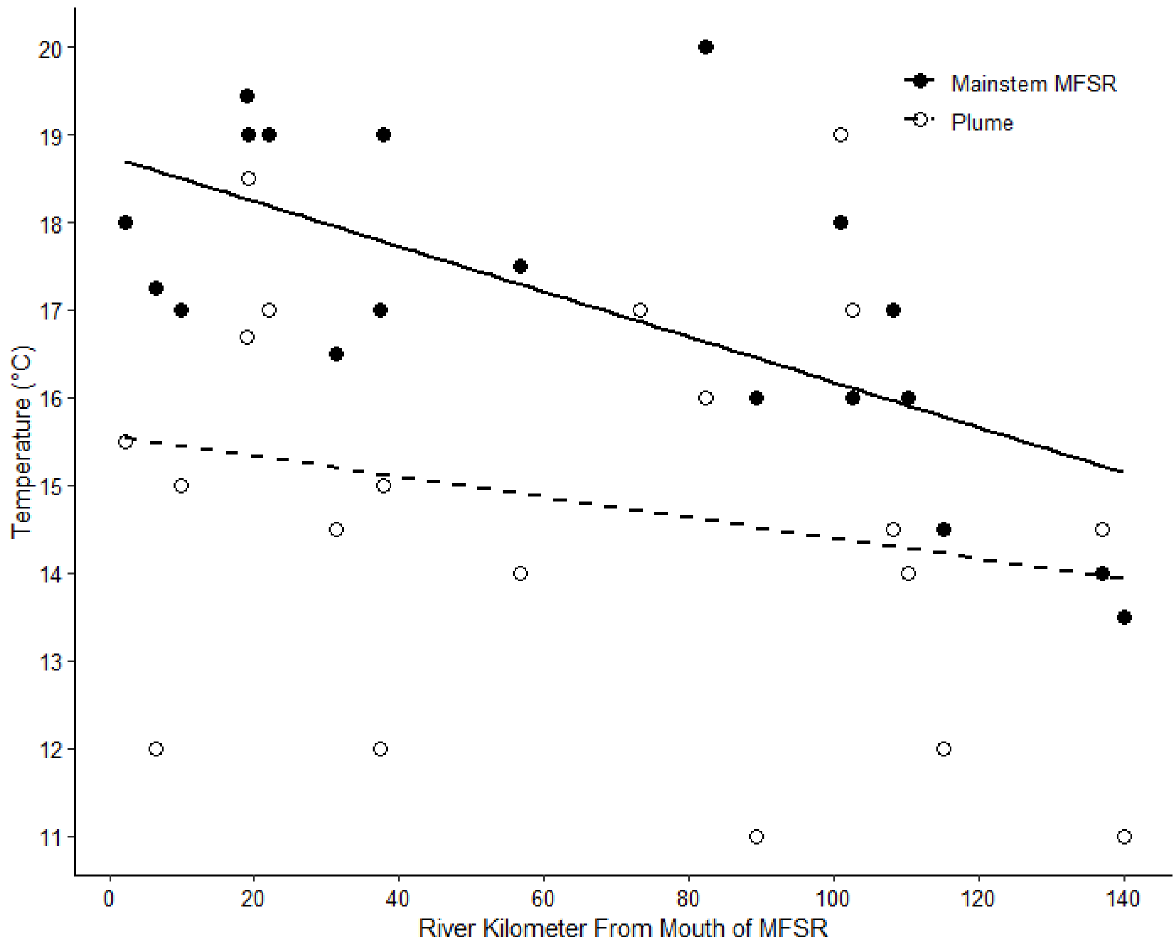

Figure 26. Comparison of water temperature differences recorded at 20 selected plume (open circles) and main-stem sites (black circles) in the Middle Fork Salmon River, 2022, starting from the lowest downriver site at Goat Creek to the highest upriver site at Elkhorn Creek. Each of the 20 sites are paired with the main-stem (above plume) data points directly above their corresponding plume data points.

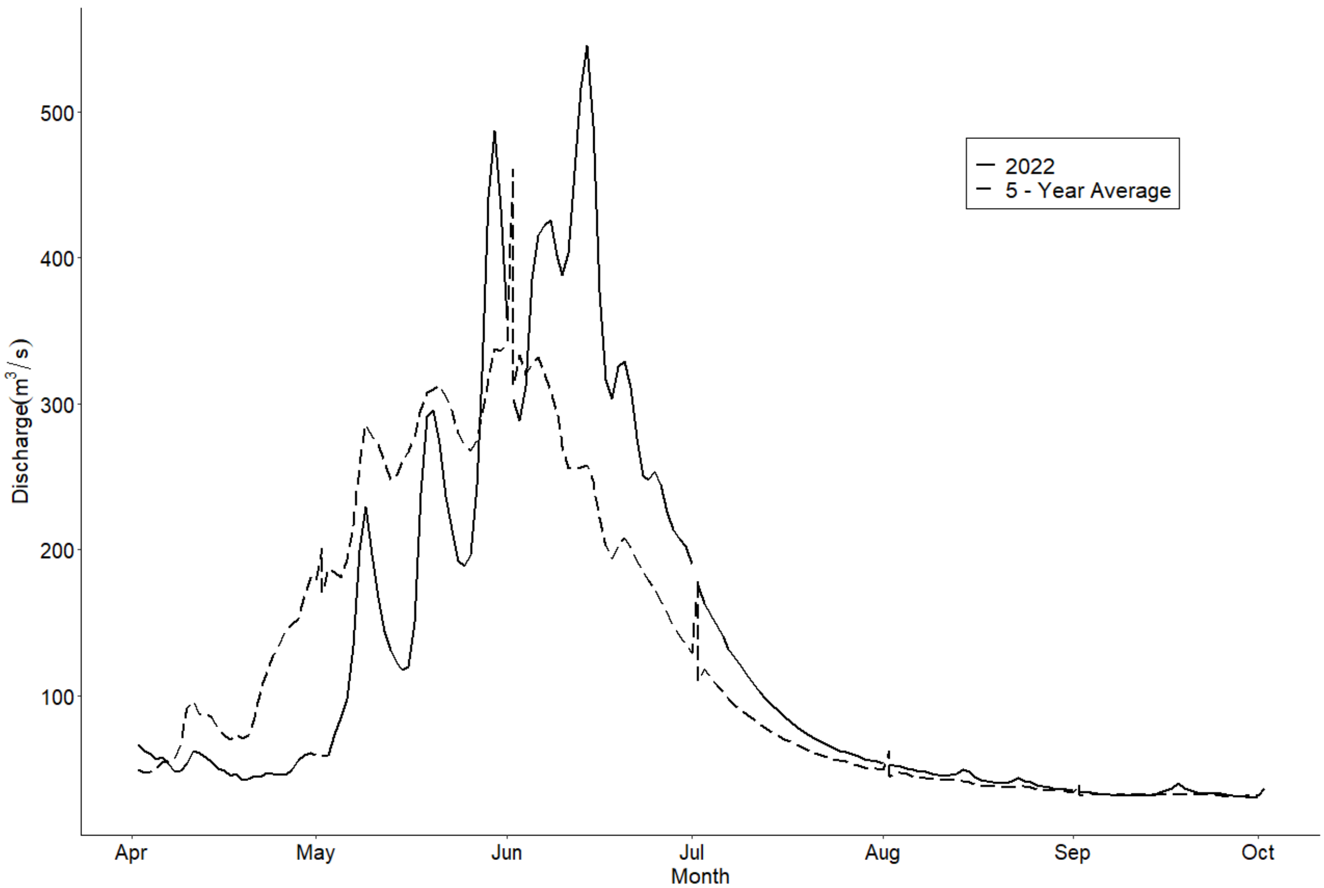

Figure 27. Summer discharge (m^3/s; solid line) recorded by the U.S. Geological Survey's gage number 13310199 at the mouth of the Middle Fork Salmon River in 2022 along with the previous 5-year average (dashed line) of discharge at this location.

WILD TROUT REDD COUNTS

ABSTRACT

Regional fisheries staff conducted redd count surveys for resident Rainbow Trout *Oncorhynchus mykiss* and Bull Trout *Salvelinus confluentus* populations in 2022, as part of an annual trend monitoring program. In the spring of 2022, we counted 136 Rainbow Trout redds in Big Springs Creek and 29 in the Lemhi River. During Bull Trout redd surveys in the fall of 2022, we counted 16 in Fishhook Creek, 0 in Alpine Creek, 29 in Fourth of July Creek, 13 in Champion Creek, 69 in Hayden Creek, 15 in East Fork Hayden Creek, 17 in Big Timber Creek, 2 in Rocky Creek, and 58 in Bear Valley Creek. Compared to surveys in 2021, the number of Rainbow Trout redds increased in Big Springs Creek and the Lemhi River. The number of Bull Trout redds counted in 2022 increased in Fourth of July Creek, but decreased or remained the same in all other transects.

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INTRODUCTION

Idaho Department of Fish and Game (IDFG) Salmon Region staff conduct annual redd count surveys for resident and fluvial Rainbow Trout *Oncorhynchus mykiss* and Bull Trout *Salvelinus confluentus* in eleven streams in the region to monitor trends in spawner abundance. In 1994, the department began counting Rainbow Trout redds in Big Springs Creek, a tributary to the upper Lemhi River near Leadore. In 1997, another transect was established for Rainbow Trout on the upper Lemhi River just above the confluence with Big Springs Creek. Redd count monitoring for Rainbow Trout in these transects provides a general indication of population abundance trends over time. Numerous habitat improvement projects, changes in water-use practices, alterations in land management practices, and fisheries regulation changes have occurred in the upper Lemhi River Valley in the last decade, many of which have likely benefited resident fish populations.

Bull Trout were listed as threatened under the Endangered Species Act (ESA) on June 10, 1998. That fall, the Salmon Region established the first trend monitoring transects for enumerating Bull Trout redds. Trend monitoring transects were established on Alpine and Fishhook Creeks in the Sawtooth Valley south of Stanley in 1998. Additionally, trend monitoring transects were established on Bear Valley and East Fork Hayden creeks in the Lemhi River drainage in 2002, on Fourth of July Creek in the Sawtooth Valley in 2003, and on upper Hayden Creek in the Lemhi River drainage in 2006.

Over the years, as additional redd production areas have been located (outside of established transect boundaries), new trend monitoring transects have been added to encompass as much spawning production as possible. New trend monitoring transects were added to Bear Valley Creek in 2007, Fishhook Creek in 2008, and Alpine Creek in 2011. In upper Hayden Creek, the trend transect was moved altogether in 2010 when staff determined the existing transect was too low in the drainage and the majority of Bull Trout spawning occurred farther upstream. Additionally, there was a new transect added to Fourth of July Creek in 2019 and Champion Creek in 2020 for Bull Trout redd monitoring.

OBJECTIVES

Continue annual redd counts to monitor trends in spawner population abundance of resident and fluvial trout populations throughout the region.

STUDY SITES AND METHODS

To document abundance, use, and distribution of spawning salmonids, single or multi-pass redd surveys are conducted on selected streams throughout the Salmon Region. For every trend monitoring transect where single pass surveys are conducted (i.e., Lemhi River, Fishhook Creek, Alpine Creek, and Fourth of July Creek) all redds in progress or completed redds are counted during the survey. For all other trend monitoring transects, multiple (i.e., two or three) pass surveys are conducted when time permits. For multiple pass surveys, all redds in progress or completed redds are enumerated during the first survey and marked with flagging. On subsequent passes, additional completed redds are counted and included with the number of flagged redds to provide a total number of redds. All flagging is removed on final passes. In addition, waypoints of all redds are documented with GPS units to map overall redd distribution.

Reported numbers are the total redds observed in a single pass survey or a sum of all redds if multiple passes were conducted. Surveyors are required to wear polarized sunglasses to improve the ability to see through any glare on the water's surface and evaluate and identify redds. Surveyors always work in pairs and conduct redd surveys moving in a downstream direction. See appendix A for redd count transect details (date established, start/end points, total stream length). Rainbow Trout Redd Count Monitoring

Big Springs Creek

Big Springs Creek is a tributary to the Lemhi River, located approximately 8 km north of Leadore, Idaho. The first resident/fluvial Rainbow Trout redd count trend transects in the region were established in Big Springs Creek in 1994. Two trend transects (i.e., Tyler and Neibaur transects) are surveyed annually (Estep et al. 2021). Redd counts for Big Springs Creek are conducted near the peak timing of RBT spawning (late April/early May). In 2022, surveys occurred on May 3rd and 9th (Tyler transect) and May 5th and 10th (Neibaur transect).

Lemhi River

The Lemhi River flows approximately 100 km from its headwaters near Leadore, Idaho to its confluence with the Salmon River at Salmon, Idaho. The upper Lemhi River redd count trend site was established in 1997 and includes a 3 km section of Lemhi River flowing through the property known as the Beyeler Ranch from the fence line 100 meters upstream of the upper water gap to the lower fenced boundary. Redd counts for the Lemhi River are usually conducted during the peak of RBT spawning (late April/early May). In 2022, redd counts were conducted on April 28th.

Bull Trout Redd Count Monitoring

<u>Alpine Creek</u>

Alpine Creek is a tributary to Alturas Lake Creek, which flows into Alturas Lake in the Sawtooth Valley, approximately 35 km south of Stanley, Idaho. Two trend transects are walked annually on Alpine Creek. Historically, two redd surveys are conducted annually, about two weeks apart, on both transects in Alpine Creek. Due to time constraints, a single survey was conducted in 2022 on September 16th.

<u>Fishhook Creek</u>

Fishhook Creek is a tributary of Redfish Lake in the Sawtooth Valley, approximately 10 km south of Stanley, Idaho. Two trend transects (i.e., older and newer) are walked on Fishhook Creek annually. Historically, two ground counts are conducted annually, about two weeks apart, on each of the two Fishhook Creek transects. In 2022, a single pass was completed on the 14th of September.

<u>Fourth of July Creek</u>

Fourth of July Creek is a tributary of the upper Salmon River in the Sawtooth Valley, located approximately 28 km south of Stanley, Idaho. Historically, only one trend transect (i.e., older) was established in Fourth of July Creek. An additional site was added to Fourth of July

Creek in 2019 (i.e., newer; Appendix A). Typically, one single ground count is conducted on Fourth of July Creek annually. The single pass count of both transects was completed on September 13th in 2022.

Champion Creek

Champion Creek is a tributary of the upper Salmon River in the Sawtooth Valley, located approximately 29 km south of Stanley, at river kilometer 631. A trend transect was created in Champion Creek in 2020. The trend transect in Champion Creek is typically walked twice annually, however, regional staff only a single pass count was conducted on September 15th, 2022.

Hayden Creek

Hayden Creek is the largest tributary to the Lemhi River and serves as a reference watershed for habitat restoration actions completed on the Lemhi River. Two trend transects (i.e., older and newer) were historically surveyed annually. The older transect produced single digit Bull Trout redd counts each year between 2006 and 2009. In 2010, an additional transect was created (newer; Messner et al. 2016) to encompass the bulk of spawning activity (M. Biggs, IDFG, personal communication). The older trend transect is walked annually to count both Chinook Salmon *Oncorhynchus tshawytscha* and Bull Trout redds. The older and newer Hayden Creek trend transects are typically walked multiple times annually, approximately one week apart. The older transect was surveyed on September 1st, 8th, 22nd, and 30th. The newer transects was surveyed once on September 7th, 2022.

Bear Valley Creek

Bear Valley Creek is a tributary of Hayden Creek in the Lemhi River drainage, located approximately 60 km south of Salmon, Idaho. Historically, two trend transects are walked annually on Bear Valley Creek to enumerate Bull Trout redds (i.e., older and newer). Two to three visual ground counts are conducted annually about one week apart on the Bear Valley Creek transects. A third pass is typically only conducted when the ratio of live fish to redds is greater than one on the second pass. In 2022, four counts were conducted on August 24th, and September 1st, 8th, and 26th on the newer transect and one count was walked on September 26th and 28th on the older transect which was broken into two segments.

East Fork Hayden Creek

East Fork Hayden Creek is a tributary of Hayden Creek in the Lemhi River drainage. The confluence of the East Fork Hayden Creek and Hayden Creek is located approximately 15 km upstream from Hayden Creek's confluence with the Lemhi River. Single-pass redd counts were conducted annually on the East Fork Hayden Creek trend transect to enumerate Bull Trout redds from 2002 to 2015, but surveys were not conducted from 2016 to 2020 due to time constraints. In 2022, East Fork Hayden Creek was surveyed on September 21st.

Big Timber and Rocky creeks

Big Timber Creek is a tributary of the Lemhi River located approximately 3 km west of Leadore, Idaho and Rocky Creek is a tributary of Big Timber Creek. During initial watershed surveys by the Anadromous Fish Screen Program in 2003 fluvial Bull Trout were observed spawning throughout the upper Big Timber Creek watershed. Single pass redd count transects were established by the screen program in 2007 and surveys have been conducted annually since. The first transect was from 3.2 km upstream of Rocky Creek downstream to Rocky Creek. The second transect is from the mouth of Rocky Creek downstream to the mouth of Grove Creek on Big Timber Creek. The transect in Rocky Creek starts approximately 2.7 km upstream of its confluence with Bear Valley Creek. The transect on Big Timber Creek was surveyed on September 24th and September 27th, and the Rocky Creek transect was surveyed on September 27th.

RESULTS AND DISCUSSION

Rainbow Trout Redd Count Monitoring

Big Springs Creek and Lemhi River

Fisheries staff observed 136 Rainbow Trout redds in Big Springs Creek in 2022 (Table 14; Figure 28). On Big Springs Creek, 114 redds were counted in the historic Neibaur Ranch transect while 22 redds were observed in the Tyler Ranch transect (Table 14). Twenty-nine redds were counted in the Beyeler reach of the Lemhi River. Total Rainbow Trout redds in the Lemhi River and Big Springs Creek transects have ranged from 39 to 558 since counts began in 1994. The 2012 to 2014 trend counts were three of the four highest counts on record, but spawner abundance decreased in 2015 and has remained relatively low from 2017 to2022. The overall trend count in 2022 was below the 10-year average (mean ± SE; 211 ± 25) but increased slightly compared to the past three years (Figure 28). It is worth noting that water was relatively turbid during redd surveys in 2022 and visibility of redds might have been negatively influenced. Resident trout redds can be more challenging to identify than larger salmon redds, and observer error could contribute to variability in counts over time. Additionally, aside from Chinook redd counts observed in 2022, declines in redd counts have been observed in all species throughout the Lemhi River and tributaries since 2015, a pattern which has not been explained by observer error or prevailing environmental conditions (Meyer et al. *In Prep*). Finally, it is possible that spawning distribution has shifted and is not captured in current trend count transects. These trend transects will continue to be monitored annually but additional transects could be explored to determine if spawning habitat has changed.

Bull Trout Redd Count Monitoring

Alpine Creek

Fisheries staff did not observe any Bull Trout redds in Alpine Creek in 2022 (Table 15; Figure 29). Redd counts in the upper (old) transect have been highly variable, and on multiple occasions no redds have been observed (2008 through 2012, 2017, 2018). The number of Bull Trout redds observed in Alpine Creek in 2022 was a decrease from the number of redds observed in the prior five years and represents the fewest observed redds since none were counted in 2012. Survey timing for redd counts has been relatively consistent in previous years in Alpine Creek. It is possible that these fluctuating numbers in Alpine Creek represent changes in spawning habitat and spawning distribution and these changes aren't being captured in trend transects. These trend transects will continue to be monitored annually but additional transects should be established if spawning habitat has changed.

Fishhook Creek

Fisheries staff observed a total of 16 Bull Trout redds in Fishhook Creek in 2022. Four Bull Trout redds were counted in the upper (i.e., older) trend transect in Fishhook Creek, and 12 redds were counted in the lower (i.e., newer) transect (Table 15; Figure 30). Redd counts appear to be quite variable, having peaked in 2015-2016 (Table 15; Figure 30). Prior to 2015, Bull Trout redd numbers in Fishhook Creek have remained relatively consistent over the years, suggesting a stable population (mean ± SE = 31.2 ± 2.8).

Fourth of July Creek

Fisheries staff observed 29 Bull Trout redds in Fourth of July Creek trend transects in 2022 (Table 15; Figure 31). Twenty-four redds was observed in the older (i.e., upper) transect and five were counted in the newer (i.e., lower) transect. Prior analyses of Fourth of July Creek redd count data suggested cyclical patterns in peak spawner abundance. While variable, spawner abundance appeared to peak every four years, with 2006, 2010, 2014, and 2018 having relatively higher counts. However, recent years redd counts (2021 or 2022) that would be predicted to represent "peaks" in this pattern actually had counts well below prior peaks and the 10-year average. As mentioned above, the high variability of these trends should be investigated further to determine if environmental factors, year effects, or life history variations are driving them.

Champion Creek

Fisheries staff observed 13 Bull Trout redds in Champion Creek in 2022 (Table 15). The total number of redds in Champion Creek in 2022 is less than half of the 32 counted in 2021. Prior to 2020, redd counts had not been conducted for Bull Trout on Champion Creek, so there are little data for comparison. However anecdotal observations by regional staff suggest that few fish moved into the upper reaches of Champion Creek to spawn in the past. Given the lack of prior data, this decrease in redd counts may merely represent the natural fluctuation in spawner abundance observed in tributaries across the basin.

Determining the population age-structure and genetic relatedness of Bull Trout in upper Salmon River tributaries could improve managers understanding of cyclical redd trends in the Upper Salmon River Basin. The decline in redd counts in Fish Hook Creek corresponds with a similar decline for nearby Fourth of July Creek. However, exploitation of new habitat in Champion Creek by fluvial spawners could account for decreases in other spawning grounds, if spawners do not demonstrate high site fidelity. Identifying the extent of straying between spawning areas through genetics studies could elucidate these relationships. Additionally, spawner abundance across the Sawtooth Valley appears to be highly variable over time. It is unknown if these changes are related to true changes in adult Bull Trout abundance or if there is a response to abiotic or biotic factors in the watershed that prevent fish from spawning. These trends warrant further investigation and modeling using environmental conditions to identify which factors influence the observed changes in spawner abundance.

Hayden Creek

Fisheries staff observed 69 Bull Trout redds in Hayden Creek in 2022. Of the 69 redds, 3 redds were counted in the newer Hayden Creek trend site in 2022 (Table 16, Figure 32). Sixty-six redds were observed in the older Hayden Creek trend site which represents a major increase in spawning in that reach (Figure 32). In 2021, Bull Trout redd counts in Hayden Creek were the lowest number recorded since surveys began in 2005. Counts in 2022 suggest that the prior year decline could represent natural variation in spawner abundance. Additionally, spawning habitat quality varies interannually, and Bull Trout have been observed shifting between habitats over time. It is possible that the index sites on Hayden Creek do not capture the extent of Bull Trout spawning habitat and therefore redds. As previously mentioned, Hayden Creek serves as a reference stream for the Lemhi Intensively Monitored Watershed project (IMW). Information generated from this project such as Chinook Salmon redd counts, anadromous fry production, fish densities, and anadromous parr and smolt emigration via a rotary screw trap may be useful to further understand what may be driving trends in Bull Trout redd counts.

Bear Valley Creek

Fisheries staff observed 58 total Bull Trout redds in Bear Valley Creek in 2022. Twenty-eight Bull Trout redds were observed in the older (i.e, upper) Bear Valley Creek trend transect in 2022 and 30 redds in the newer (i.e., lower) trend transects (Table 16; Figure 33). Bull Trout redds have been below the average of 86 (SE = 10.0) since 2002. Bear Valley Creek typically has the highest redd count of all streams that surveyed in the Salmon Region for Bull Trout redds, however this was not the case in 2022. As mentioned above, the Hayden Creek drainage, including Bear Valley Creek serves as the reference stream for the Lemhi IMW project when evaluating restoration actions on other streams. These two streams (Hayden and Bear Valley) could be used as an indicator of overall Bull Trout production in the basin.

East Fork Hayden Creek

Fisheries staff observed a total of 15 Bull Trout redds in the East Fork Hayden Creek trend transect in 2022 (Table 16). This population has remained relatively stable from 2002-2015, ranging from 23 to 61 redds per year (41 ± 3.1). No redd surveys were conducted on East Fork Hayden Creek from 2016-2020. Forty-six redds were counted in 2021, which was relatively close to the average number of redds prior to the six-year gap in surveys. The lower number of observed redds in 2022 could be related to count timing, spawning distribution shifts, true variation in spawner abundance, or a variety of environmental factors. Without data for the period between 2016-2020, determining true variation from the mean is not possible. This spawning population should be monitored closely for more large shifts in abundance by implementing redd counts in adjacent habitats or moving to a multiple pass survey method to determine if surveyors are identifying peak spawning numbers.

Big Timber and Rocky creeks

In 2022, two transects were surveyed in Big Timber Creek to estimate Chinook Salmon redd abundance and Bull Trout redd counts were conducted concurrently. Fisheries staff observed a total of 19 Bull Trout redds in Big Timber and Rocky creeks in 2022 (Table 17; Figure 34). Two redds were counted in the Rocky Creek trend transect. In Big Timber Creek, 17 redds were counted (Table 17).

Overall Bull Trout redd abundance in the Salmon Region appears to be highly variable year to year. Roth et al. (2021) examined annual survival of Bull Trout in the East Fork Salmon River and found that the number of emigrating salmonid smolts in the upper Salmon River positively influenced growth and survival of Bull Trout. When growth is positively influenced, it can also be assumed that fecundity and overall health are also positively influenced, and this may account for some of the variability in the overall abundance of Bull Trout redds observed in Region

7. Furthermore, many of the Bull Trout from these tributaries overwinter in the mainstem Salmon River (Schoby 2006) and are likely exposed to similar effects that influence survival, growth, and fecundity. Bull Trout have been shown to skip reproductive events at poor body condition (Johnston and Post 2009). Low quality winter foraging in the Salmon River could increase frequency of skipped spawning events for both Lemhi and Upper Salmon River spawning populations and give the appearance of spawner abundance declines. A basin-wide analysis based on redd abundance versus smolt abundance and environmental factors would likely help to identify some factors driving the high variability of Bull Trout spawner abundance observed in the Upper Salmon River region.

MANAGEMENT RECOMMENDATIONS

1. Continue monitoring trends in redd counts for resident trout populations in designated transects.

2. Implement expanded redd surveys on three-year interval to identify and account for shifts in spawning distribution of resident salmonids.

3. Investigate new ways of reporting redd numbers in each system (e.g., total number of redds per river km) to make redd abundance more comparable through time.

4. Investigate variability in Bull Trout redd abundance through a basin-wide analysis of relatedness and straying, redd abundance, smolt abundance, and environmental factors.

Table 14. Summary of Rainbow Trout redds counted in the upper Lemhi River and Big Springs Creek (BSC) transects, 1994 – 2022.

	Big Springs Creek		Lemhi River	
Year	Neibaur Ranch	Tyler Ranch	Beyeler Ranch	Total
1994	--	--	--	40
1995	57	--	--	57
1996	32	--	7	39
1997	44	45	8	97
1998	93	124	18	235
1999	39	71	29	139
2000	160	123	23	306
2001	95	186	2	283
2002	as	193	3	556
2003	128	103	56	287
2004	174	45	15	234
2005	75	43	3	121
2006	63	143	9	215
2007	163	62	8	233
2008	82	108	9	199
2009	100	54	10	164
2010	132	57	18	207
2011	103	49	20	172
2012	130	224	14	368
2013	159	122	49	330
2014	185	280	93	558
2015	65	60	75	200
2016	124	66	46	236
2017	52	46	139	237
2018	60	39	11	110
2019	50	32	--	82
2020	10	39	41	90
2021	57	35	26	118
2022	114	22	29	165

Table 15. Bull Trout redds counted in tributaries of the upper Salmon River in the Sawtooth National Recreation Area, 1998 – 2022.

	Alpine Creek			Fishhook Creek			Fourth of July Creek			Champion Creek		
Year	Old	New	Total	Old	New	Total	Old	New	Total	Old	New	Total
1998	1	--	1	11	--	11	--	--	--	--	--	--
1999	3	--	3	15	--	15	--	--	--	--	--	--
2000	9	--	9	18	--	18	--	--	--	--	--	--
2001	15	--	15	26	--	26	--	--	--	--	--	--
2002	14	--	14	17	--	17	--	--	--	--	--	--
2003	14	--	14	17	--	17	16	--	16	--	--	--
2004	9	--	9	11	--	11	33	--	33	--	--	--
2005	13	--	13	23	--	23	41	--	41	--	--	--
2006	13	--	13	25	--	25	71	--	71	--	--	--
2007	18	--	18	22	--	22	49	--	49	--	--	--
2008	0	--	0	13	14	27	25	--	25	--	--	--
2009	0	--	0	21	12	33	50	--	50	--	--	--
2010	0	1	1	17	10	27	56	--	56	--	--	--
2011	0	2	2	11	7	18	51	--	51	--	--	--
2012	0	0	0	21	9	30	50	--	50	--	--	--
2013	1	2	3	15	13	28	21	--	21	--	--	--
2014	4	0	4	6	8	14	85	--	85	--	--	--
2015	3	0	3	61	2	63	48	--	48	--	--	--
2016	6	7	13	47	13	60	8	--	8	--	--	--
2017	0	12	12	12	2	14	39	--	39	--	--	--
2018	0	1	1	21	10	31	59	--	59	--	--	--
2019	3	2	5	2	7	9	8	9	17	--	--	--
2020	8	1	9	10	22	32	12	12	24	36	--	36
2021	4	5	9	6	12	18	1	11	12	32	--	32
2022	0	0	0	4	12	16	24	5	29	13	--	13

Table 16. Bull Trout redds counted in the Hayden Creek drainage in the Lemhi River Valley, 2002 – 2022.

	Bear Valley Creek			Hayden Creek			East Fork Hayden Creek	
Year	Old	New	Total	Old	New	Total	Old	Total
1998	--	--	--	--	--	--	--	--
1999	--	--	--	--	--	--	--	--
2000	--	--	--	--	--	--	--	--
2001	--	--	--	--	--	--	--	--
2002	26	--	26	--	--	--	33	33
2003	42	--	42	--	--	--	25	25
2004	44	--	44	--	--	--	26	26
2005	34	--	34	--	--	--	41	41
2006	26	60	86	113	--	113	49	49
2007	25	115	140	141	--	141	52	52
2008	27	21	48	49	--	49	61	61
2009	42	24	66	22	--	22	54	54
2010	37	22	59	--	29	29	55	55
2011	36	103	139	--	49	49	32	32
2012	33	91	124	--	39	39	49	49
2013	41	78	119	--	14	14	34	34
2014	66	134	200	--	29	29	23	23
2015	39	98	137	--	18	18	40	40
2016	30	59	89	4	37	41	--	--
2017	24	53	77	0	43	43	--	--
2018	28	51	79	4	33	37	--	--
2019	43	20	63	3	43	47	--	--
2020	9	83	92	0	51	51	--	--
2021	5	56	61	0	13	13	46	46
2022	28	30	58	66	3	69	15	15

Table 17. Bull Trout redd counts on Big Timber Creek and Rocky Creek from 2007-2022.

Year	Big Timber Cr	Rocky Cr	Total redds
2007	8	7	15
2008	2	6	8
2009	--	--	--
2010	5	16	21
2011	1	35	36
2012	23	29	52
2013	--	--	--
2014	17	31	48
2015	31	33	64
2016	17	--	17
2017	--	--	--
2018	4	--	4
2019	9	13	22
2020	19	3	22
2021	12	13	25
2022	17	2	19

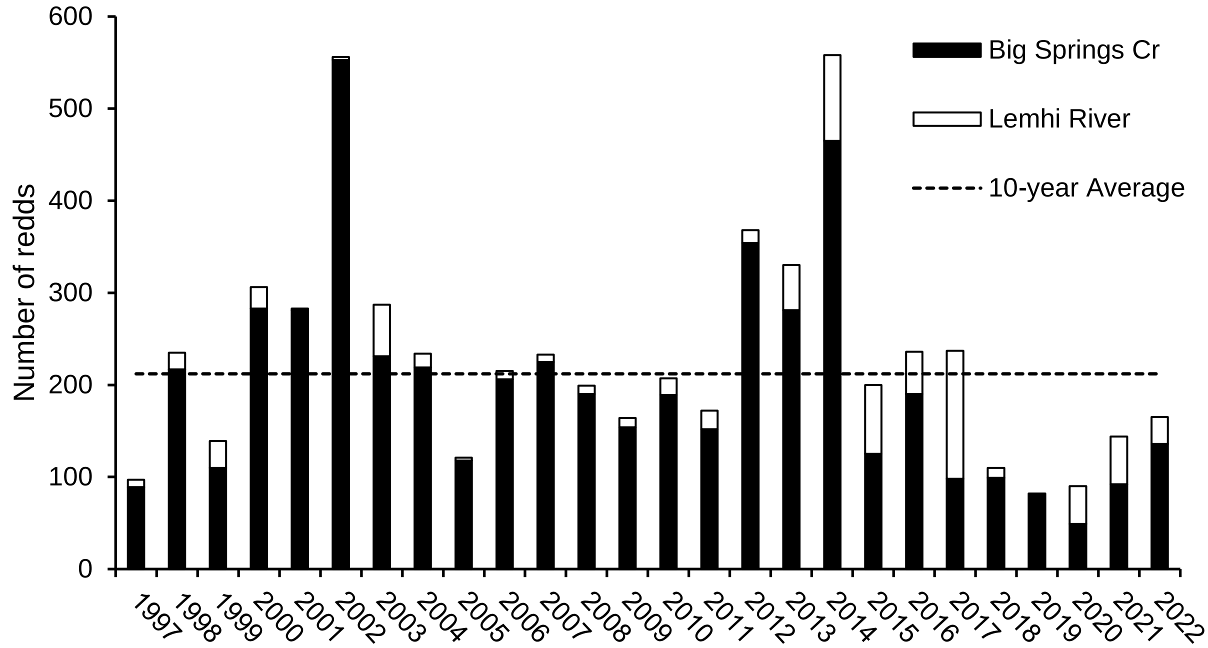

Figure 28. Resident Rainbow Trout redds counted during ground surveys in the upper Lemhi River (Beyeler Ranch) and Big Springs Creek (BSC; Neibaur and Tyler ranches), 1997 – 2022.

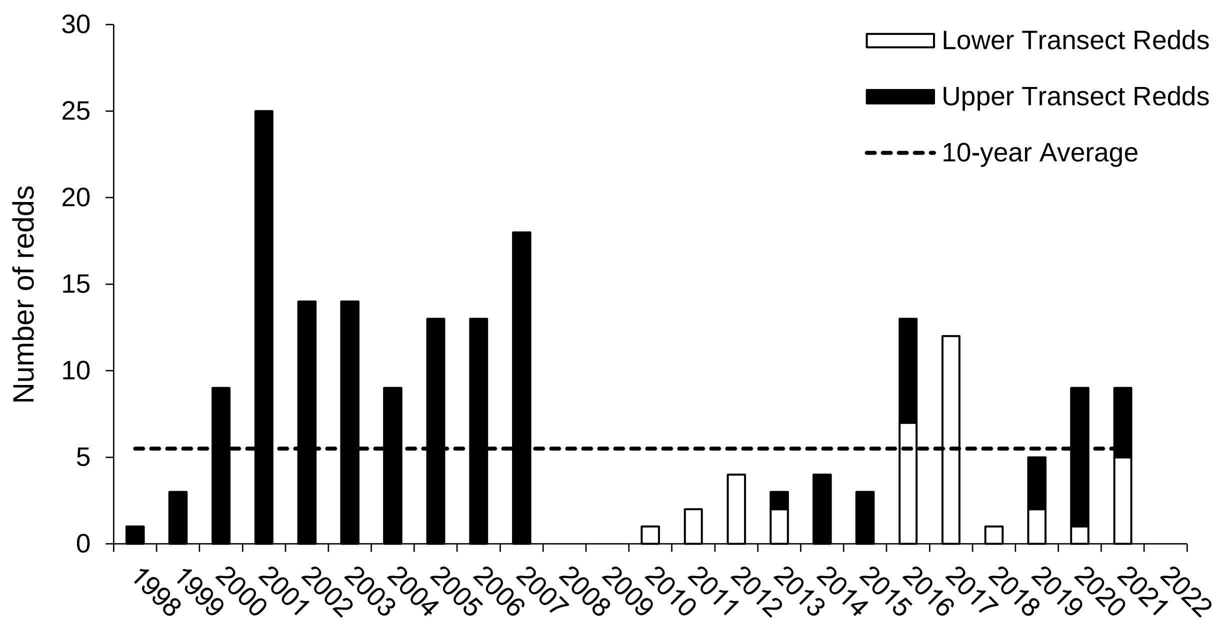

Figure 29. Number of Bull Trout redds counted in both survey transects on Alpine Creek, 1998 – 2022.

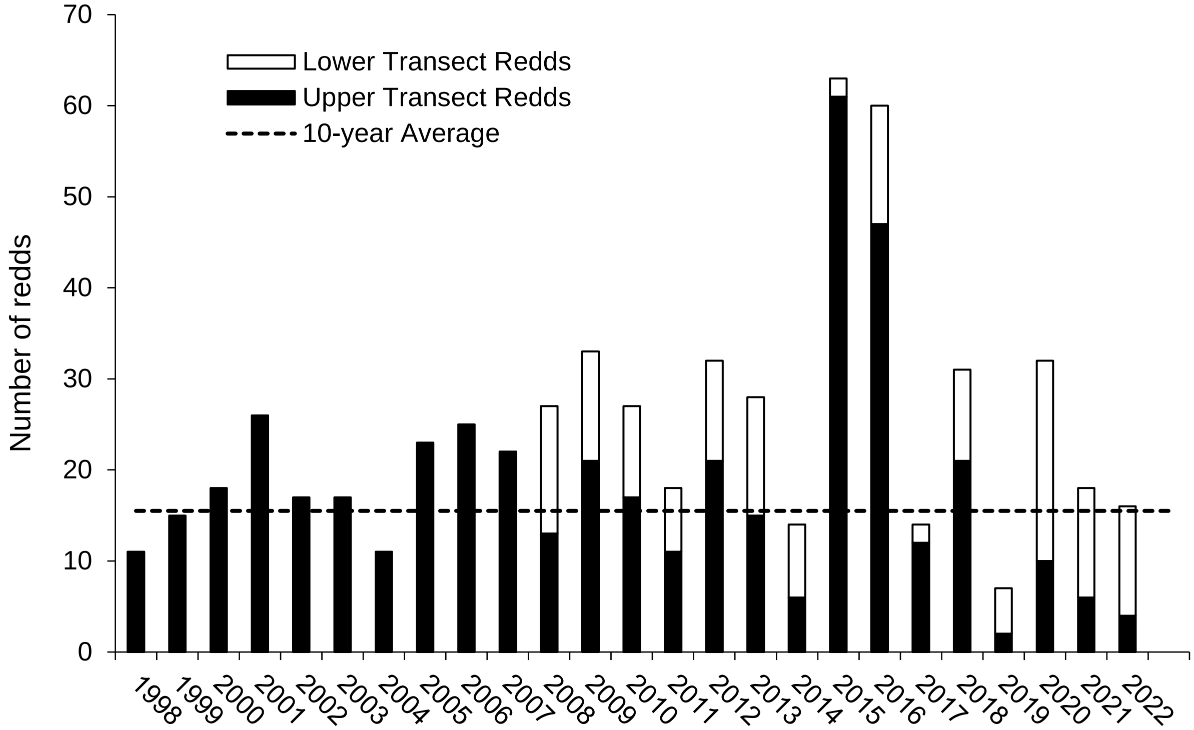

Figure 30. Number of Bull Trout redds counted in both transects on Fishhook Creek, 1998 – 2022.

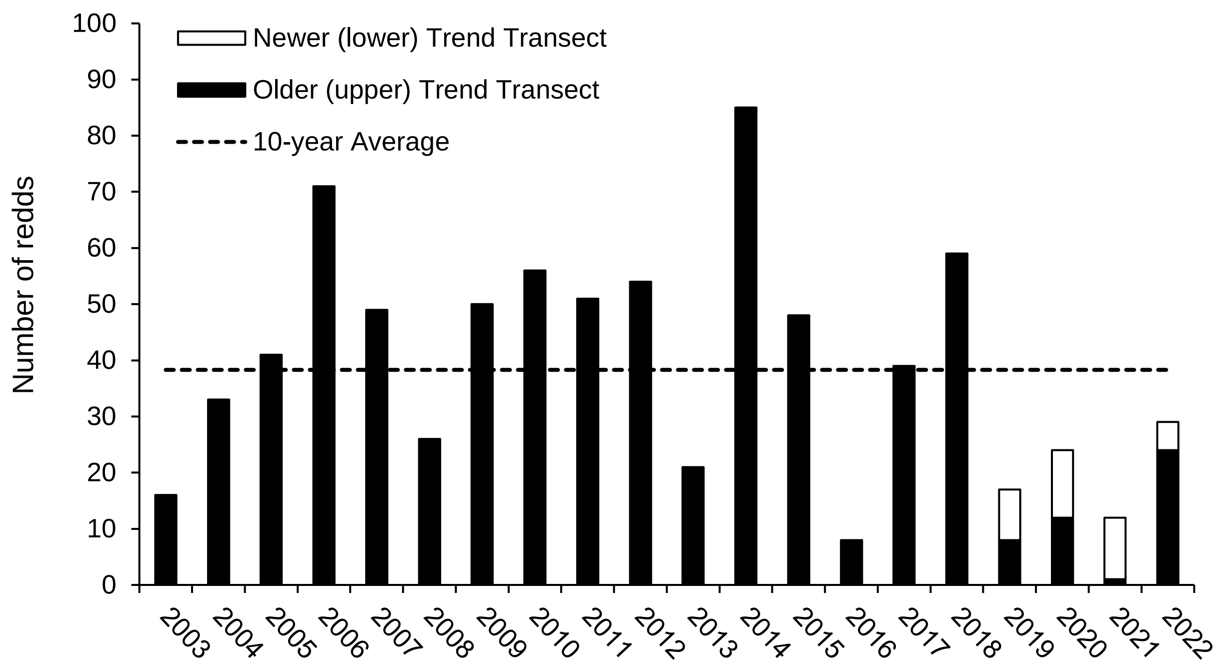

Figure 31. Number of Bull Trout redds counted on Fourth of July Creek from 2003 to 2022.

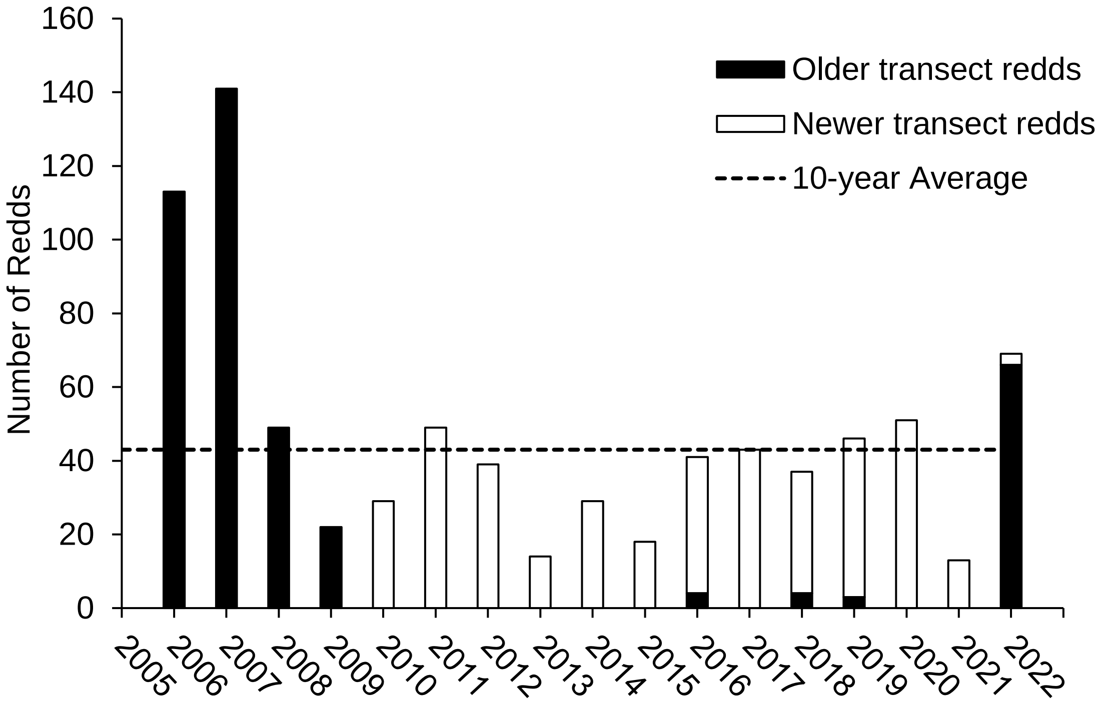

Figure 32. Number of Bull Trout redds observed in upper Hayden Creek redd count trend transects, 2006 – 2022. The horizontal dashed line displays the current 10-year average.

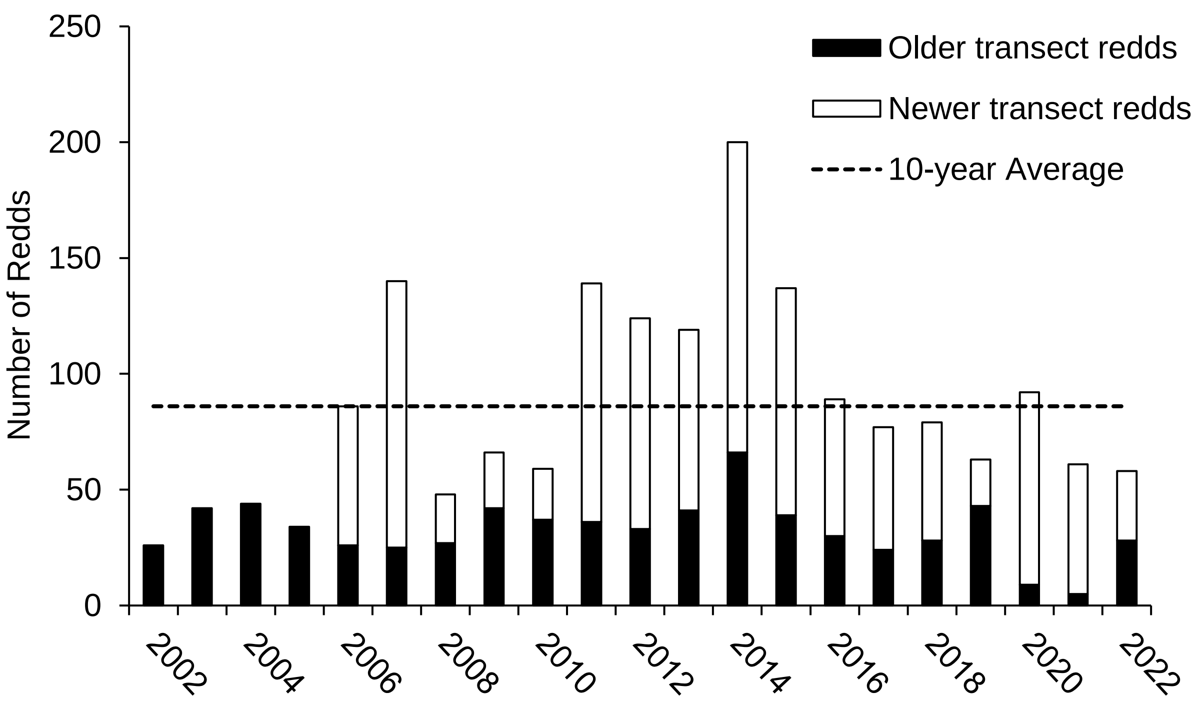

Figure 33. Number of Bull Trout redds observed in the Bear Valley Creek transects, 2002 – 2022. The horizontal dashed line displays the current 10-year average.

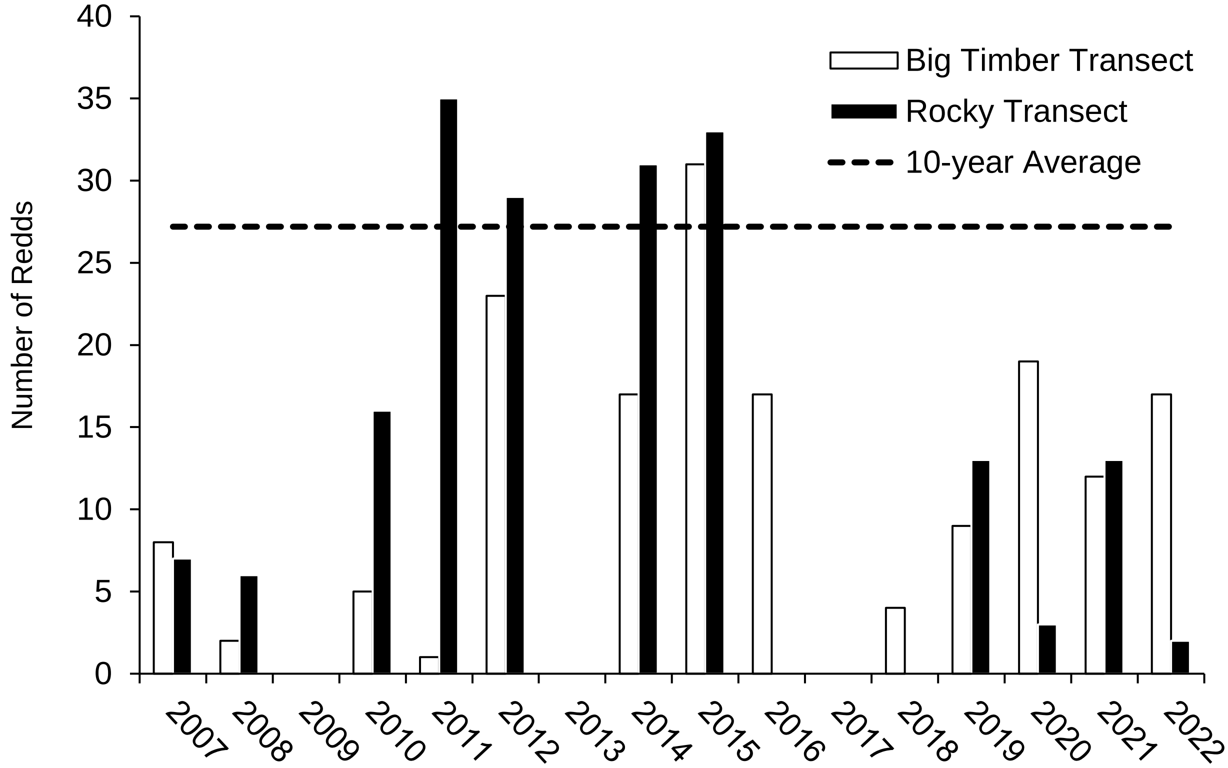

Figure 34. Number of Bull Trout redds observed in Big Timber Creek and Rocky Creek transects, 2007 – 2022. The horizontal dashed line displays the current 10-year average.

UPPER SALMON RIVER TRIBUTARY SURVEYS

ABSTRACT

Backpack electrofishing and habitat surveys were conducted at 32 sites in the upper Salmon River basin in 2022 to assess fish distribution, composition, and abundance. Survey sites were established on Alturas Lake Creek, Big Casino Creek, Basin Creek, East Fork Basin Creek, Slate Creek, and Kinnikinic Creek. Eight salmonid species (including hybrids) were observed across all surveys. Westslope Cutthroat Trout was the most prevalent species occupying 15 sites, followed by Rainbow Trout (n = 14 sites), Brook Trout (n = 9 sites), Bull Trout (n = 9 sites), Mountain Whitefish (n = 6 sites), and Chinook Salmon (n = 5 sites). Westslope Cutthroat Trout also had the widest observed distribution, occupying sites across all six surveyed streams, however most individuals were collected in Kinnikinic Creek where they were the only salmonid present. Six native salmonid species were observed in Basin Creek and no non-native species were present. Relative abundance (CPUE; fish/min) of each species varied greatly between site and by stream. Overall, BKT were found in highest abundance in Big Casino Creek and Alturas Lake Creek, and native salmonid CPUE was higher across sites where BKT were absent. Results from fish surveys conducted in 2022 suggest that native species occurrence and abundance are negatively affected by Brook Trout populations within tributaries of the Upper Salmon River basin. However, in the absence of Brook Trout, certain tributaries such as Basin Creek and Kinnikinic Creek harbor self-sustaining populations of native fishes.

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INTRODUCTION

The upper Salmon River currently provides popular fishing opportunities for anadromous species such as Chinook Salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* (anadromous Rainbow Trout) yet is generally under-utilized as a trout fishery. The Department's current statewide fisheries management plan lists "Improv[ing] the quality of Cutthroat Trout fishing in the main stem Salmon River" as an objective (Idaho Department of Fish and Game 2019), and the upper Salmon River was designated as a distinct geographic management unit (GMU) in the 2013 *Management Plan for the Conservation of Westslope Cutthroat Trout in Idaho* (Idaho Department of Fish and Game 2013; Westslope Cutthroat Trout *O. clarkii lewisi* [WCT] management plan hereafter). The primary goals of the WCT management plan are to: (1) ensure the long-term persistence of the subspecies within the current range in Idaho, (2) manage populations at levels capable of providing angling opportunities, and (3) restore WCT to those parts of its historical range where feasible. Thus, identifying actions that concurrently address goals listed in both management plans will help regional fisheries staff prioritize management activities for the upper Salmon River.

In recent decades, multi-agency restoration efforts have occurred throughout the upper Salmon River to rehabilitate systems affected by anthropogenic influences to benefit the recovery of anadromous fishes listed under the Endangered Species Act. These projects have also benefitted native resident fishes by increasing the amount and quality of tributary fish habitat, improving watershed connectivity, and decreasing diversion entrainment rates. In certain cases, entire tributaries were reconnected to the main stem Salmon River after years of being disconnected due to irrigation activities. These projects have likely resulted in the renewal of fluvial WCT life histories and increased gene flow among local tributary populations. Anecdotally, anglers have noticed an improvement of the resident fisheries in the upper main stem Salmon River and results from a recent IDFG creel survey suggested that anglers and landowners have shown a renewed interest in continuing to enhance trout fishing opportunities in the Sawtooth Valley (Estep et al. 2021). As such, better understanding the spatial distribution of WCT populations and the relative contribution of tributaries to the fluvial WCT in the main stem Salmon River will allow fisheries staff to execute targeted management actions. These actions could include habitat improvement projects focused on increasing production in streams with existing fluvial WCT, increasing watershed connectivity by identifying and removing potential migration barriers or screening irrigation diversions, implementing a stocking/transplantation program to establish fluvial populations in streams where that life history is absent, or removing non-native fish species that could have competitive or predatory interactions with WCT (e.g., Brook Trout *Salvelinus fontinalis*).

Brook Trout (BKT), native to eastern North America, were historically stocked throughout the western United States to bolster trout fishing opportunities. These stockings included many high mountain lakes, lowland lakes, and streams throughout Idaho, including the upper Salmon River basin. Brook Trout have since established naturally reproducing populations and colonized new systems outside initial stocking locations (Kennedy et al. 2016). However, there is a growing body of literature documenting negative effects of introduced BKT on native fishes. Brook Trout tend to outcompete and displace Bull Trout *S. confluentus* (BLT; Rieman et al. 2006; Voss et al. 2023) and Cutthroat Trout (Peterson et al. 2004) across their native range, and Meyer et al. (2022) found WCT occupancy in central Idaho to decline with increasing BKT abundance. Furthermore, hybridization with BKT decreases the reproductive potential of BLT (Kanda et al. 2002). Therefore, gaining insight on the spatial distribution and abundance of BKT will further prioritize tributaries within the upper Salmon River where eradication or suppression may be feasible management options to benefit native fishes.

To better understand fish distribution, composition, and abundance in the upper Salmon River basin, staff conducted fish and habitat surveys throughout tributaries to the upper Salmon River in 2022. Results will guide regional management actions to achieve goals in concordance with statewide management plans and prioritize tributaries where work is most pertinent.

OBJECTIVES

- Assess fish distribution, composition, and abundance in the upper Salmon River basin within the Sawtooth Valley.
- Identify core populations of WCT.
- Identify tributaries where WCT are absent or in low abundances and future introduction or translocation may be feasible.
- Collect genetic samples from WCT in major tributaries that may be primary contributors to the mainstem Salmon River fishery for later GSI analysis.
- Identify tributaries where BKT eradication or suppression could be implemented to help conserve native fishes and improve fishing opportunities.
- Assess physical habitat conditions associated with WCT and BKT occurrence.

STUDY SITES

All sites surveyed in 2022 were contained within the Salmon-Challis or Sawtooth National Forests near Stanley, Idaho (Figure 35). Primary land cover consists of coniferous forest at high elevations (up to 3,277 m) and sagebrush-grass steppe at lower elevations. Sites were distributed across five HUC12 watersheds within the Upper Salmon River basin (HUC4; Figure 35). Common fishes of the upper Salmon River basin are WCT, Rainbow Trout/steelhead (RBT), BLT, BKT, Chinook Salmon (CHK), Mountain Whitefish *Prosopium williamsoni* (MWF), Northern Pikeminnow *Ptycheilus oregonensis*, Redside Shiner *Richardsonius balteatus*, suckers *Catastomus* spp., sculpins *Cottus* spp., and dace *Rhinichthys* spp.

METHODS

Field Sampling

Tributaries surveyed in 2022 were selected for two primary objectives: 1) collect 30 to 50 genetic tissue samples from WCT in major tributaries that may contribute to the mainstem Salmon River fishery, or 2) monitor fish species composition and abundance in tributaries upstream of the Sawtooth Hatchery weir, particularly those that may contain WCT, BKT, or both. Survey sites were delineated depending on the previous objectives.

For objective 1, the Basin Creek, Big Casino Creek, Kinnikinic Creek, and Slate Creek watersheds (HUC12) were selected after reviewing previous survey data for WCT presence. Within each system, five primary sites were designated starting from the mouth and working upstream. Basin Creek was split into lower and upper subbasins due to watershed size. Lower Basin Creek was focused on in 2022, and upper Basin Creek is planned for the 2023 field season. To increase overall sample size, three sites were also established on East Fork Basin Creek. Each site was a minimum of 1 km away from the next upstream site. Where possible, exact site coordinates were selected based on previously established sites so that fish data were comparable through time. Each site consisted of a single-pass backpack electrofishing surveys within a 100-m reach. Fish were then tallied by species, measured (TL; mm), and weighed (g). Westslope Cutthroat Trout >80 mm received a PIT tag and had fin tissue sample collected for later genetic analysis. At the stream level, the goal was to collect 30 to 50 genetic samples from a minimum of three sites to capture genetic variability at a broader scale. For example, even if all samples could have been collected from site one (furthest downstream), no more than 20 were to be collected from site 1, and then a maximum of 15 samples each in sites two and three. This ensured that samples were more evenly distributed throughout the watershed. Alternatively, in the case that five sites did not result in enough genetic samples, roving sites could then be opportunistically conducted in areas where WCT catch rates would be maximized.

For objective 2, Alturas Lake Creek (upstream of Alturas Lake) was selected as it was the next drainage upstream of surveys conducted in 2021 (Kelly et al. *in review*). Survey sites were established at one km intervals starting at the mouth of the stream. Field crews conducted electrofishing and habitat surveys every two km (i.e., 1, 3, 5, 7…) unless WCT and BKT were found in sympatry. Once WCT and BKT were found in sympatry, crews conducted surveys every km until WCT were found in allopatry or until there were no more survey sites available. Each site was sampled following protocols outlined in Gillies-Rector (2021). Reach lengths ranged from 95 to 102 m depending on natural instream habitat breaks (e.g., beaver dams, etc.). Fishes were sampled via single-pass backpack electrofishing to reduce sampling logistics. After the completion of each electrofishing pass, fish were identified to species, enumerated, measured (TL; mm), and weighed (g). Westslope Cutthroat Trout >80 mm received a PIT tag, and all WCT and BLT >80 mm had fin clips taken for later genetic analysis. Physical habitat characterization was conducted after fish sampling to minimize disturbance to the reach. Habitat measurements were taken at ten equally spaced transects throughout the reach (e.g., 10 m, 20 m, 30 m, …, 100 m). Primary habitat measurements of interest included macrohabitat type (riffle, run, pool), wetted width (m), number of large woody debris pieces and aggregates, percent unstable banks, percent undercut banks, and percent substrate cover (silts and sand, gravel, cobble, boulder, and bedrock).

Statistical Analyses

Fish species occurrence and percent composition was summarized at each site. Site level relative fish abundance was indexed as CPUE (fish/min) by summing the number of individuals collected and then standardizing the cumulative count by the total electrofishing effort (minutes). Mean (± SE) CPUE was then calculated at the stream level by averaging all site-specific CPUEs by species. The CPUE of all native salmonid species collected at a site was then compared between sites with and without BKT using a Mann Whitney U test because of the small sample size within each group. Since fish data was limited, particularly across sites where BKT were present, statistical significance was evaluated using an α level of 0.10. Lastly, length-frequency histograms were created for each salmonid species (including hybrid species) by stream.

RESULTS

We observed six salmonid species across 32 sites (Table 18). Westslope Cutthroat Trout were the most prevalent and abundant species, totaling 84 individuals across 15 occupied sites. Rainbow Trout occupied 14 sites totaling 79 individuals, BKT occupied nine sites totaling 64 individuals, BLT occupied nine sites totaling 22 individuals, MWF occupied six sites totaling 14 individuals, and 12 CHK were observed across five sites. Rainbow Trout x Westslope Cutthroat Trout were observed at four sites (n = 6 fish) and BLT x BKT were observed at two sites (n = 2 fish) both within Alturas Lake Creek. Westslope Cutthroat Trout also had the largest distribution, occupying sites across all six surveyed streams and accounting for the only salmonid species present in Kinnikinic Creek (Table 18; Figure 36). Chinook Salmon and MWF had the narrowest distribution as both species were only detected in Basin Creek (Table 18). Basin Creek also had the highest native species diversity, harboring six native salmonid species (including hybrids; Figure 36).

Relative abundance (CPUE; fish/min) varied considerably between species and streams (Figure 36). Westslope Cutthroat Trout CPUE ranged from 0.00 to 1.31 fish/min and was highest on average in Kinnikinic Creek (0.72 ± 0.2 fish/min). Mean RBT CPUE was highest in East Fork Basin Creek (0.68 ± 0.1 fish/min) and ranged from 0.00 to 0.86 fish/min. Brook Trout CPUE ranged from 0.00 to 1.04 fish/min and was highest on average in Big Casino Creek (0.73 ± 0.2 fish/min). Bull Trout CPUE ranged from 0.00 to 0.29 and was also highest on average in Big Casino Creek (0.07 ± 0.07 fish/min). Mountain Whitefish were only observed in Basin Creek and CPUE ranged from 0.00 to 0.12 and averaged 0.05 (± 0.02) fish/min. Chinook Salmon were also only observed in Basin Creek and CPUE ranged from 0.00 to 0.16 fish/min with an average of 0.05 (± 0.02) fish/min. Mean RBT x WCT CPUE ranged from 0.00 to 0.15 fish/min and was highest in East Fork Basin Creek (0.08 ± 0.04 fish/min). Bull Trout x Brook Trout hybrids were only observed at two sites in Alturas Lake Creek and CPUE was 0.05 at both sites. Across all sites and streams, mean native salmonid CPUE was higher when BKT were absent (Figure 37; W = 144, p = 0.09).

Salmonids collected across all streams were generally of smaller size classes (mean TL < 150 mm). Westslope Cutthroat Trout were largest on average in Alturas Lake Creek (mean TL = 198 mm, n = 2) but Basin Creek displayed the widest range with individuals from 112 to 340 mm TL (Figure 38). Mean RBT TL was similar across the four occupied streams, but largest in Slate Creek (mean TL = 143 mm, n = 3). The widest range of RBT lengths was observed in Basin Creek with individuals from 88 to 195 mm (Figure 39). Multiple age classes of BKT were observed in both Alturas Lake Creek (mean TL = 129 mm, n = 28) and Big Casino Creek (mean TL = 106 mm, n = 36; Figure 40). Only juvenile stage BLT were collected, with a maximum observed TL of 216 mm in Big Casino Creek (Figure 41). Mountain Whitefish lengths ranged from 237 to 360 mm and averaged 293 mm TL (n = 10; Figure 42). Chinook Salmon were also only observed at juvenile stages as FL ranged from 70 to 92 mm and averaged 80 mm (n = 12; Figure 43). Rainbow Trout x Westslope Cutthroat Trout hybrids were slightly larger on average in Basin Creek (range = 85 to 210 mm, mean = 120 mm, n = 4) compared to East Fork Basin Creek (range = 81 to 132 mm, mean = 107 mm, n = 2; Figure 44), though samples sizes were low for both systems (n < 5 fish). Two BLTxBKT hybrid individuals were observed in Alturas Lake Creek and lengths were 87 and 138 mm TL (mean = 113 mm; Figure 45).

DISCUSSION

Results from surveys conducted in 2022 suggest that fish species composition in tributaries to the upper Salmon River varied in part due to BKT occurrence. When present, BKT comprised the majority of the stream's fish community and mean CPUE was over two times greater than that of the next most prevalent species. Though BKT were sympatric with native species at the stream level, mean relative abundance of native salmonids was generally higher at sites unoccupied by BKT. Furthermore, occurrence patterns of BKT and WCT at the site level aligned with previous work (Meyer et al. 2022), where WCT were rarely observed in sites occupied by BKT. Another concerning finding was the presence of BLT x BKT hybrid individuals in Alturas Lake Creek, demonstrating a loss in reproductive potential for BLT in the greater Alturas system (Kanda et al. 2002). Combined with results from tributary inventories conducted in 2021 (Kelly et al. *in review*), BKT appear to be one of the key limiting factors to native species in various tributaries throughout the Upper Salmon River.

Interestingly, BKT did not inhabit the Basin Creek or Slate Creek watersheds, despite both streams having a perennial hydrological connection to the Salmon River (i.e., no passage barriers to invasion). This could be due in part to historic stocking events. Dating back to 1913, no BKT stocking records currently exist in the IDFG database for any waterbody (including high mountain lakes) within the Basin Creek or Slate Creek drainages. Conversely, over 120,000 BKT were periodically stocked into Alturas Lake from 1927 through 1952, so individuals observed in Alturas Lake Creek in 2022 are likely the result of upstream colonization. Brook Trout were also observed in high abundance throughout Big Casino Creek despite no record of BKT stocking within the drainage. However, while no record exists of BKT stocking in the IDFG database, BKT establishment into all three of the headwater alpine lakes (Casino Lake #1, Casino Lake #2, and Casino Lake #3) without human assistance is unlikely. Regardless, the current spatial distribution of BKT throughout the Upper Salmon basin has likely been influenced by historical stocking. The fact that multiple connected tributaries to the Upper Salmon are devoid of BKT either suggests that BKT do not use the Salmon River as a migration corridor as effectively as native species or that certain subwatersheds are unsuitable for BKT due to environmental conditions.

Results from 2022 also revealed that Kinnikinic Creek harbors a healthy self-sustaining WCT population. Moreover, Kinnikinic Creek was the only tributary sampled in 2022 that has the potential to be a significant contributor of WCT to the mainstem Salmon River fishery. Of note, the fact that WCT were the only species observed in the drainage, aside from *Cottus* sp. in the furthest downstream site, is due to the hydrology of the outlet. Though the system maintains perennial flow to the mainstem Salmon River, there is a box culvert that serves as an upstream fish passage barrier at the intersection of Kinnikinic Creek and US Highway 75. This barrier is roughly 30 meters upstream of the mouth and features a drop in height of over six feet. Surprisingly, BKT were stocked into Kinnikinic Creek annually between 1953 and 1955, but concurrent Cutthroat Trout (subspecies not specific) stockings from 1940 to 1954 outnumbered BKT approximately 16:1. Environmental factors could have also contributed to the successful establishment of WCT over BKT and conducting follow up fine-scale habitat surveys throughout tributaries surveyed in 2022 is recommended to investigate any habitat differences in streams with and without BKT.

Overall, fish community and distribution information gained from surveys conducted in 2022 will help prioritize fish management in the Upper Salmon River basin. Tributaries where native species are being limited due to a high abundance of BKT such as Big Casino Creek are good candidates for potential eradication (e.g., piscicide treatment) or suppression actions (e.g., manual suppression coupled with Myy BKT stocking). Additionally, Kinnikinic Creek appears to be a favorable donor source for potential WCT translocations to other tributaries throughout the Upper Salmon River, though care should be taken to not remove too many individuals from the isolated population. Routine fish population monitoring should continue on tributaries where only native species were observed for early detection of any future BKT invasion.

MANAGEMENT RECOMMENDATIONS

1. Resample survey sites established in 2022 every three to five years to monitor potential shifts in fish distribution and abundance, particularly those where BKT co-occurred with native fishes.

2. Evaluate management options to suppress or eradicate non-native BKT to benefit native fish species.

3. Conduct follow up fine-scale stream habitat surveys to investigate any habitat features that may be hindering or assisting BKT establishment.

4. Submit WCT fin tissue samples to the Eagle Fish Health and Genetics Lab to assess genetic variation within Kinnikinic Creek. These results will also serve as a baseline for future Genetic Stock Identification efforts on mainstem fluvial WCT.

Table 18. Electrofishing summary statistics for six tributaries to the upper Salmon River surveyed in 2022. Characteristics include stream name, number of sites sampled, total number of fish collected, the percentage of catch that is Brook Trout (BKT), Bull Trout (BLT), Bull Trout x Brook Trout hybrid (BLT x BKT), Chinook Salmon (CHK), Mountain Whitefish (MWF), Rainbow Trout (RBT), Rainbow Trout x Westslope Cutthroat Trout hybrid (RBT x WCT), and Westslope Cutthroat Trout (WCT), followed by each species' sample size (n).

Stream	Number sites	Number fish	Percent BKT (*n*)	Percent BLT (*n*)	Percent BLT x BKT (*n*)	Percent CHK (*n*)	Percent MWF (*n*)	Percent RBT (*n*)	Percent RBT x WCT (*n*)	Percent WCT (*n*)
Kinnikinic Creek	5	59	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100 (59)
Slate Creek	5	5	0 (0)	20 (1)	0 (0)	0 (0)	0 (0)	60 (3)	0 (0)	20 (1)
Big Casino Creek	4	48	75 (36)	6 (3)	0 (0)	0 (0)	0 (0)	15 (7)	0 (0)	4 (2)
East Fork Basin Creek	3	35	0 (0)	6 (2)	0 (0)	0 (0)	0 (0)	54 (19)	6 (2)	34 (12)
Basin Creek	8	91	0 (0)	3 (3)	0 (0)	13 (12)	15 (14)	55 (50)	4 (4)	9 (8)
Alturas Lake Creek	7	45	62 (28)	29 (13)	4 (2)	0 (0)	0 (0)	0 (0)	0 (0)	4 (2)

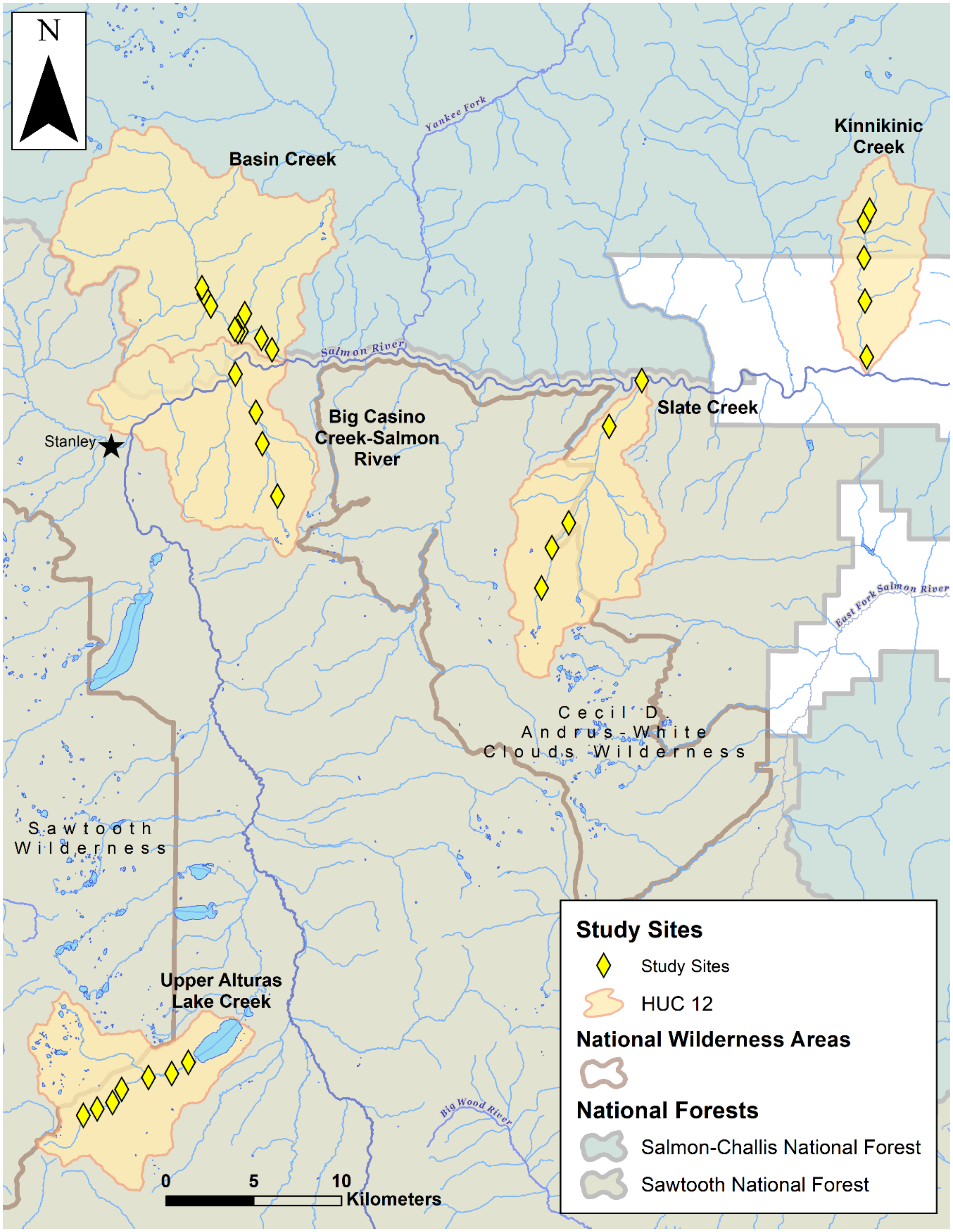

Figure 35. Locations of 32 stream surveys conducted in the Upper Salmon River Basin near Stanley, Idaho in 2022. Study area watersheds (HUC 12) are displayed in orange polygons and study sites are depicted within by yellow diamonds.

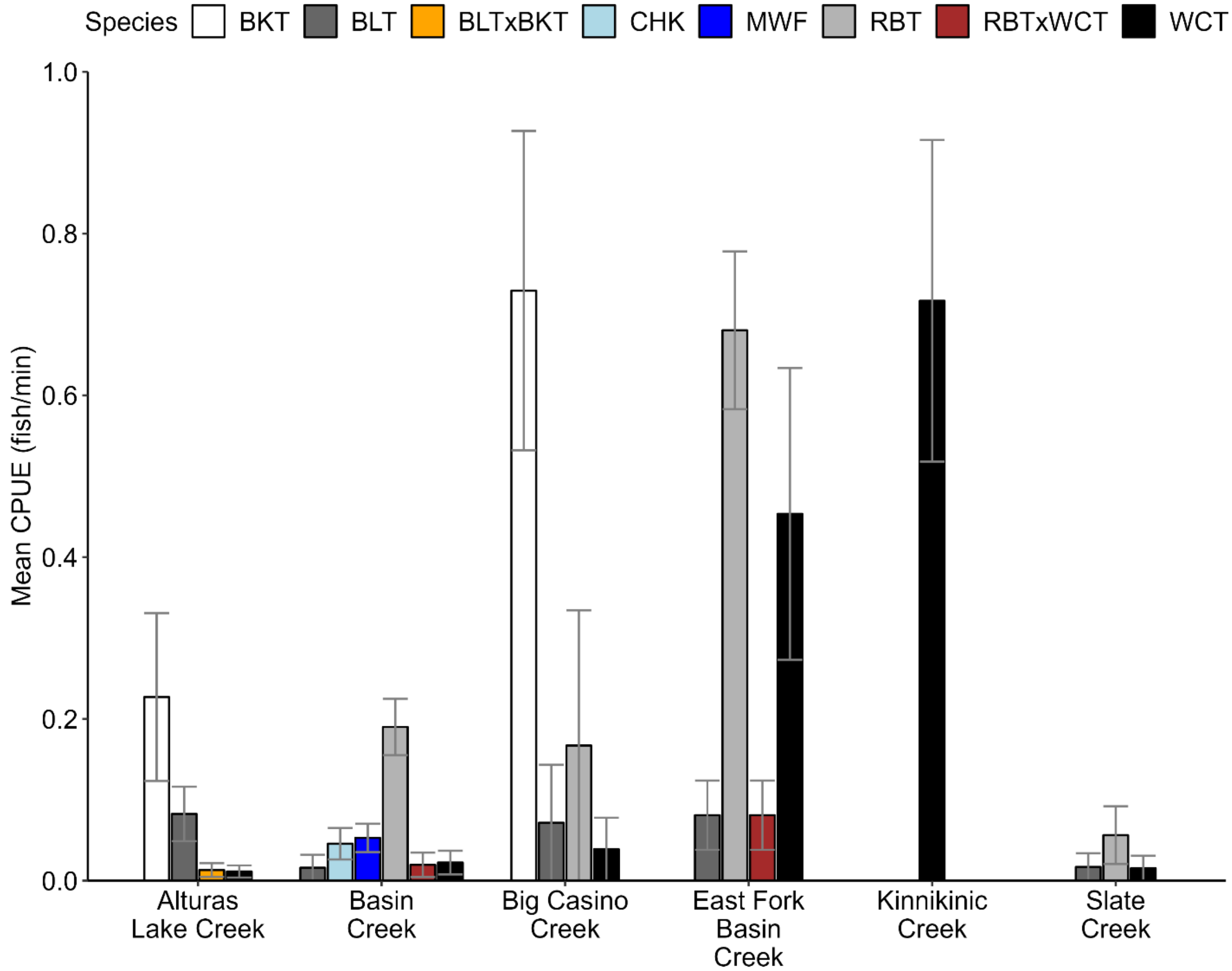

Figure 36. Bar chart of mean (± SE) CPUE (fish/min) for salmonid species observed at 32 sites across six tributaries in the Upper Salmon River Basin in 2022. Gray bars on each column display standard error estimates around the mean. Fish species observed include Brook Trout (BKT), Bull Trout (BLT), Bull Trout x Brook Trout hybrid (BLT x BKT), Chinook Salmon (CHK), Mountain Whitefish (MWF), Rainbow Trout (RBT), Rainbow Trout x Westslope Cutthroat Trout hybrid (RBT x WCT), and Westslope Cutthroat Trout (WCT). Refer to Table A for samples sizes associated with the number of surveys conducted in each stream.

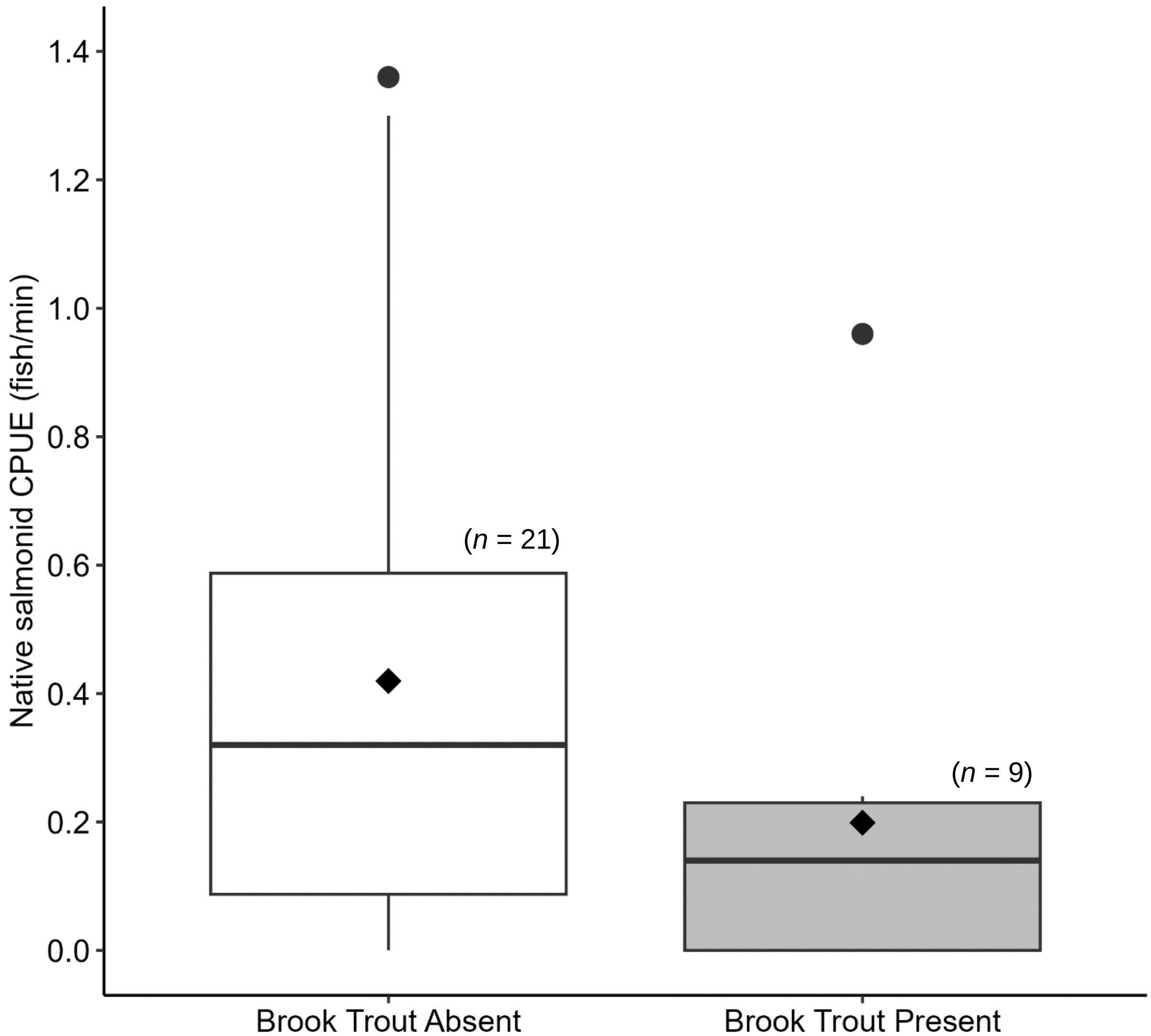

Figure 37. Box and whisker plot displaying native salmonid CPUE (fish/min) at sites with (n = 9) and without (n = 23) Brook Trout. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River in 2022. Native salmonid species include Bull Trout, Chinook Salmon, Mountain Whitefish, Rainbow Trout, and Westslope Cutthroat Trout. Each group's mean CPUE value is represented by a black diamond and outliers are represented by black circles. Sample sizes are shown above boxes in parentheses.

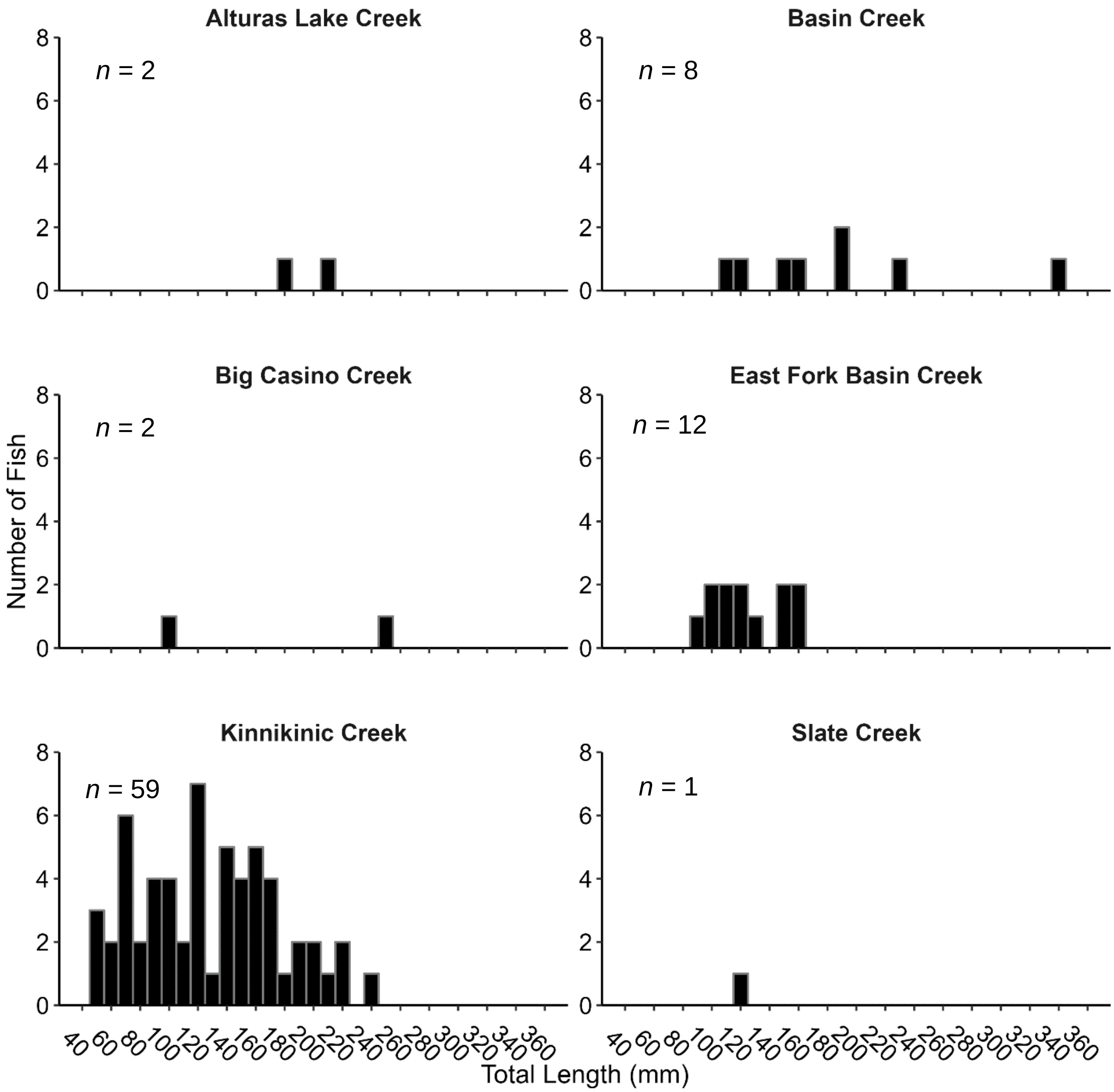

Figure 38. Length-frequency distributions for Westslope Cutthroat Trout collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

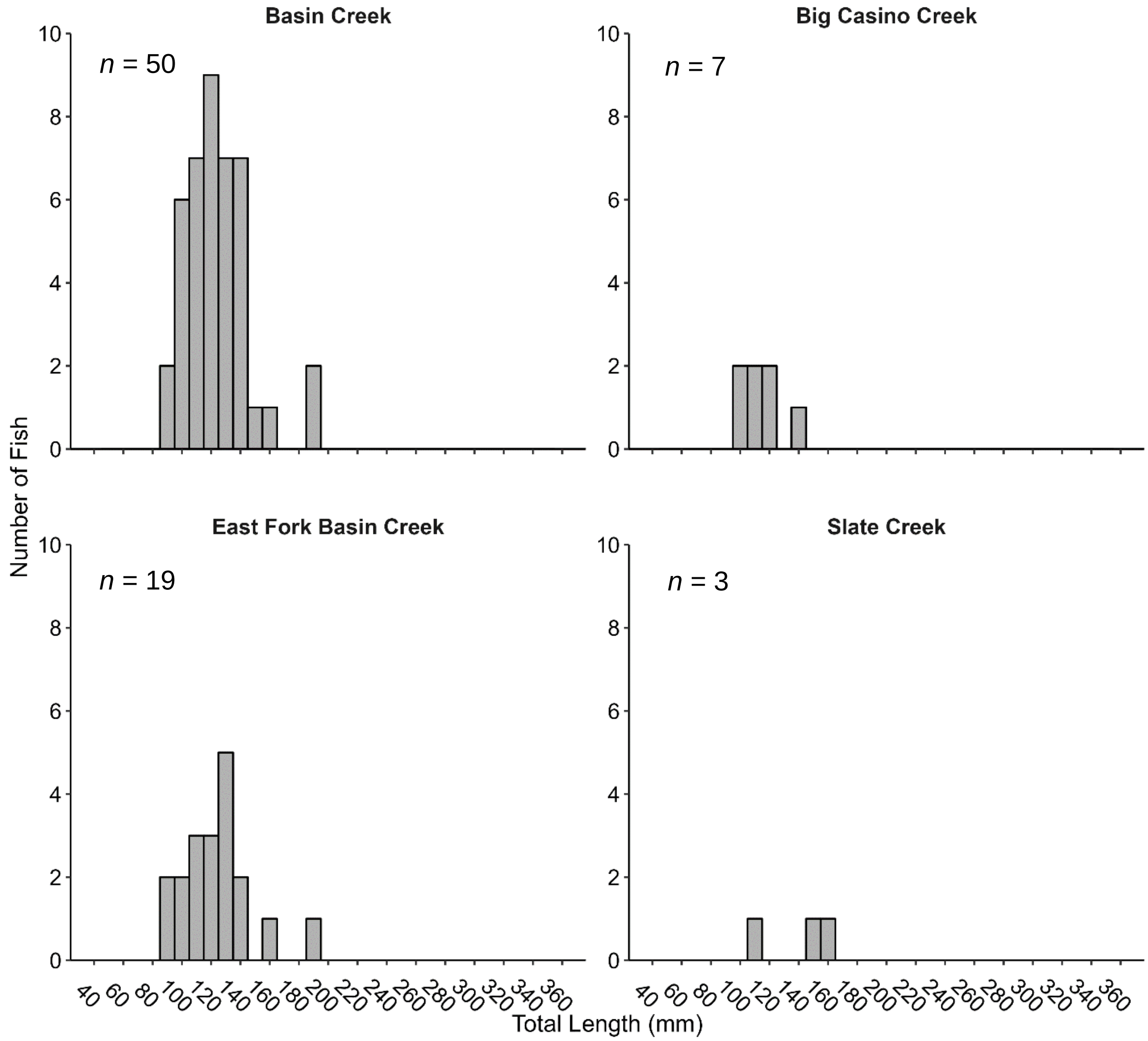

Figure 39. Length-frequency distributions for Rainbow Trout collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

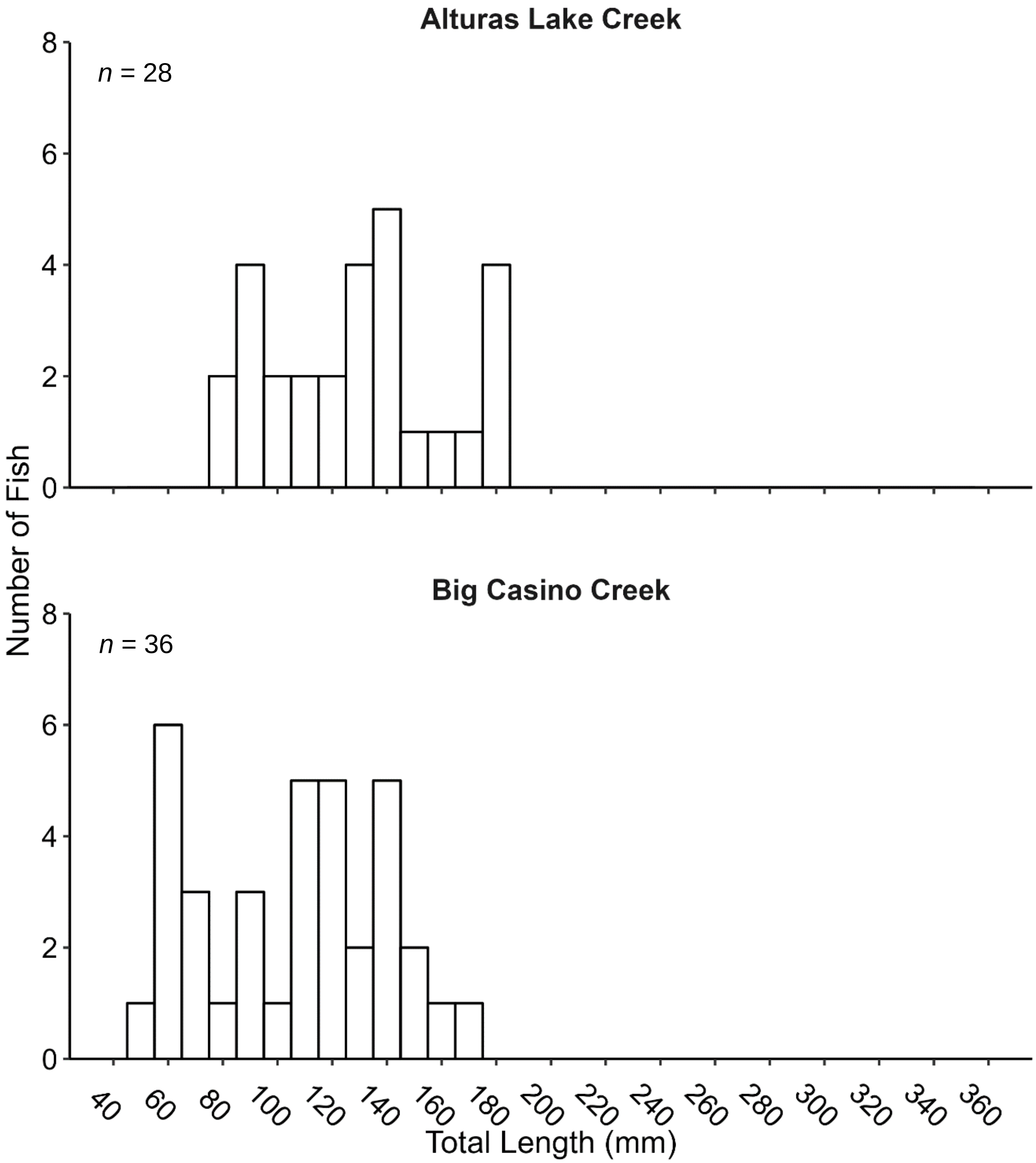

Figure 40. Length-frequency distributions for Brook Trout collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

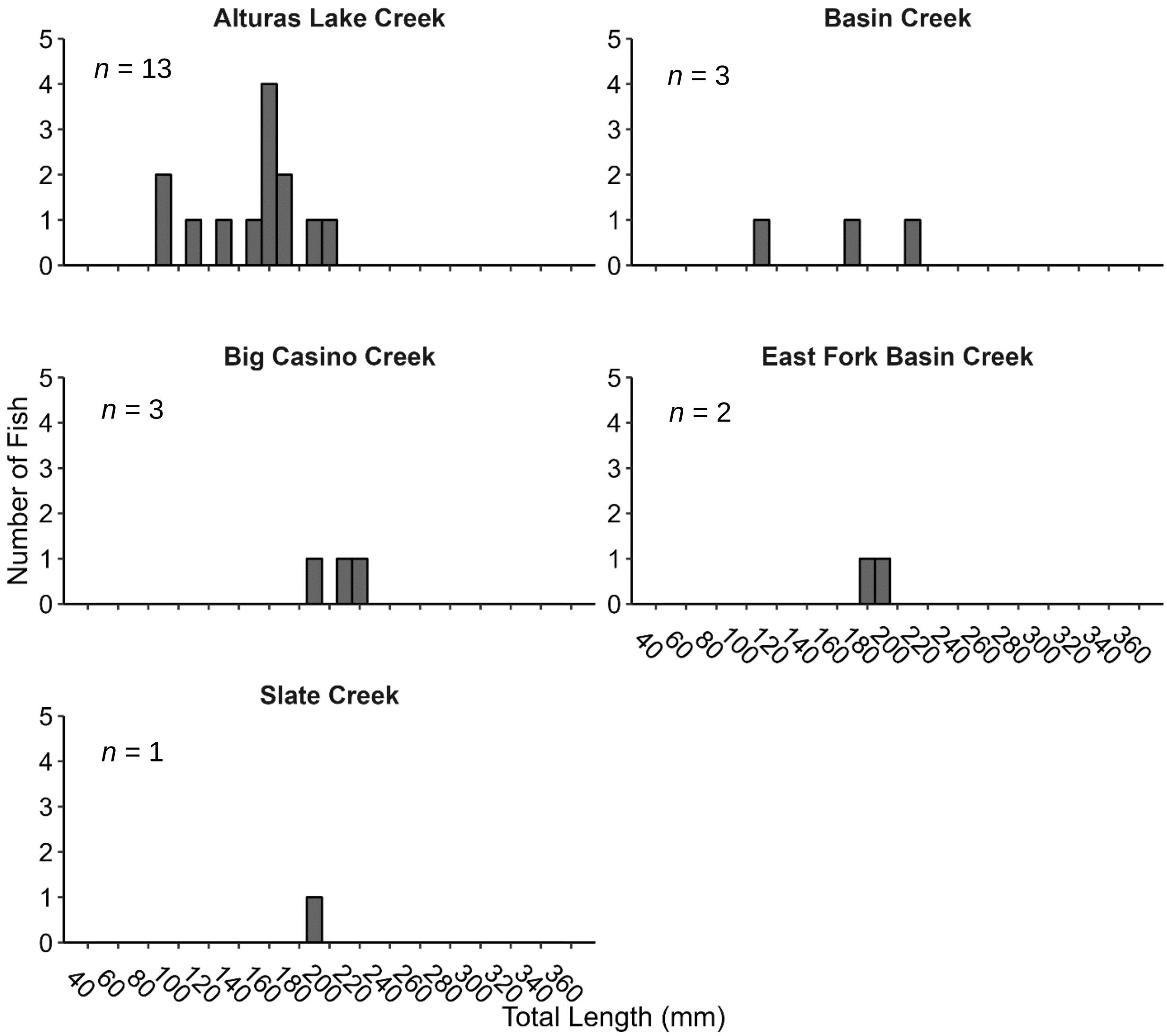

Figure 41. Length-frequency distributions for Bull Trout collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

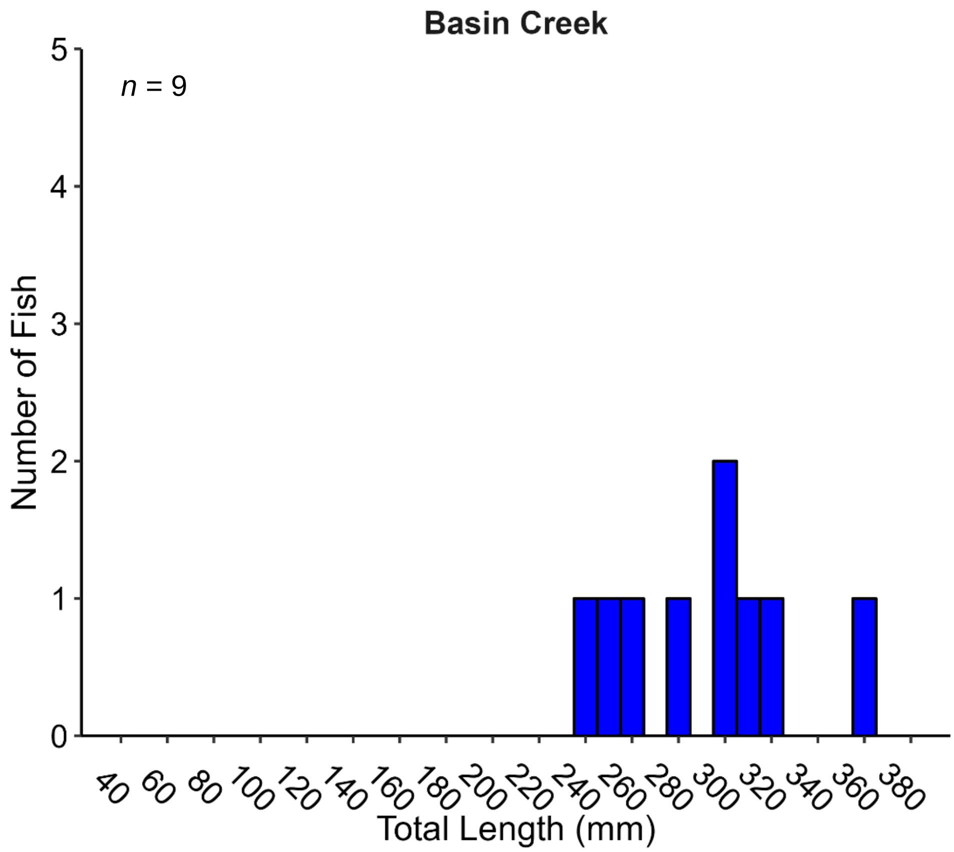

Figure 42. Length-frequency distributions for Mountain Whitefish collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

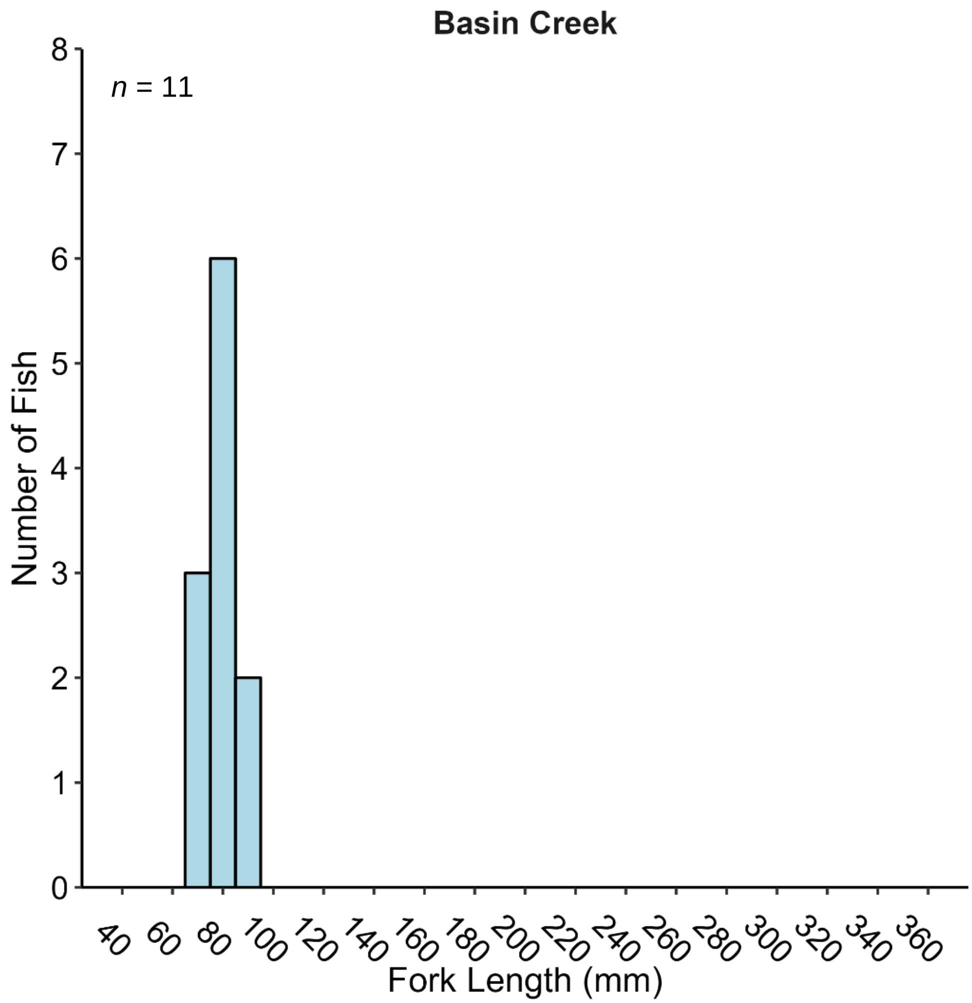

Figure 43. Length-frequency distributions for Chinook Salmon collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

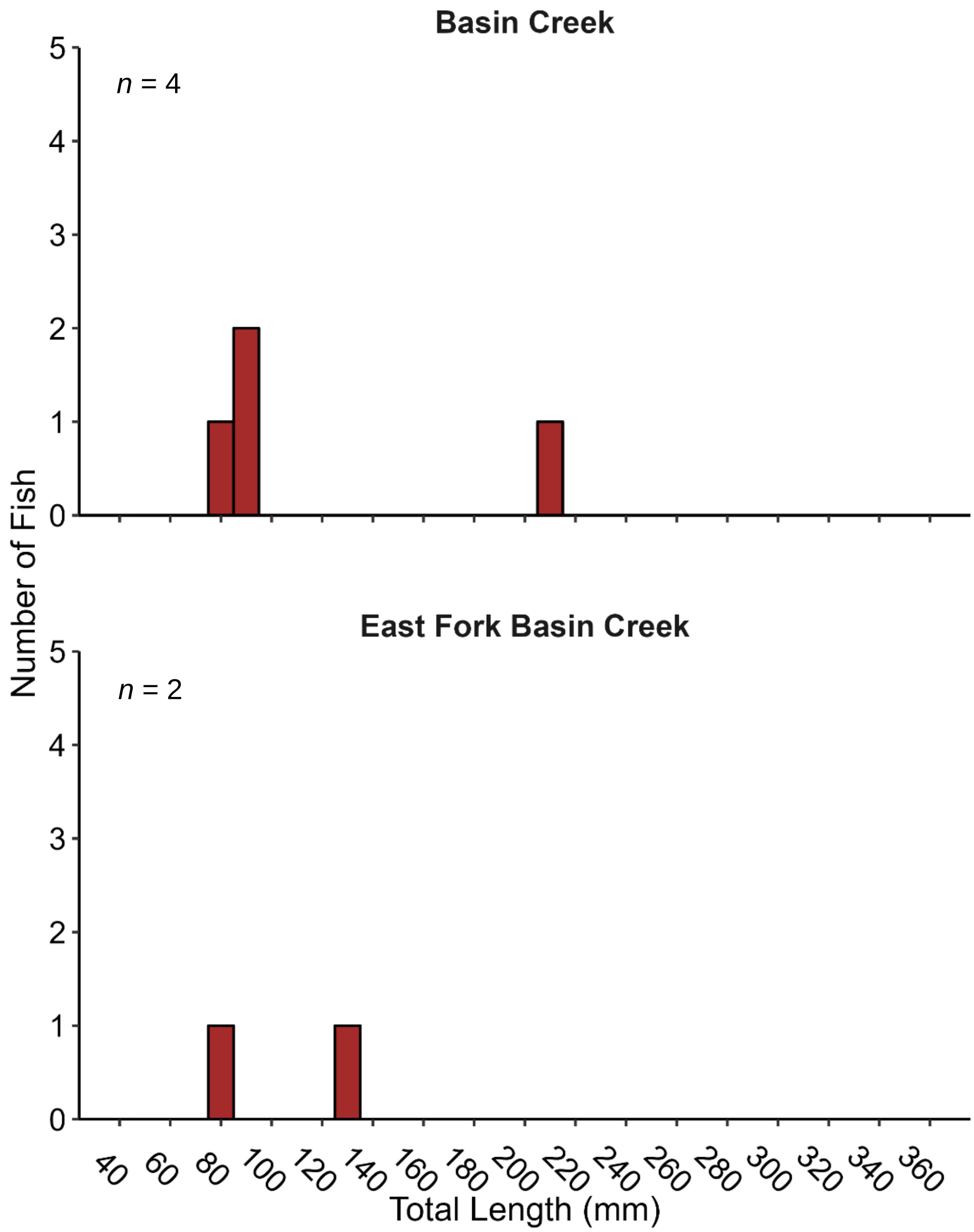

Figure 44. Length-frequency distributions for Rainbow Trout x Westslope Cutthroat Trout hybrids collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

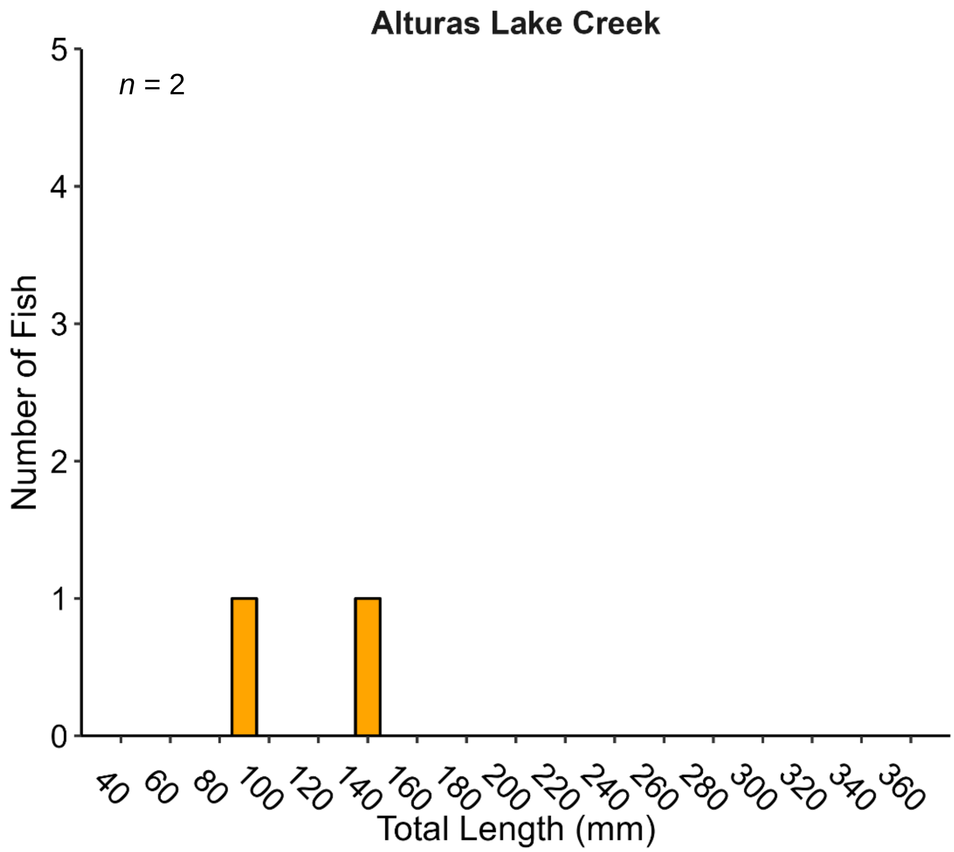

Figure 45. Length-frequency distributions for Bull Trout x Brook Trout hybrids collected during stream surveys in 2022. Stream surveys were conducted at 32 sites across six tributaries to the upper Salmon River.

UPPER SALMON RIVER ELECTROFISHING SURVEYS

ABSTRACT

Boat electrofishing surveys were conducted at four transects on the main stem upper Salmon River in 2022 to continue trend monitoring of salmonid species composition, relative abundance, and size structure. Electrofishing occurred over four days between October 25 and November 1 beginning at the East Fork Salmon River boat ramp and extending downstream to the Watts Bridge access area. Six salmonid species (including hybrids) were observed across surveys. Catch composition was largely comprised of Mountain Whitefish *Prosopium williamsoni* (n = 2,377; 98.5%), followed by Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* (n = 47; 1.9%), Rainbow Trout *O. mykiss* (n = 20; 0.8%), Bull Trout *Salvelinus confluentus* (n = 20; 0.8%), Chinook Salmon *O. tshawytscha* (n = 9; 0.4%), and Rainbow Trout x Westslope Cutthroat Trout hybrids (n = 7; 0.3%). Resident trout PSD values ranged from 31 (Rainbow Trout) and 34 (Westslope Cutthroat Trout) to 90 (Bull Trout). Relative weights for all target salmonids were below 100 on average. Species composition and relative abundances were generally consistent with previous surveys aside from considerably lower catch rates of Chinook Salmon parr and juvenile Rainbow Trout in 2022. Size structure and body condition indices mostly aligned with previous years though Westslope Cutthroat Trout were slightly larger on average in 2022. Differences observed in 2022 from past surveys are likely due in part to inconsistencies with survey timing and methods (i.e., single- versus multiple-pass electrofishing). Future trend monitoring should be conducted annually, and survey timing should be changed to coincide with past surveys. Overall, results from 2022 suggest that resident trout populations in the main stem Salmon River display balanced size structure and offer quality fishing opportunities.

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INTRODUCTION

The upper Salmon River is most popular for its anadromous Chinook Salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* (anadromous Rainbow Trout) fisheries. However, general trout fishing on the upper Salmon River has increased in popularity in recent years, particularly between Challis and Stanley. These angling opportunities are primarily supported by fluvial forms of resident fishes such as Westslope Cutthroat Trout *O. clarkii lewisi* (WCT), Rainbow Trout (RBT), and Bull Trout *Salvelinus confluentus* (BLT). Annual supplemental stockings of sterile hatchery RBT (denoted by an adipose fin clip) also occurs within the Sawtooth Valley and these fish serve as the only trout harvest opportunities in the main stem. Mountain Whitefish *Prosopium williamsoni* (MWF) are also an abundant salmonid game species throughout the upper Salmon River. Despite the recent increase in trout fishing effort, a 2019 creel survey showed that anglers targeting trout in the upper Salmon River throughout the Sawtooth Valley had an overall CPUE of only 0.17 fish/h from June to September (Estep et al. 2021). Additionally, the current statewide fisheries management plan lists improving the quality of resident trout fishing in the upper Salmon River during the summer months as a primary objective (Idaho Department of Fish and Game 2019).

The spatial distribution of fishes in the upper Salmon River can display strong seasonal variation depending on species' life history strategy and seasonal requirements (i.e., spawning, foraging, and overwintering; Schoby 2006). For example, while WCT, RBT, and BLT all exhibit upstream migrations into headwater reaches of tributaries to spawn, all three species occupy mainstem portions of the river variably throughout the year for forage and shelter, particularly during the winter (Schoby 2011). The spawning and overwintering habits of these species highlight the importance of watershed connectivity to support fishery quality. Thus, identifying tributaries where juvenile production leads to recruitment in the mainstem trout fishery will help regional staff target management actions. These actions could include identifying and removing potential migration barriers or screening irrigation diversions to increase stream connectivity, implementing a stocking/transplantation program to establish fluvial populations in streams where such life histories are absent, habitat improvement projects to increase available spawning and rearing habitat, or removing non-native fish species from tributaries where they could have competitive or predatory interactions with native fishes (e.g., Brook Trout *S. fontinalis*).

Salmon Region fisheries staff began conducting annual electrofishing surveys on the main stem Salmon River in 2016 to evaluate trout species composition, abundance, and size structure. Survey transects were established on river reaches popular for trout angling as well as perceived overwintering locations. Since 2016, electrofishing transects have ranged as far upstream as Torrey's Hole boat ramp in the Sawtooth National Recreation Area to the Spring Creek Campground downstream of the North Fork Salmon River confluence. Though an extensive portion of the upper Salmon River has been surveyed, trend transects were established between East Fork Salmon River (EFSR) boat ramp to Deadman Hole recreation site as well as Pennal Gulch to Watt's Bridge access areas. In 2022, we conducted electrofishing surveys over four transects on the upper Salmon River between the EFSR boat ramp and Watt's Bridge access area to continue trend monitoring efforts of resident fish species composition, trout abundance, and size structure.

OBJECTIVES

- Assess resident trout distribution, composition, and abundance in the upper Salmon River.
- Implant T-bar anchor tags into resident trout to track angler use through the Tag! You're It! program.
- Collect genetic samples from WCT for later Genetic Stock Identification (GSI) analysis to determine which tributaries are primarily contributing to the main stem trout fishery.
- Evaluate MWF abundance and size structure in the upper Salmon River.

STUDY SITES

Surveys were conducted on the main stem upper Salmon River between the EFSR confluence (upstream) and Watts Bridge access area (downstream; Figure 46). Annual mean discharge measured upstream at the Yankee Fork Salmon River confluence with the Salmon River is 984 cfs. Common fishes of the upper Salmon River are WCT, Rainbow Trout/steelhead (RBT), BLT, Chinook Salmon (CHK), Mountain Whitefish (MWF), Northern Pikeminnow *Ptycheilus oregonensis*, Redside Shiner *Richardsonius balteatus*, suckers *Catastomus* spp., sculpins *Cottus* spp., and dace *Rhinichthys* spp.

METHODS

Field Sampling

We conducted four electrofishing surveys on the main stem upper Salmon River between the EFSR boat ramp and Watts Bridge boat ramp (Figure 46) over four days between October 25 and November 1, 2022. The cumulative length of river surveyed was 41 km, split into two sections each comprising two contiguous transects. The upstream reach contained the EFSR to Deadman Hole and Deadman Hole to Bayhorse Campground transects, while the downstream reach contained the Challis Bridge to Pennal Gulch and Pennal Gulch to Watts Bridge transects (Figure 46). There is a 14 km stretch of river separating the upstream and downstream reaches that was not surveyed.

Transects were selected for sampling based on previous survey locations (Messner 2019) and in efforts to maximize the potential of collecting genetic samples from fluvial WCT near tributaries surveyed earlier in 2022 for GSI analysis. All surveys were single-pass based on management recommendations proposed by regional staff (Messner 2019). Transects were sampled via two rafts equipped with Infinity model electrofishing units (Midwest Lake Management, Inc., Polo, Missouri). Pulsed direct current was produced by Honda 4000- or 5000W generators. Electrofishing settings were 290-310 volts, 60 pulses per second (Hz), and 25% duty cycle, producing 1400 to 2200 watts. Each raft was equipped with two booms extending from the bow terminating in Wisconsin ring anodes as well as a linear array of five dropper cables hanging off both sides of the raft to serve as the cathodes. Surveys were conducted in the downstream direction with rafts floating in tandem. During instances where the river channel split, rafts would separate and sample both channels independently. Each raft carried one rower that operated the electrofishing unit and one netter at the bow of the raft. Once captured, fish were placed into an aerated live well on the raft and were processed routinely throughout the transect based on live well density. The first 50-100 meters of river downstream of each fish workup station was not sampled to minimize recapture events.

Netters were instructed to net all salmonid species (target species) and one individual from all other observed species (non-target species). Target species were measured to the nearest mm (TL; FL for CHK), weighed (g), scanned for Passive Integrated Transponder (PIT) tags, and examined for external tags and marks. Adult stage anadromous fish (Chinook Salmon and steelhead) were not netted during surveys. If anadromous adults were observed, shocking was temporarily halted and resumed 50 to 100 m downstream. Westslope Cutthroat Trout, RBT, BLT, and trout hybrids (RBT x WCT) were implanted with PIT tags if they weren't already tagged, and WCT, RBT, and RBT x WCT were also administered a T-bar anchor tag. Genetic samples from caudal fin tissue were collected on WCT, BLT, and fish identified as RBT x WCT in the field based on phenotypic traits. Mountain Whitefish were considered a secondary target species, so once 100 individuals per transect were weighed and measured, subsequently captured individuals were only tallied for cumulative CPUE estimates. All MWF were fin clipped to denote previous capture.

Statistical Analyses

Fish species occurrence and percent composition was summarized for each transect. Relative fish abundance was indexed as CPUE (fish/hr) by summing the number of individuals collected within the transect by both boats then standardizing the cumulative count by the total electrofishing effort (hours). Proportional stock density (PSD) indices were calculated for WCT, RBT, and BLT over the entire 41 km reach using the formula:

$$\text{PSD-}X = \frac{(\text{Number of fish } \geq \text{specified length})}{(\text{Number of fish } \geq \text{minimum stock length})} \times 100$$

where *X* indicates the length category of interest (e.g., preferred, memorable, etc.). Proposed PSD length categories were derived from Anderson and Neumann (1996).

Length-frequency histograms were created for WCT, RBT, BLT, and MWF. Due to sufficient samples sizes of MWF, length-frequency histograms were created and compared at the transect level. Relative weights (W_r) were also calculated for WCT (TL ≥ 130 mm), RBT (TL ≥ 120 mm), BLT (TL ≥ 120 mm), and MWF (TL ≥ 140 mm) using the standard weight (W_s) equation:

$$Log_{10}(W_s) = a + b * \ Log_{10}(\text{total length (mm)})$$

where *a* = the intercept value and *b* = slope derived from Neumann et al. (2012). The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$W_r = \left(\frac{\text{weight (g)}}{W_s}\right) * 100$$

Relative weights were then compared between transects by species to evaluate differences in body condition by river reach. Differences in mean relative weight were tested for each species via one-way analysis of variance (ANOVA) and compared across electrofishing transects using a post-hoc test (Tukey's honestly significant difference). Given our limited sample sizes for target species, statistical significance was evaluated using an α level of 0.10.

RESULTS

We collected 2,480 individuals composed of six salmonid species across four electrofishing transects (Table 19). Overall target species composition was 95.8% MWF (n = 2,377), 1.9% WCT (n = 47), 0.8% RBT (n = 20), 0.8% BLT (n = 20), 0.4% wild CHK parr (n = 9), and 0.3% trout hybrids (RBT x WCT; n = 7). Westslope Cutthroat Trout had the highest catch rates of primary target species (salmonids excluding MWF) within three of four transects, except for Deadman to Bayhorse where WCT, RBT, and BLT CPUE were equal (CPUE = 2.8 fish/hr; Table 19; Figure 47). Mountain Whitefish CPUE ranged from 62.4 to 240.8 fish/hr and was highest from Pennal Gulch to Watts Bridge (Table 19). Rainbow Trout were not observed in the EFSR to Deadman transect, but RBT x WCT hybrids were detected. Non-target species observed included Largescale Sucker *Catostomus macrocheilus*, Northern Pikeminnow, Redside Shiner, Speckled Dace *Rhinichthys osculus*, and Longnose Dace *R. cataractae*. Although they were not netted, multiple adult steelhead (<5 fish) were observed over the four days of electrofishing.

Size structure and body condition metrics varied among species but were relatively consistent between transects. Westslope Cutthroat Trout total lengths ranged from 229 to 470 mm (mean TL = 325 ± 9.1 mm) across the entire 41 km reach and were highest on average in the Deadman to Bayhorse transect (mean TL = 379 ± 20.5 mm; Figure 48). Westslope Cutthroat Trout PSD was 34% and PSD-P was 4% (Table 20). Relative weights of WCT ranged from 65 to 114 across all transects and was highest on average in the Challis Bridge to Pennal Gulch transect (mean W_r = 87; Figure 50), though differences in relative weight were not significantly different between transects (ANOVA: $F_{3, 42}$ = 1.34, P = 0.27). Rainbow Trout lengths ranged from 163 to 438 mm and averaged 299 mm (± 20.8 mm) over the 41 km reach (Table 19; Figure 48). Average RBT length was similar between the Challis Bridge to Pennal Gulch transect (mean = 352 ± 49.9 mm) and Pennal Gulch to Watts Bridge transect (mean = 350 ± 20.2 mm), but approximately 45% lower in the Deadman to Bayhorse transect (mean = 194 ± 10.1 mm; Table 19; Figure 48). Overall RBT PSD was 31% (Table 20). Rainbow Trout relative weights ranged from 52 to 109 (mean W_r = 81) and were not significantly different between transects (ANOVA: $F_{2, 17}$ = 0.3, P = 0.75; Figure 51). Bull Trout total lengths ranged from 206 to 772 and averaged 460 mm (± 24.7 mm; Table 1; Figure 48). Bull Trout PSD was 90%, PSD-P was 15%, and PSD-M was 10% across the entire reach (Table 20). Mean BLT relative weights ranged from 77 to 100 (mean W_r = 84) and did not differ significantly between transects (ANOVA: $F_{3, 15}$ = 1.05, P = 0.40; Figure 52). Total lengths of Rainbow Trout x Westslope Cutthroat Trout hybrids ranged from 227 to 507 mm (mean = 320 ± 44.3 mm) and were largest on average in the EFSR to Deadman transect. Chinook Salmon parr fork lengths averaged 109 mm (± 2.2 mm; range = 103 to 120 mm) over the four transects. Mountain Whitefish total lengths ranged from 121 to 506 mm and averaged 337 mm (± 2.6 mm) throughout the entire reach. Average MWF TL was slightly higher from Pennal Gulch to Watts Bridge (mean TL = 345 ± 4.6 mm), but relatively consistent across all transects (Table 19; Figure 49). Mountain Whitefish relative weights were not significantly different between transects (ANOVA: $F_{3, 392}$ = 1.14, P = 0.33; Figure 53).

We distributed 64 non-reward T-bar anchor tags over the four electrofishing transects. Species composition of tagged fish was 70% WCT (n = 45), 20% RBT (n = 13), and 10% RBT x WCT (n = 6). Tagged fish ranged in TL from 229 to 507 mm and averaged 333 mm. As of January 12, 2024, only one fish tagged during the 2022 surveys had been reported as being caught in the IDFG Tag! You're It! online database. A WCT originally tagged in the EFSR to Deadman transect on October 25, 2022 was caught and released on November 22, 2022 below the Bayhorse Creek outlet. Cumulative year-one angler use estimates for all three species were <1%.

DISCUSSION

Fish species composition and relative abundance was notably consistent across transects, but somewhat inconsistent with past survey results. WCT had the highest relative abundance of resident trout species throughout all transects in 2022. This aligns with previous surveys conducted on the upper Salmon River, where catch rates of WCT commonly exceeded CPUE of BLT and adult RBT (>300 mm; Messner 2017, 2018, 2019). Westslope Cutthroat Trout catch rates observed in trend transects in 2022 were relatively consistent with values from previous years (Messner 2017, 2018, 2019) aside from 2016 where mean WCT CPUE was 57% (8.2 fish/hr) greater in the Pennal Gulch to Watts Bridge transect. Unlike previous years, in 2022 we did not separate catch data of RBT between size classes (>300 mm versus <300 mm; Messner 2018, 2019; Estep 2021) for analysis due to the low sample sizes of RBT collected and the difficulty of reliably assigning a life history strategy based on phenotypic traits given the absence of tags or marks. Rainbow Trout less than 300 mm also generally overlap in use of the main stem river and still contribute to the trout fishery. Regardless, relative abundance of RBT in trend transects was lower in 2022 than all previous years (2015-2017). Over the past three surveys, RBT CPUE in the EFSR to Deadman transect ranged from 3.4 to 8.3 fish/hr whereas RBT were not detected in 2022. In the Pennal Gulch to Watts Bridge transect, RBT CPUE was 81% lower in 2022 compared to the most recent survey in 2016 (14.2 fish/hr). Aside from resident fishes, the largest differences in species composition and catch rates were observed for CHK. Chinook Salmon parr were the most abundant fish collected throughout all surveys conducted in 2017 and mean CPUE in the EFSR to Deadman transect exceeded 34 fish/hr (*n* = 481 fish). In 2022, only 9 CHK parr were collected across all four transects. While catch rates of select species in 2022 may warrant concern, observed differences can likely be attributed to survey timing and methodology. Past surveys were conducted using multiple passes over the first three weeks of October. However, results from those surveys determined that recapture rates were low and abundance estimates had wide margins of error due to downstream movements of fish between recapture events. Regional staff then recommended that subsequent surveys be completed with one pass and to use CPUE for monitoring trends in trout abundance. Scheduling logistics delayed main stem electrofishing surveys in 2022 until October 25. Furthermore, descending tributary and mainstem river temperatures are presumed to be one of the primary environmental cues for fish to begin their downstream migrations (Jakober et al. 1998), and the mean river temperature over our survey period was 50% lower than the previous six-year mean temperature over the first three weeks of October (Appendix B; Appendix C). Therefore, we can likely attribute the low numbers of target species encountered in 2022 to missing most of the downstream movement and data resolution differences when using one electrofishing pass versus three. Future survey timing should be standardized to coincide with original survey dates to better compare fish data across years. Consideration should also be given to the spatial scale at which fishery metrics are compared. While similar river transects should be sampled annually, results compiled across the entire river length surveyed compared from year to year will allow for more meaningful comparisons than individual trend transects given that fish are highly migratory during this period and there are no barriers between transects (i.e., open system).

Size structure of the catch in 2022 revealed that resident trout in the main stem Salmon River are achieving sizes that provide quality fishing opportunities. Proportional stock density values for WCT and RBT species were 34 and 31, respectively, suggesting both populations display a balanced population size structure. Bull Trout PSD was markedly high (PSD = 90) and 10% of the BLT catch was of memorable size (≥650 mm). The disproportionate amount of large BLT found in the catch may be partially attributed to the size selectivity of the gear or that BLT juveniles rear and overwinter in habitats not readily surveyed via raft or included in our transects. Nonetheless, while BLT relative abundance is generally lower than WCT and RBT in the upper

Salmon River, they exhibit sizes that are highly desirable for anglers. Length frequency plots displayed very similar length distributions of resident trout compared to previous surveys (Messner 2017, 2018, 2019; Estep 2021). Mean lengths of WCT observed in 2022 were the highest compared to all preceding surveys, regardless of transect, but were generally within 1-2 standard deviations of recorded averages (Messner 2017, 2018, 2019; Estep 2021). Past surveys also generally detected BLT of larger size classes, where individuals <250 mm were detected infrequently (Messner 2017; 2018; Estep 2021). While the range of RBT lengths observed in 2022 was comparable, the length distribution in 2022 was more evenly spread across sizes classes, whereas catch in past years was skewed towards juvenile fish (<250 mm). Mean relative weights were below 100 for all target species, including MWF. While not uncommon compared to previous surveys (Messner 2017; 2018; Estep 2021), all trout visually appeared to be in good body condition. Relative weight may have not been completely representative for BLT and MWF given that adult BLT have presumably spawned within the previous two months and MWF were beginning the spawning process (individuals commonly expressed gametes during body measurements). Since salmonid species collected during main stem surveys routinely have relative weights below the national standard but appear to be in good body condition, it may be that the low conductivity of the upper Salmon River watershed negatively biases condition indices. Regardless, continuing to monitor body condition trends through time will allow for baseline comparisons at the regional scale.

Sampling conducted in 2022 marks the first extensive survey of fluvial MWF populations within the upper Salmon River main stem downstream of the Sawtooth Valley. While MWF may not be the primary target for most anglers, MWF are regulated by IDFG as a game species and typically offer high catch rate fishing opportunities. Relative abundance of MWF in the main stem was exceptionally high. Length distributions displayed balanced population size structure for all transects. Although only a subsample of MWF were measured at each transect, multiple MWF exceeded 500 mm in length and nearly equaled the current Idaho catch and release record (546 mm). Though survey logistics may preclude surveying MWF populations annually, monitoring trends in relative abundance and size structure every five years is recommended.

Tag return rates using the Tag! You're it! program were very low and angler use estimates for all species were near zero. This can likely be attributed to the timing of the surveys and the small sample size of tags compared to the size of the fishery. Tags were deployed late in the year when overall angler effort is dropping due to river conditions (e.g., ice formation). Additionally, river reaches where tags were deployed are further upstream than where fall and winter steelhead anglers generally target. Natural mortality is likely another contributing factor, as fish may have died throughout the biologically stressful winter months (Alexiades et al. 2012) or after the following spring's spawning activity. Since tag reporting rates and use estimates were so low, achieving a larger sample size of tagged fish in 2023 will hopefully allow for more tag returns and improved use estimates.

MANAGEMENT RECOMMENDATIONS

1. Standardize future survey timing to within the first three weeks of October to better compare trend data across years.

2. Continue surveying a consistent spatial extent of the upper Salmon River to improve trend monitoring and data comparisons across years.

3. Continue implanting T-bar anchor tags to increase sample size and obtain angler use estimates of resident trout in the main stem upper Salmon River.

4. Submit WCT fin tissue samples to the Eagle Fish Health and Genetics Lab for Genetic Stock Identification of fluvial WCT compared to nearby tributary samples.

Table 19. Site summaries of catch (n), CPUE (fish/hr), size structure, and body condition for target salmonid species encountered on mainstem upper Salmon River electrofishing surveys conducted in 2022.

Transect	Species	Catch (*n*)	CPUE (fish/hr)	Mean TL (mm; ± SE)	Mean W_r
EFSR to Deadman	Westslope Cutthroat Trout	15	3.5	328.2 (± 16.8)	86
	Rainbow Trout	0	0.0	-	-
	Rainbow Trout x Westslope Cutthroat Trout	2	0.5	383.0 (± 87.0)	-
	Bull Trout	9	2.1	450.0 (± 40.5)	88
	Chinook Salmon	1	0.2	114	-
	Mountain Whitefish	470	108.5	330 (± 5.5)	80
Deadman to Bayhorse	Westslope Cutthroat Trout	6	2.8	379.3 (± 20.5)	78
	Rainbow Trout	6	2.8	194.2 (± 10.1)	80
	Rainbow Trout x Westslope Cutthroat Trout	1	0.5	227	-
	Bull Trout	6	2.8	416.8 (± 30.6)	84
	Chinook Salmon	2	1.0	103.0 (± 0.0)	-
	Mountain Whitefish	132	62.4	331.8 (± 5.7)	77
Challis Bridge to Pennal Gulch	Westslope Cutthroat Trout	11	2.5	313.5 (± 19.5)	87
	Rainbow Trout	3	0.7	352.0 (± 49.9)	81
	Rainbow Trout x Westslope Cutthroat Trout	2	0.5	253.5 (± .05)	-
	Bull Trout	3	0.7	462.0 (± 20.3)	86
	Chinook Salmon	5	1.1	112.0 (± 3.1)	-

Table 19. (continued)

Transect	Species	Catch (n)	CPUE (fish/hr)	Mean TL (mm; ± SE)	Mean W_r
	Mountain Whitefish	776	173.7	338.3 (± 5.1)	77
Pennal Gulch to Watts Bridge	Westslope Cutthroat Trout	15	3.6	309.7 (± 14.4)	82
	Rainbow Trout	11	2.7	349.5 (± 20.2)	85
	Rainbow Trout x Westslope Cutthroat Trout	2	0.5	371.5 (± 135.5)	-
	Bull Trout	2	0.5	603.5 (± 168.5)	77
	Chinook Salmon	1	0.2	105	-
	Mountain Whitefish	999	240.8	345 (± 4.6)	79

Table 20. Proportional stock density indices for Westslope Cutthroat Trout, Rainbow Trout, and Bull Trout observed in electrofishing surveys on the main stem upper Salmon River in 2022.

	Target Species		
PSD Category	Westslope Cutthroat Trout	Rainbow Trout	Bull Trout
PSD	34	31	90
PSD-P	4	0	15
PSD-M	0	0	10

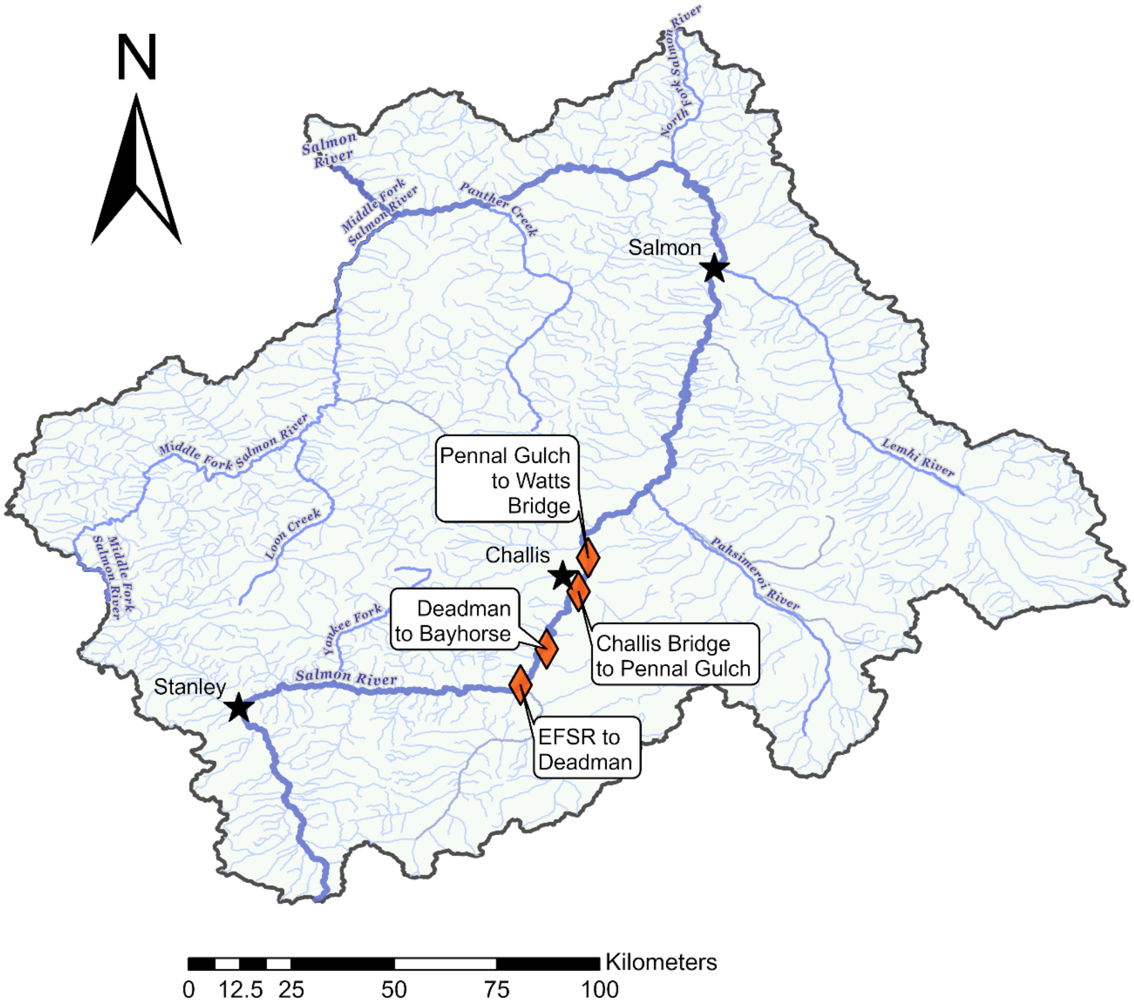

Figure 46. Start locations of four electrofishing transects conducted on the main stem upper Salmon River in 2022.

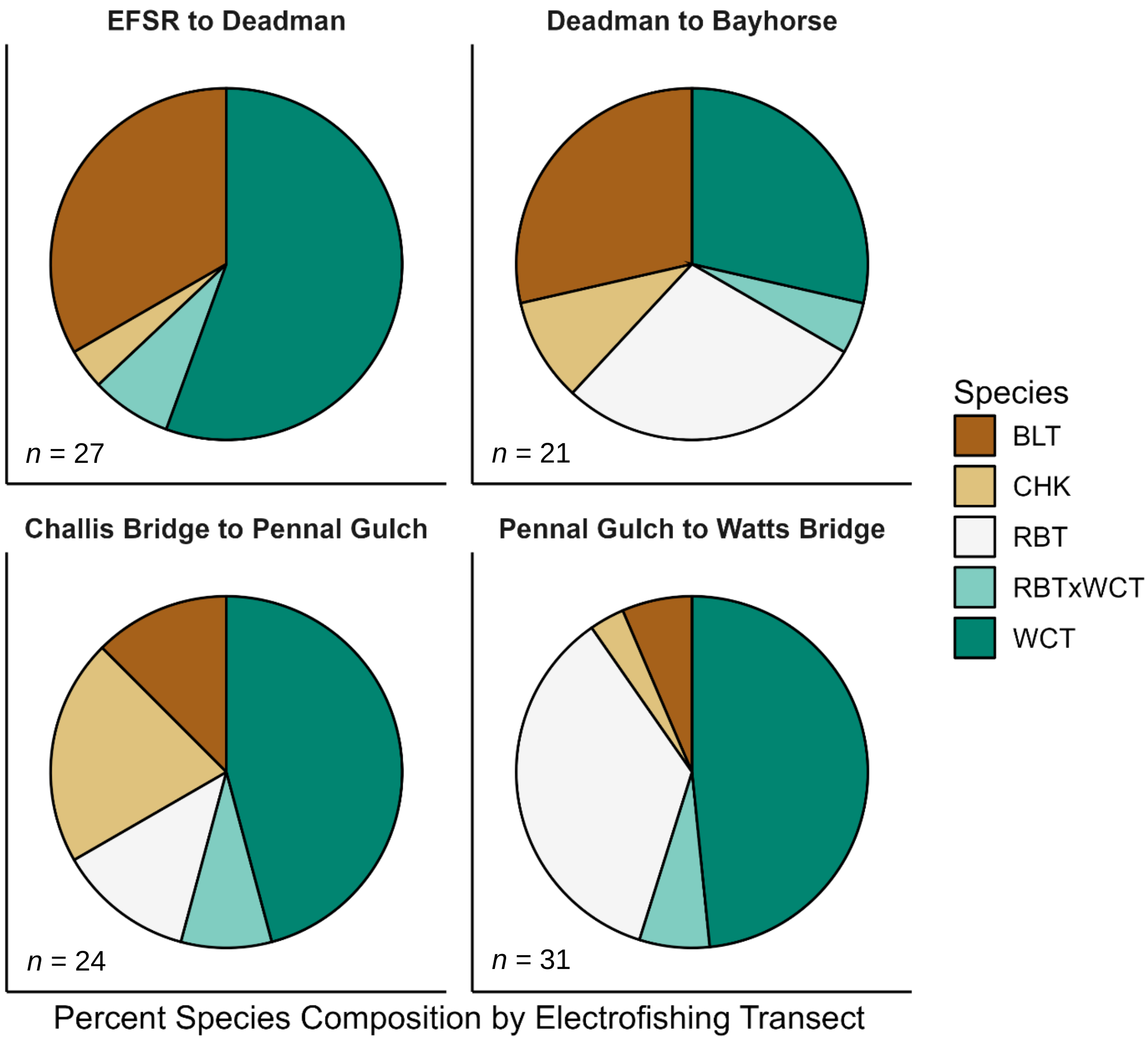

Figure 47. Pie charts demonstrating the percent composition of primary target species (salmonids excluding Mountain Whitefish) observed across four electrofishing transects on the main stem upper Salmon River in 2022. Cumulative samples sizes of primary target species observed within a transect are shown in the bottom left corner of each panel (n). Bull Trout (BLT) are depicted in brown, Chinook salmon (CHK) are shown in tan, Rainbow Trout (RBT) are displayed in white, Rainbow Trout x Westslope Cutthroat Trout hybrids (RBT x WCT) are shown in turquoise, and Westslope Cutthroat Trout are displayed in teal (WCT).

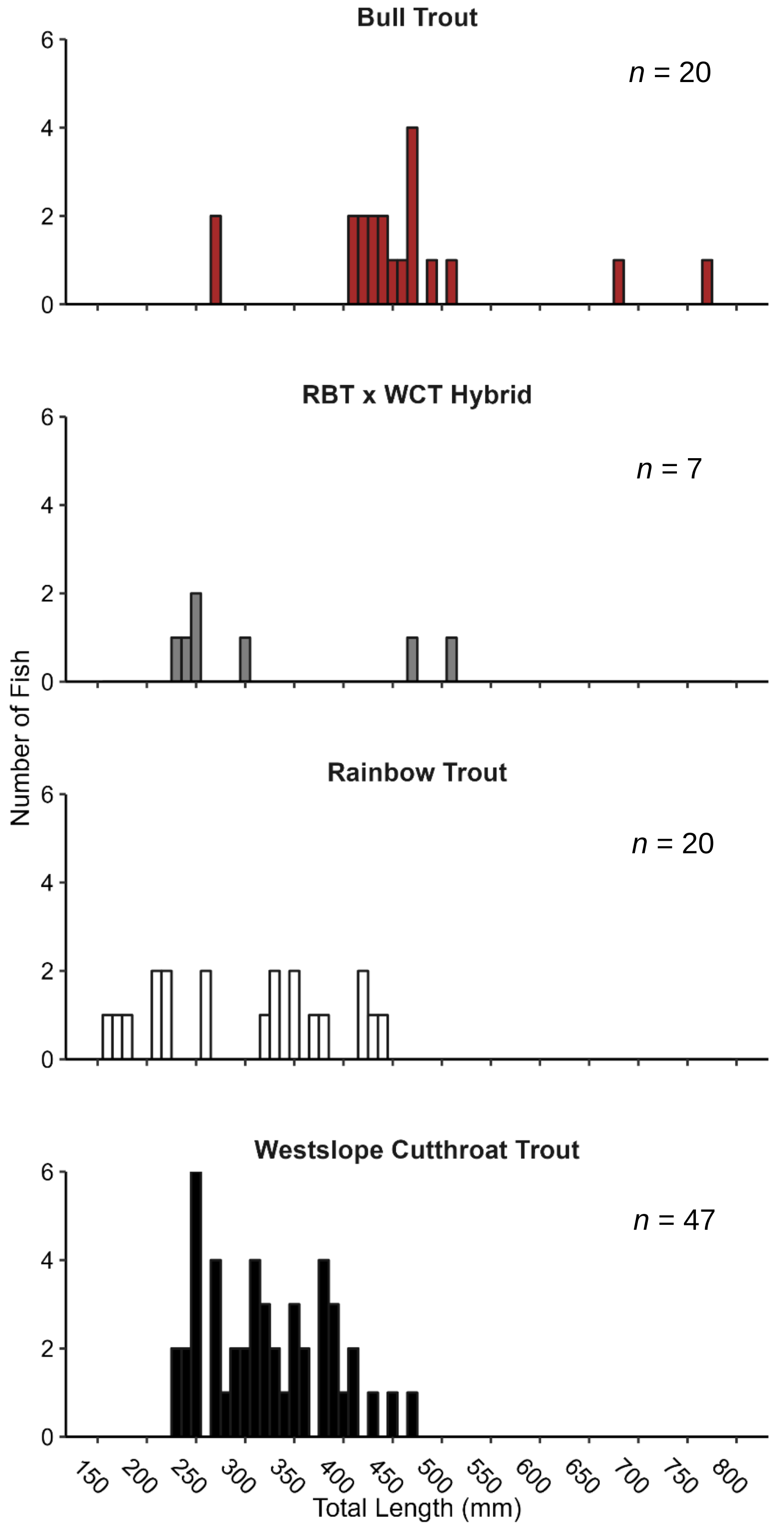

Figure 48. Length frequency histograms of Westslope Cutthroat Trout (black bars), Rainbow Trout (white bars), RBT x WCT hybrids (gray bars), and Bull Trout (brown bars) collected across four electrofishing transects on the main stem upper Salmon River in 2022.

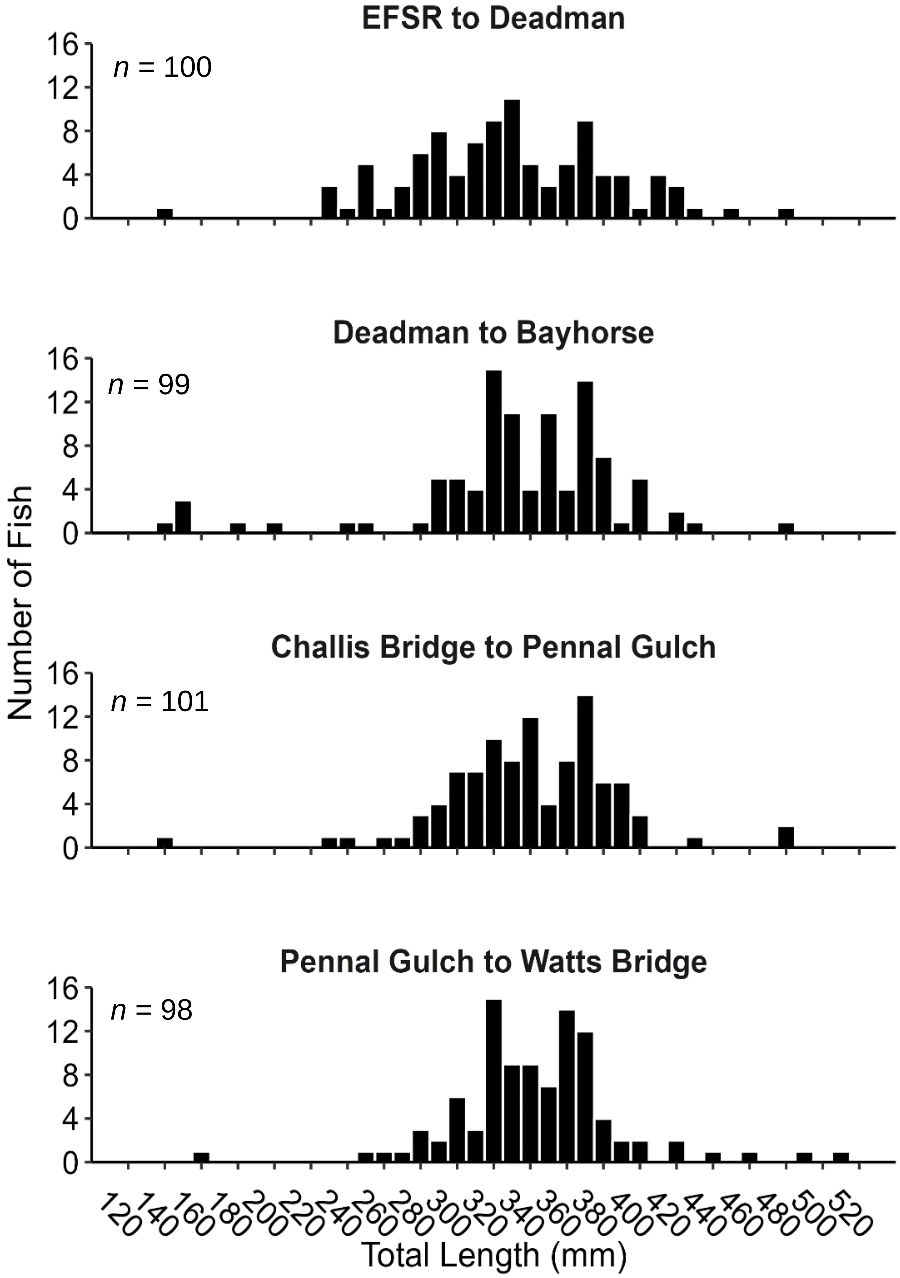

Figure 49. Length frequency histograms of Mountain Whitefish collected in four electrofishing transects on the main stem upper Salmon River in 2022. Samples sizes shown only refer to Mountain Whitefish individuals that were measured (TL) and weighed. See Table 1 for total samples sizes within each transect.

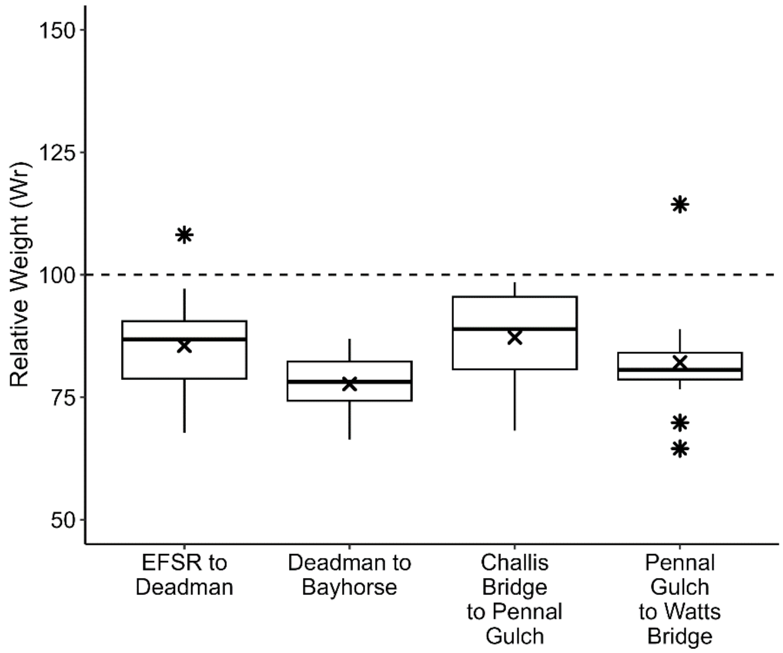

Figure 50. Boxplots displaying the relative weights (W_r) of Westslope Cutthroat Trout caught in the main stem upper Salmon River during electrofishing surveys in 2022. Mean values are depicted by “x” and outliers are denoted by asterisks.

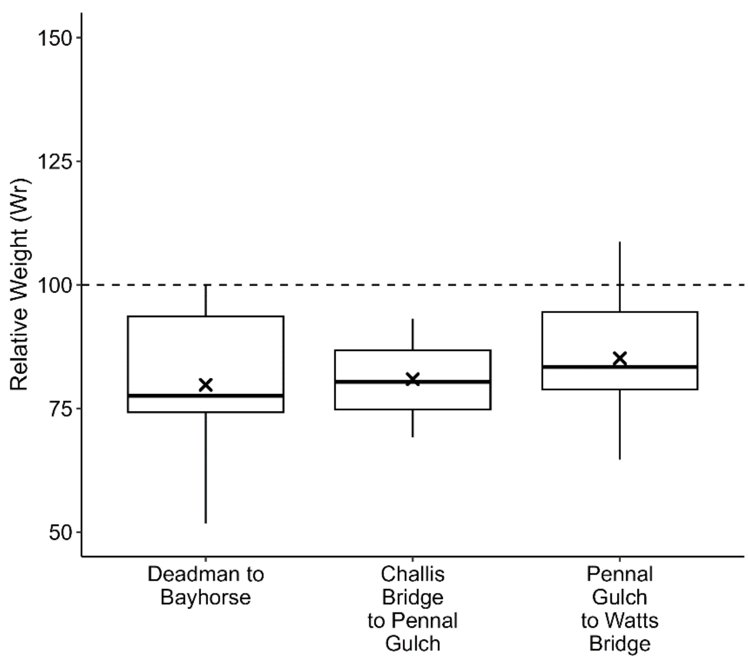

Figure 51. Boxplots displaying the relative weights (W_r) of Rainbow Trout caught in the main stem upper Salmon River during electrofishing surveys in 2022. Mean values are depicted by “x” and outliers are denoted by asterisks.

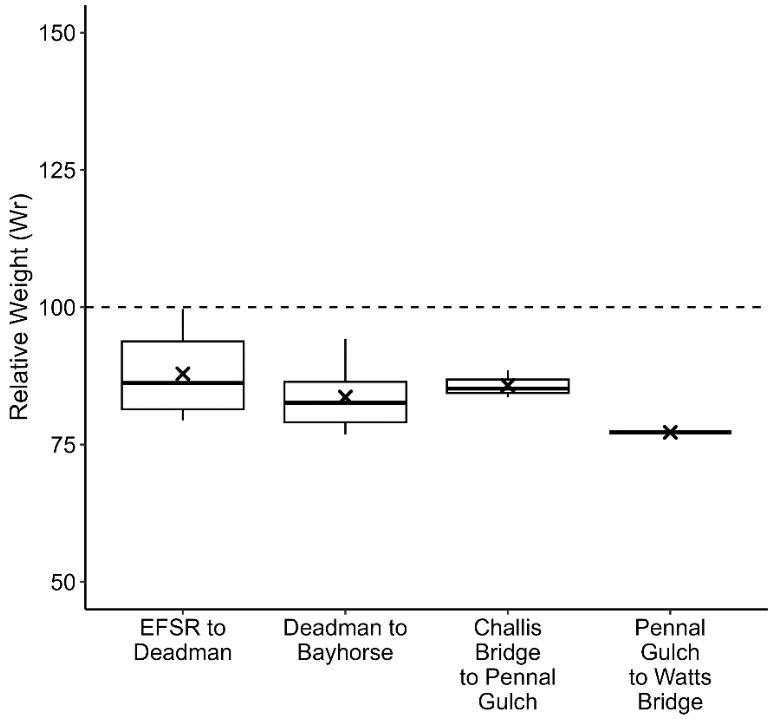

Figure 52. Boxplots displaying the relative weights (W_r) of Bull Trout caught in the main stem upper Salmon River during electrofishing surveys in 2022. Mean values are depicted by “x” and outliers are denoted by asterisks.

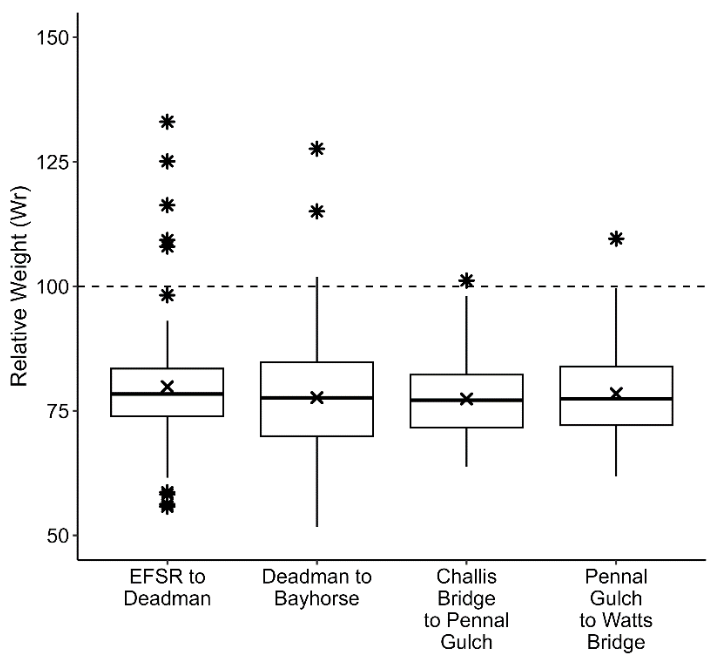

Figure 53. Boxplots displaying the relative weights (W_r) of Mountain Whitefish caught in the main stem upper Salmon River during electrofishing surveys in 2022. Mean values are depicted by “x” and outliers are denoted by asterisks.

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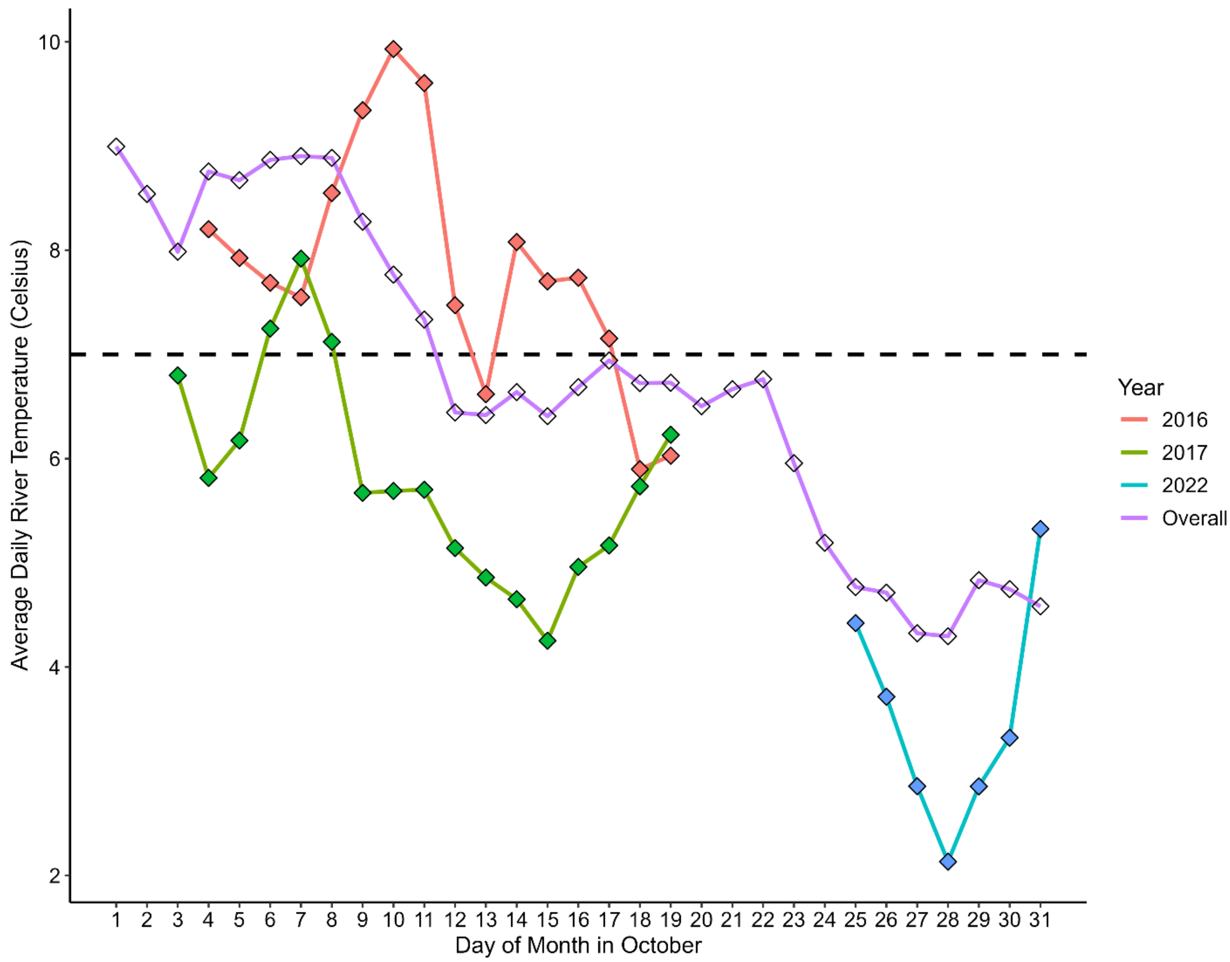
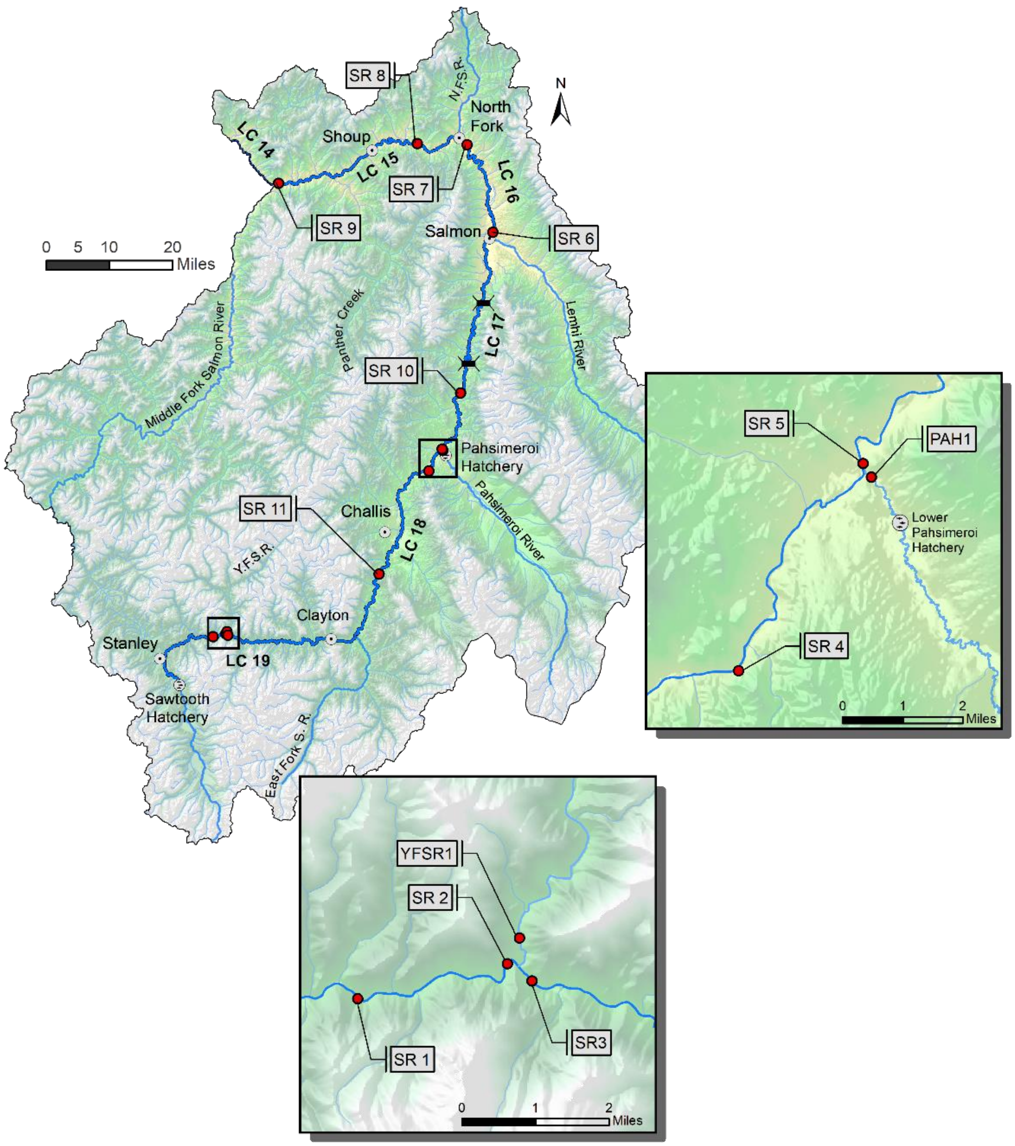
Appendix A. Transect, year established, coordinates (WGS84: datum) and length for resident trout redd count transects in the Salmon Region.

Stream name - Transect	Year established	Start		End		Length (km)
		Latitude (°N)	Longitude (°W)	Latitude (°N)	Longitude (°W)	
Rainbow Trout						
Big Springs Creek - Tyler	1994	44.70896	113.39917	44.72855	113.43430	3.4
Big Springs Creek - Neibaur	1994	44.70047	113.38436	44.70896	113.39917	4.5
Upper Lemhi River - Beyeler	1994	44.68689	113.36273	44.69945	113.37074	3.0
Bull Trout						
Alpine Creek – older (i.e., upper)	1998	43.90705	114.93078	43.90357	114.94457	1.5
Alpine Creek – newer (i.e., lower)	2010	43.89707	114.91327	43.90245	114.92246	1.5
Champion Creek	2019	44.01433	114.78966	44.00883	114.73914	4.5
Fishhook Creek – older (i.e., upper)	1998	44.13706	114.96703	44.13472	114.97622	1.0
Fishhook Creek –newer (i.e., lower)	2008	44.14882	114.93716	44.13992	114.96205	3.5
Fourth of July Creek-older (i.e., upper)	2003	44.04112	114.75831	44.05039	114.69165	5.0
Fourth of July Creek-newer (i.e., lower)	2019	44.02873	114.80093	44.04038	114.75725	5.0
Big Timber (Rocky-Grove)	2007	44.54851	113.41122	44.52067	113.43354	3.6
Big Timber (Upper-Rocky)	2007	44.49912	113.46187	44.52067	113.43354	3.5
Rocky Creek	2007	44.52067	113.43354	44.52937	113.46415	2.7
Hayden Creek- older (i.e., upper)	2005	44.70624	113.73430	44.37053	113.75771	2.5
Hayden Creek – newer (i.e., lower)	2010	44.83938	113.66061	44.77209	113.70842	8.4
Bear Valley Creek – older (i.e., upper)	2007	44.78332	113.75496	44.79685	113.80820	4.7
Bear Valley Creek – newer (i.e., lower)	2002	44.77624	113.74259	44.78332	113.75496	1.7
East Fork Hayden Creek	2002	44.72984	113.67145	44.72438	113.66671	1.5

Appendix B. Average daily river temperature (°C) during the month of October on the upper Salmon River main stem. Years with temperature data displayed as solid points along lines are years when trend electrofishing transects (EFSR to Deadman and Pennal Gulch to Watts Bridge) were surveyed whereas the purple line with hollow points represents average values across all years with data available (2016 to 2022). The red line and points denote data collected in 2016, green denotes 2017, and blue denotes 2022. Daily average values are depicted by diamond points on lines. The black dashed line displays the mean temperature value during the first three weeks of October from 2016 to 2021 to illustrate the previous 5-year average temperature during the original survey period. All temperature data was recorded from the same logging location, located near the Bayhorse Bridge near Challis, ID (SR 11; Appendix C).



Appendix C. Temperature logging locations managed by IDFG throughout the upper Salmon River watershed as of 2022. Map credit to Brent Beller (Pacific States Marine Fisheries Commission).



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