

# IDAHO DEPARTMENT OF FISH AND GAME FISHERY MANAGEMENT ANNUAL REPORT <br> Jim Fredericks, Director 



## MCCALL REGION

2021

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## HIGH MOUNTAIN LAKE SURVEYS

## ABSTRACT

The McCall sub-region of the Idaho Department of Fish and Game (IDFG) surveyed 31 high mountain lakes (HMLs) in 2021. We evaluated species composition, relative abundance, size structure, and amphibian presence in all lakes (Bear Pete, Black, Buck, Center, Coffee Cup, Creek, Crystle, Deep, Doe, Eden, Ellis, French Creek \#1, Hard Butte, Horton, Kenneth, Lower Granite, Lower Twin, Morehead, Morgan, Neal, North, Partridge Creek, Ruth, Shelly Ann's, Slab Butte, Summit, Trail, Twin \#2, Upper Twin, Victor, and Warm Spring Creek lakes). We captured Westslope Cutthroat Trout Oncorhynchus clarki lewisi, Rainbow Trout O. mykiss, Rainbow x Cutthroat hybrids, Brook Trout Salvelinus fontinalis, and Arctic Grayling Thymallus arcticus at the surveyed lakes, with relative abundance ranging from zero to 68 fish caught per net night. Fish presence was documented in all HMLs except Eden, Horton, Lower Granite, Neal, Partridge Creek, and Shelly Ann's lakes. Columbia Spotted Frogs Rana luteiventris and/or Western Toads Anaxyrus boreas were observed at 24 of the 31 surveyed lakes. This survey information will be used to guide our management strategies for HMLs in the McCall sub-region.

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## INTRODUCTION

High mountain lakes (HMLs) provide diverse opportunities for anglers to pursue trout in highly scenic environments. Idaho anglers consistently express a high level of satisfaction with HML fisheries (IDFG 2018). The McCall sub-region currently stocks 165 HMLs on one-to-threeyear rotations with Westslope Cutthroat Trout (WCT), Rainbow Trout (RBT), Golden Trout (GNT) O. aguabonita, and Arctic Grayling (GRA). Brook Trout (BKT) also occur in several HMLs because of historical stocking events.

The purpose of each HML survey is to inform long-term management decisions for each lake or basin. Since HMLs are often difficult to access and require extra effort to sample, surveys are conducted by watershed and stocking rotation to maximize efficiency. Stocked lakes and those with the oldest or least amount of available data are prioritized for sampling. The objective of the McCall subregion is to sample each lake at least once every ten years (IDFG 2021).

The current statewide fisheries management plan (hereafter, "FMP"; 2019-2024) directs fishery managers to strive toward providing diverse HML fishing opportunities while balancing management actions with the long-term persistence of native biota (including amphibians) in each watershed (IDFG 2018). Based on the information collected from these surveys, fishery managers determine if changes in management actions (stocking densities, rotations, harvest regulations) are warranted to improve recreational fishing opportunity and/or maintain native species persistence within each watershed. Additionally, fishery managers may modify or eliminate stocking HMLs where self-sustaining trout populations are identified.

## OBJECTIVES

1. Assess fish presence, species composition, relative abundance, and size structure information from HMLs to guide management actions for these fisheries.
2. Determine if changes in management strategies (stocking density, rotation, harvest regulations) are warranted to improve fishing quality and/or maintain native species persistence.

## STUDY AREAS

The majority of HMLs sampled in 2021 required backcountry travel to access. In addition to information provided below for each lake, Table 1 describes each HML by Hydrologic Unit Code (HUC6), Latitude Longitude Identification Number (LLID), and trail/cross-country distance required to access. Table 2 provides relevant background information for each HML, such as date last surveyed, current stocking rotation, and stocking density (fish/ha). All HMLs surveyed in 2021 are listed below in alphabetical order by river drainage.

## Little Salmon River Drainage

## Black Lake

Black Lake ( $45.18829^{\circ} \mathrm{N},-116.55976^{\circ} \mathrm{W}$ ) is a 10.4-ha lake located at an elevation of 2,200 m approximately 50 km northwest of McCall. The lake is accessed from Black Lake Road after traveling north on Council Cuprum Road. No additional hiking is required.

## Buck Lake

Buck Lake ( $45.23230^{\circ} \mathrm{N},-116.24055^{\circ} \mathrm{W}$ ) is a 6.3-ha lake located at an elevation of 2,098 m approximately 38 km north of McCall. The lake is accessed by hiking 2.2 km cross-country from Hazard Tepee Road 50287.

## Coffee Cup Lake

Coffee Cup Lake ( $45.17074^{\circ} \mathrm{N},-116.21795^{\circ} \mathrm{W}$ ) is a 2.2-ha lake located at an elevation of 2,232 m approximately 31 km north of McCall. The lake is accessed by hiking the Grass Mountain Trail \#257 (off Hazard Lake Road) for approximately 4.8 km.

## Crystle Lake

Crystle Lake (Paradise Creek Lake \#4; $45.22233^{\circ} \mathrm{N},-116.55412^{\circ} \mathrm{W}$ ) is a 3.7 -ha lake located at an elevation of 2,473 m approximately 37 km northwest of McCall. The lake is accessed by hiking the Rankin Mill Trail (off Black Lake Road) for approximately 9.7 km , before hiking crosscountry for 2.4 km to the lake.

## Doe Lake

Doe Lake $\left(45.23845^{\circ} \mathrm{N},-116.24263^{\circ} \mathrm{W}\right)$ is a 0.4 -ha lake located at an elevation of 2,156 m approximately 38 km north of McCall. The lake is accessed by hiking cross-country for approximately 3.2 km off Hazard Tepee Road 50287. Buck Lake is within 1 km cross-country distance from Doe Lake.

## Morgan Lake

Morgan Lake $\left(45.17379^{\circ} \mathrm{N},-116.24400^{\circ} \mathrm{W}\right)$ is a 1.7 -ha lake located at an elevation of $1,898 \mathrm{~m}$ approximately 32 km north of McCall. The lake is accessed by hiking the Grass Mountain Trail \#257 (off Hazard Lake Road) for 7.2 km .

## Neal Lake

Neal Lake ( $45.08742^{\circ} \mathrm{N},-116.15108^{\circ} \mathrm{W}$ ) is a 1.3-ha lake located at an elevation of 2,192 m approximately 21 km north of McCall. The lake is accessed by hiking 3.2 km cross-country off Hazard Lake Road (on eastern side of Goose Lake).

## Ruth Lake

Ruth Lake $\left(45.24168^{\circ} \mathrm{N},-116.55663^{\circ} \mathrm{W}\right)$ is a 3.5 -ha lake located at an elevation of 2,217 m approximately 52 km northwest of McCall. The lake is accessed by hiking 9.7 km on the Rankin Mill Trail (off Black Lake Road), then by hiking 5.0 km on the Carbonate Hill Trail.

## Slab Butte Lake

Slab Butte Lake ( $45.09086^{\circ} \mathrm{N},-116.13654^{\circ} \mathrm{W}$ ) is a 1.4-ha lake located at an elevation of $2,300 \mathrm{~m}$ approximately 21 km north of McCall. The lake is accessed by hiking 4.8 km crosscountry off Hazard Lake Road (near eastern side of Goose Lake).

## Twin Lake \#2

Twin Lake \#2 $\left(45.15363^{\circ} \mathrm{N},-116.51997^{\circ} \mathrm{W}\right)$ is a 2.6 -ha lake located at an elevation of 2,096 m approximately 43 km northwest of McCall. The lake is accessed by hiking 8 km on the Echols Ridge Trail (off Black Lake Road).

## Middle Fork Salmon River Drainage

## Morehead Lake

Morehead Lake ( $44.57941^{\circ} \mathrm{N},-115.33658^{\circ} \mathrm{W}$ ) is a 3.3-ha lake located at an elevation of $2,280 \mathrm{~m}$ approximately 71 km southeast of McCall. The lake is accessed by hiking approximately 14 km cross-country (faint user-trail) off the Artillery Dome Road.

## Mainstem Salmon River Drainage

## Center Lake

Center Lake ( $45.23468^{\circ} \mathrm{N},-116.05619^{\circ} \mathrm{W}$ ) is a 0.6 -ha lake located at an elevation of 2,030 m approximately 37 km north of McCall. The lake is accessed by hiking the Center Ridge Trail (off Warren Wagon Road) for approximately 6.5 km before hiking cross-country for 1.6 km to the lake.

## Eden Lake

Eden Lake ( $45.24347^{\circ} \mathrm{N},-116.20533^{\circ} \mathrm{W}$ ) is a 0.2-ha lake located at an elevation of 2,305 m approximately 39 km north of McCall. The lake is accessed by hiking the Hard Butte and Partridge Creek Trails (off Hazard Lake Road) for approximately 8 km .

## French Creek Lake \#1

French Creek Lake \#1 $\left(45.18070^{\circ} \mathrm{N},-116.07113^{\circ} \mathrm{W}\right)$ is a 2.8 -ha lake located at an elevation of $2,313 \mathrm{~m}$ approximately 30 km north of McCall. The lake is accessed by hiking crosscountry 8.1 km from Fisher Creek Saddle.

## Hard Butte Lake

Hard Butte Lake ( $45.26549^{\circ} \mathrm{N},-116.20953^{\circ} \mathrm{W}$ ) is a 1.7 -ha lake located at an elevation of $2,374 \mathrm{~m}$ approximately 40 km north of McCall. The lake is accessed by hiking the Hard Butte Trail (off Hazard Lake Road) for approximately 4.8 km .

## Kenneth Lake

Kenneth Lake $\left(45.21764^{\circ} \mathrm{N},-116.11768^{\circ} \mathrm{W}\right)$ is a 0.6 -ha lake located at an elevation of $2,251 \mathrm{~m}$ approximately 35 km north of McCall. The lake is accessed by hiking a 0.8 km heavily used trail off Elk Meadows Road 50308.

Lower Twin Lake
Lower Twin Lake $\left(45.26913^{\circ} \mathrm{N},-116.20190^{\circ} \mathrm{W}\right)$ is a 1.3-ha lake located at an elevation of $2,326 \mathrm{~m}$ approximately 40 km north of McCall. The lake is accessed by hiking 3.4 km on the Hard Butte Trail (off Hazard Lake Road). Lower Twin Lake is within 400 m of Upper Twin Lake.

## Partridge Creek Lake

Partridge Creek Lake ( $45.27564^{\circ} \mathrm{N},-116.19926^{\circ} \mathrm{W}$ ) is a 1.1 -ha lake located at an elevation of $2,192 \mathrm{~m}$ approximately 42 km north of McCall. The lake is accessed by hiking 5.6 km on the Hard Butte and Partridge Creek Trails (off Hazard Lake Road).

## Upper Twin Lake

Upper Twin Lake $\left(45.26812^{\circ} \mathrm{N},-116.20750^{\circ} \mathrm{W}\right)$ is a 2.7 -ha lake located at an elevation of 2,361 m approximately 40 km north of McCall. The lake is accessed by hiking 3.9 km on the Hard Butte Trail (off Hazard Lake Road). The lake is within 400 m cross-country of Lower Twin Lake.

## Warm Spring Creek Lake

Warm Spring Creek Lake ( $45.26259^{\circ} \mathrm{N},-116.19872^{\circ} \mathrm{W}$ ) is a 0.7 -ha lake located at an elevation of 2,326 m approximately 41 km north of McCall. The lake is accessed by hiking 4.0 km on the Hard Butte Trail (off Hazard Lake Road). The lake is within 400 m cross-country of Hard Butte Lake.

## North Fork Payette River Drainage

## Deep Lake

Deep Lake ( $45.16454^{\circ} \mathrm{N},-115.93191^{\circ} \mathrm{W}$ ) is a 12.8 -ha lake located at an elevation of 2,239 m approximately 31 km north of McCall. The lake is accessed by hiking the Deep Lake Trail (off Warren Wagon Road) for approximately 1.6 km .

Ellis Lake
Ellis Lake $\left(45.12869^{\circ} \mathrm{N},-116.09542^{\circ} \mathrm{W}\right)$ is a 1.5 -ha lake located at an elevation of 2,278 m approximately 24 km north of McCall. The lake is accessed by hiking cross-country approximately 2.6 km from the Deep Creek Trailhead (off Granite Lake Road near Granite Lake).

## Horton Lake

Horton Lake $\left(45.12905^{\circ} \mathrm{N},-116.08632^{\circ} \mathrm{W}\right)$ is a 1.5 -ha lake located at an elevation of 2,263 m approximately 24 km north of McCall. The lake is accessed by hiking the Deep Creek Trailhead (off Granite Lake Road near Granite Lake) cross-country for 3 km .

## Lower Granite Lake

Lower Granite Lake $\left(45.11909^{\circ} \mathrm{N},-116.09611^{\circ} \mathrm{W}\right)$ is a 2.1 -ha lake located at an elevation of $2,170 \mathrm{~m}$ approximately 23 km north of McCall. The lake is accessed by hiking the Deep Creek Trailhead (off Granite Lake Road near Granite Lake) cross-country for 1.5 km .

## South Fork Salmon River Drainage

## Bear Pete Lake

Bear Pete Lake $\left(45.30753^{\circ} \mathrm{N},-115.95600^{\circ} \mathrm{W}\right.$ ) is a 1.8 -ha lake located at an elevation of $2,080 \mathrm{~m}$ approximately 45 km north of McCall. The lake is accessed by hiking the Bear Pete Ridge Trail (off Burgdorf/French Creek Road 50246) for approximately 6.4 km before hiking crosscountry for approximately 1.6 km to the lake.

## Creek Lake

Creek Lake ( $45.32729^{\circ} \mathrm{N},-115.97360^{\circ} \mathrm{W}$ ) is a 2.4-ha lake located at an elevation of 2,326 m approximately 48 km north of McCall. The lake is accessed by hiking the Bear Pete Ridge Trail (off Burgdorf/French Creek Road 50246) for approximately 4.3 km , before hiking cross-country for 0.6 km to the lake.

## North Lake

North Lake $\left(45.14707^{\circ} \mathrm{N},-115.91458^{\circ} \mathrm{W}\right)$ is a 2.7-ha lake located at an elevation of 2,359 m approximately 31 km north of McCall. The lake is accessed by hiking the Victor Creek Trail (off Warren Wagon Road) for 6.4 km before hiking cross-country 1.6 km to the lake.

## Shelly Ann's Lake

Shelly Ann's Lake ( $45.34676{ }^{\circ} \mathrm{N},-115.96929^{\circ} \mathrm{W}$ ) is a 1.1-ha lake located at an elevation of $2,155 \mathrm{~m}$ approximately 48 km north of McCall. The lake is accessed by hiking 2.4 km crosscountry from the Bear Pete Ridge trailhead (off Burgdorf/French Creek Road 50246).

## Summit Lake

Summit Lake $\left(45.17087^{\circ} \mathrm{N},-115.91360^{\circ} \mathrm{W}\right)$ is a 6.6 -ha lake located at an elevation of 2,348 m approximately 33 km north of McCall. The lake is accessed by hiking 1.6 km crosscountry from Deep Lake. The trailhead can be found off Warren Wagon Road.

Trail Lake
Trail Lake ( $45.15781^{\circ} \mathrm{N},-115.94112^{\circ} \mathrm{W}$ ) is a 3.6 -ha lake located at an elevation of 2,252 m approximately 32 km north of McCall. The lake is accessed by hiking 1.6 km cross-country from Deep Lake. The trailhead can be found off Warren Wagon Road.

## Victor Lake

Victor Lake ( $45.14857^{\circ} \mathrm{N},-115.90009^{\circ} \mathrm{W}$ ) is a 5.2-ha lake located at an elevation of 2,226 m approximately 32 km north of McCall. The lake is accessed by hiking 6.4 km on the Victor Creek Trail (off Warren Wagon Road), followed by hiking 3.2 km cross-country.

## METHODS

All HMLs were sampled with one sinking and one floating Swedish backpacking-style monofilament gill net set overnight, unless otherwise specified. Each gill net was 36 m long by 1.8 m deep composed of 6 panels (10.0-, 12.5-, 18.5-, 25.0-, 33.0-, 38.0-mm bar measure). Catch-per-unit-effort (CPUE) was calculated as the number of fish caught per net night. In addition to the netting effort, HMLs were angled from shore or inflatable raft for at least 0.5 h to estimate catch rates when time permitted. Catch rates were further separated by gear type ("spin" gear v. "fly" gear).

All fish captured were identified by species, enumerated, measured (mm; TL), and weighed ( g ). Size structure was summarized using length-frequency histograms and condition of fish was assessed using relative weights ( $W_{r}$ ) for fish larger than 130 mm TL (Simpkins and Hubert 1996; Kruse and Hubert 1997; Hyatt and Hubert 2001). Relative weight was calculated by first using a standard weight (Ws) equation for each species:

$$
\log _{10}\left(W_{s}\right)=a+b * \log _{10}(\text { total length }(\mathrm{mm}))
$$

where $a=$ the intercept value and $b=$ slope derived from Blackwell et al. (2000). The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$
W_{r}=\left(\frac{\text { weight }(\mathrm{g})}{W_{s}}\right) * 100
$$

After setting the nets, a single-person inflatable raft was used to collect water chemistry data (i.e., temperature, pH , conductivity) and to determine the maximum depth of the lake using an electronic depth finder. The perimeter of each lake was walked to visually search for fish and amphibians, assess available spawning substrate, and to determine a relative level of human use (i.e., trails and campsites). Relative human use was assessed as low (i.e., no campsites or trails), moderate (i.e., campsite and trail around lake perimeter), or high (i.e., multiple campsites, worn trails, and proximity to trailhead or road). A modified timed visual encounter survey (VES; Crump and Scott 1994) was used to determine the presence of amphibians (i.e., Columbia Spotted Frog, Western Toad, and Long-Toed Salamander Ambystoma macrodactylum) at each lake.

## RESULTS AND DISCUSSION

In 2021, we surveyed a total of 31 HMLs in the McCall sub-region. Lake survey history (last surveyed, stocking rotation and density, current species observations) has been summarized in Table 2. Lake biological data (species, relative abundance, body condition) has been summarized in Table 3. Lake physio-chemical (i.e., max depth, total spawning area and suitability) and amphibian presence has been summarized in Table 4. Additional information (catch statistics and management recommendations) for each lake is provided below.

## Little Salmon River Drainage

## Black Lake

We caught a total of six RBT in a paired gill net set at Black Lake in 2021 (CPUE = 6; Table 3). Lengths ranged from 120 to 400 mm (mean $=302 \mathrm{~mm}$ ) and mean relative weight was 55 (range = 41 to 67; Table 3; Figure 1). One angler fished for two h with artificial flies and caught two fish ( 1 fish $/ \mathrm{h}$ ). The lake is very deep ( max depth $=38.1 \mathrm{~m}$ ) and contains a large amount of high-quality spawning substrate near the inlet. We did not observe any amphibians at Black Lake (Table 4).

Black Lake is an example of a successful BKT removal project conducted by IDFG in 2007 (Koenig et al. 2015). Prior to stocking tiger muskellunge Esox masquinongy x Esox Lucius and following up with chemical treatment of tributaries, Black Lake supported a highly abundant, naturally reproducing BKT population with stunted growth. Following the removal efforts, the lake has been stocked on a mostly annual basis with approximately 5,000 RBT fingerlings. The results of our survey in 2021 confirm that the fishery is now comprised of RBT. While some RBT are surviving, they appear to be in poor body condition (mean $W_{r}=55$ ). Our low catch rates (CPUE $=3$ ) could be partially attributed to the size of the lake. Black Lake was the largest HML sampled in 2021 ( 10.2 ha ) and future surveys may benefit by employing additional nets to increase sample size. We recommend sampling Black Lake again within the next five years to evaluate if body condition and catch rates improve. We do not recommend a change to the current stocking density and rotation.

## Buck Lake

We caught a total of 17 BKT in a paired gill net set at Buck Lake in 2021 (CPUE = 17; Table 3). Lengths of BKT ranged from 215 to 290 mm (mean $=259 \mathrm{~mm}$ ) and mean relative weight was 81 (range = 66 to 100; Table 3; Figure 1). Three anglers fished with artificial flies for a combined effort of 4.5 h and caught 7 fish ( $1.6 \mathrm{fish} / \mathrm{h}$ ). We recorded a maximum depth of 17.1 m
and a small amount ( $\sim 2 \mathrm{~m}^{2}$ ) of suitable spawning substrate along the shoreline. We did not observe any amphibians at the lake (Table 4).

Buck Lake was last surveyed in 1993 and has not been stocked for over a decade. Although the exact date and method of introduction is unknown, Buck Lake supports an established BKT population. Although spawning substrate is present, natural reproduction is probably limited since overall size structure and body condition of BKT are relatively high. Buck Lake currently provides an opportunity for anglers to catch good numbers of quality sized BKT. Therefore, we do not recommend any changes to current management strategies for Buck Lake.

## Coffee Cup Lake

We caught a total of 12 fish of 2 species ( $50 \%$ WCT and $50 \%$ GRA) in a paired gill net set at Coffee Cup Lake in 2021 (CPUE = 12; Table 3). We caught six WCT that ranged in length from 308 to 370 mm (mean $=343 \mathrm{~mm}$ ) and mean relative weight was 83 (range $=70$ to 95 ; Table 3; Figure 2). We also caught six GRA that ranged in length from 286 to 303 mm (mean = 294 mm ) and mean relative weight was 79 (range $=75$ to 84). Two anglers fished with artificial flies for a combined three hours and caught four fish ( 1.3 fish $/ \mathrm{h}$ ). The lake is relatively shallow (max depth $=7.6 \mathrm{~m}$ ) and we did not observe any suitable spawning habitat along the shoreline. Columbia Spotted frogs were observed (Table 4).

Coffee Cup Lake is accessible (<5 km from trailhead) and appears to provide a unique, high quality (in terms of size structure) fishing opportunity for WCT and GRA. Based on these observations, we do not recommend any changes to the current stocking density or rotation.

## Crystle Lake

We caught a total of 20 fish of three species ( $15 \%$ WCT, $35 \%$ RBT, and $50 \%$ RBTxWCT) in a paired gill net set at Crystle Lake in 2021 (CPUE = 20; Table 3). We captured three WCT that ranged in length from 330 to 370 mm (mean $=350 \mathrm{~mm}$ ) and mean relative weight was 62 (range $=47$ to 76 ). We captured seven RBT that ranged in length from 260 to 330 mm (mean $=297 \mathrm{~mm}$ ) and mean relative weight was 80 (range $=70$ to 89). We also caught 10 RBTxWCT that ranged in length from 80 to 410 mm (mean = 195 mm ; Table 3; Figure 2). Two anglers fished with artificial flies for 2.5 h and caught 22 fish ( 8.8 fish $/ \mathrm{h}$ ). We recorded a maximum depth of 9.8 m and observed approximately $20 \mathrm{~m}^{2}$ of quality spawning substrate along the shoreline. Western Toads were observed (Table 4).

Although Crystle Lake is relatively far from the trailhead ( $\sim 12 \mathrm{~km}$ ), the majority of the trail is accessible by ATV-use and the lake appears to receive a lot of angling-use (Table 1). Results from our survey suggest that natural reproduction has been occurring in Crystle Lake, since RBT have not been stocked since 2008 and the majority of fish collected were RBT or RBTxWCT ( $85 \%$ ). These naturally reproducing RBT and RBTxWCT hybrids appear to be performing well in the lake in terms of abundance and growth. Since natural reproduction is occurring, stocked WCT are being outcompeted against, and overall body condition of all fish was relatively poor, we recommend that managers discontinue stocking WCT in Crystle Lake and allow natural reproduction to sustain the fishery.

## Doe Lake

We did not set gill nets in Doe Lake in 2021. Prior to 2021, there was no fishery data available for Doe Lake. Due to its close proximity to Buck Lake, we assessed fish presence via an angling survey; three anglers fished with artificial flies for a combined effort of 3 h and caught 2 BKT ( 0.6 fish/h; Table 3). We observed a small amount ( $\sim 5 \mathrm{~m}^{2}$ ) of suitable spawning substrate
along the shoreline. We also observed both Columbia Spotted frogs and Western Toads (Table 4).

Doe Lake is in close proximity to Buck Lake which also contains BKT. With no prior survey data, we do not recommend any changes to current management strategies for Doe Lake.

## Morgan Lake

We caught a total of 5 WCT in a paired gill net set at Morgan Lake in 2021 (CPUE = 5; Table 3). Lengths of WCT ranged from 132 to 410 mm (mean $=343 \mathrm{~mm}$ ) and mean relative weight was 131 (range $=85$ to 151 ; Table 3; Figure 3). Two anglers fished with artificial flies for a combined 2 h of effort and did not catch a fish. We recorded a maximum depth of 13.7 m and did not observe any suitable spawning substrate along the shoreline. Columbia Spotted frogs were observed (Table 4).

Morgan Lake was last surveyed in 2003. Prior to that survey, the lake was stocked with 1000 WCT in 2001 (compared to 400 WCT in 2020). Even though stocking density was higher, relative abundance was similarly low in both surveys (2003 and 2021). In our 2021 survey we observed overall good body condition and size structure. Therefore, we do not recommend any changes to stocking density or rotation.

## Neal Lake

We did not capture any fish in the paired gill net set at Neal Lake in 2021. The lake was last stocked in 1992 with WCT. We recorded a maximum depth of 2.2 m and did not observe any suitable spawning substrate. Columbia Spotted frogs were observed (Table 4).

Neal Lake is shallow (max depth $=2.2 \mathrm{~m}$ ) and likely experiences temporary anoxia during the winter season that results in winterkill. This lake was removed from the stocking rotation in 1992, and we do not recommend any changes to current management strategies for Neal Lake.

## Ruth Lake

We did not conduct a gill netting survey at Ruth Lake in 2021. Catch data from the most recent survey (2006) showed the presence of BKT in relatively high abundance. Therefore, we evaluated fish presence by conducting an angling survey. One angler fished with artificial flies for one hour and caught eight BKT ( 8 fish/h). We recorded a maximum depth of 12.4 m and observed a large amount ( $\sim 20 \mathrm{~m}^{2}$ ) of high-quality spawning substrate. Columbia Spotted frogs were observed (Table 4).

This lake is difficult to access and appears to receive very little use. We observed BKT up to 284 mm and the lake produced very high angling catch rates. Therefore, we do not recommend any changes to current management strategies for Ruth Lake.

## Slab Butte Lake

We caught a total of 5 WCT in a paired gill net set at Slab Butte Lake in 2021 (CPUE = 5; Table 3). Lengths of WCT ranged from 85 to 390 mm (mean $=288 \mathrm{~mm}$ ) and mean relative weight was 83 (range = 63 to 105; Table 3; Figure 4). Two anglers fished for a combined effort of 3 h and caught 1 fish ( 0.3 fish/h). The lake is relatively shallow (max depth $=3.4 \mathrm{~m}$ ), and we observed a relatively large amount ( $\sim 30 \mathrm{~m}^{2}$ ) of high-quality spawning substrate. We observed both Columbia Spotted frogs and Western Toads at the lake (Table 4).

Although GNT have been stocked since 1996, they have not been observed in recent fishery surveys (2005 and 2021). Although natural reproduction is possible in Slab Butte Lake,
size structure of the fish we caught (mean length $=288 \mathrm{~mm}$ and mean $\mathrm{W}_{\mathrm{r}}=83$ ) indicates natural reproduction rate is not high. Stocking should be continued at this lake to maintain the fishery, but we recommend that managers discontinue stocking GNT and maintain the current stocking density and rotation of WCT only.

## Twin Lake \#2

We caught a total of 4 BKT in a paired gill net set at Twin Lake \#2 in 2021 (CPUE = 4; Table 3). Lengths of BKT ranged from 240 to 260 mm (mean $=250 \mathrm{~mm}$ ) and mean relative weight was 71 (range = 61 to 83; Table 3; Figure 4). One angler fished with artificial flies for one hour and caught five fish ( 5 fish $/ \mathrm{h}$ ). We recorded a maximum depth of 10.5 m and observed approximately $20 \mathrm{~m}^{2}$ of suitable spawning substrate. Western Toads were observed (Table 4).

Although 500 WCT are stocked every three years in Twin Lake \#2, we did not observe any in our gill net catch. However, a single WCT was observed from the shoreline. Based on these observations, we recommend managers discontinue stocking WCT in Twin Lake \#2.

## Mainstem Salmon River Drainage

## Center Lake

We caught a total of 13 WCT in a paired gill net set in Center Lake in 2021 (CPUE = 13; Table 3). Lengths ranged from 126 to 265 (mean $=186 \mathrm{~mm}$ ) and mean relative weight was 83 (range $=76$ to 91 ; Table 3; Figure 5). Two anglers fished with artificial flies for a combined 2.5 h and caught 8 fish ( 3.2 fish $/ \mathrm{h}$ ). The lake is relatively shallow ( max depth $=8.2 \mathrm{~m}$ ), and we did not observe any suitable spawning habitat along the shoreline. Columbia Spotted frogs were observed (Table 4).

Center Lake was last surveyed in 1991 (Table 2). The lake is relatively difficult to access ( $>8 \mathrm{~km}$ from trailhead), appears to receive little angling-use, and appears to contain no spawning substrate suitable to support natural reproduction. Therefore, to improve growth conditions and size structure, we recommend changing the current stocking rotation from 500 WCT every other year to 500 WCT every three years. Center Lake should be surveyed within the next five years to evaluate the effect of reducing stocking density on overall size structure of WCT.

## Eden Lake

We assessed fish presence or absence at Eden Lake by conducting an angling survey. Two anglers fished with artificial flies for a combined effort of one h and did not catch or observe a fish. However, Columbia Spotted frogs were observed (Table 4).

Eden Lake was last stocked in 2006, with $\sim 1,500$ GRA fingerlings. This lake likely experiences temporary anoxia during the winter season due to its shallow depth ( max depth $=1.8 \mathrm{~m}$ ), which has prevented fish persistence in the absence of stocking. Therefore, we do not recommend any changes to current management strategies at Eden Lake.

## French Creek Lake \#1

We did not conduct a gill net survey in French Creek Lake \#1 in 2021. Instead, two anglers assessed fish presence by fishing with artificial flies and spinning gear (Figure 6). Catch rates were very high ( 7 fish/h and 15 fish $/ \mathrm{h}$ ) using artificial flies and spinning gear, respectively. We recorded a maximum depth of 17.3 m and although natural reproduction appears to be occurring (lake is not currently stocked), we did not observe any suitable spawning substrate along the shoreline or in the inlet or outlet (Table 4).

French Creek Lake \#1 is relatively challenging to access ( 8.1 km cross country hike) and showed little sign of angling-use. However, the lake provides an opportunity for outstanding catch rates for anglers seeking to catch BKT in a highly scenic environment. At this time, we recommend no change to current management strategies for French Creek Lake \#1.

## Hard Butte Lake

We caught a total of 10 fish of two species ( $30 \%$ WCT and $70 \%$ BKT) in a paired gill net set at Hard Butte Lake in 2021 (CPUE = 10; Table 3). We captured three WCT that ranged in lengths from 290 to 293 mm (mean $=292 \mathrm{~mm}$ ) with a mean relative weight of 97 (86 to 102). We also captured seven BKT that ranged in lengths from 107 to 260 mm (mean $=218 \mathrm{~mm}$ ) with a mean relative weight of 83 ( 71 to 94; Table 3; Figure 6). Two anglers fished with artificial flies and spinning gear for a combined effort of three $h$. Catch rates were 1 fish $/ \mathrm{h}$ with artificial flies and 7 fish/h with spinning gear. The lake is relatively shallow (max depth $=3.8 \mathrm{~m}$ ) with a large amount ( $\sim 50 \mathrm{~m}^{2}$ ) of suitable spawning substrate. Columbia Spotted frogs were observed (Table 4).

Natural reproduction is certainly occurring in Hard Butte Lake at least for BKT. Catch rates are very high for both species, but growth does not seem to be impacted; both size structure and relative weights are fair for both WCT and BKT. This lake is easy to access and appears to receive high angling-use. Therefore, we do not recommend any changes to the current stocking density or rotation. However, because Lower Twin Lake (third lake in series) has an intermittent outlet with a very high gradient, fishery managers should consider the feasibility of conducting biological or chemical removal (e.g., rotenone) on Hard Butte, and Upper and Lower Twin Lakes to remove naturally-reproducing BKT and establish new and diverse fishing opportunities in these lakes (i.e., WCT, GRA, and/or GNT).

## Kenneth Lake

We caught a total of 14 WCT in a single paired gill net set at Kenneth Lake in 2021 (CPUE = 14; Table 3). Lengths of WCT ranged from 123 to 334 mm (mean $=175 \mathrm{~mm}$ ) and mean relative weight was 97 (range $=67$ to 134; Table 3; Figure 7). One angler fished with artificial flies for 1 h and caught one fish ( $1 \mathrm{fish} / \mathrm{h}$ ). We recorded a maximum depth of 7.6 m and did not observe any suitable spawning substrate along the shoreline. We did not observe any amphibians at Kenneth Lake (Table 4).

Kenneth Lake was last sampled in 1990 and results suggested the lake was fishless. A recommendation was made to resume stocking Kenneth Lake beginning that year. Since 1994, the department has stocked 500 WCT every other year in the lake. Kenneth Lake is very accessible ( 0.8 km ) and appears to receive high angling-use (hooking scars observed on multiple fish). Therefore, we do not recommend any changes to current stocking density and rotation.

## Lower Twin Lake

We caught a total of 64 fish of two species ( $3 \%$ WCT and $97 \%$ BKT) in a paired gill net set at Lower Twin Lake in 2021 (CPUE = 64; Table 3). We caught two WCT that measured 210 and 217 respectively and relative weights were 84 and 87 . We also caught 62 BKT that ranged in lengths from 110 to 240 mm (mean $=176 \mathrm{~mm}$ ) with a mean relative weight of 83 (range $=61$ to 110; Table 3; Figure 7). Two anglers fished with artificial flies and spinning gear for a combined effort of 2 h and each caught 7 fish ( $7 \mathrm{fish} / \mathrm{h}$ ). The lake is relatively shallow (max depth $=3.2 \mathrm{~m}$ ), and we observed a large amount ( $\sim 75 \mathrm{~m}^{2}$ ) of high quality spawning substrate. Both Columbia Spotted frogs and Western Toads were observed (Table 4).

Brook Trout natural reproduction appears to be occurring at a high rate in Lower Twin Lake. We caught very few WCT $(n=2)$ that were relatively small (max length $=217 \mathrm{~mm}$ ) and average in body condition (mean $\mathrm{W}_{\mathrm{r}}=86$ ). Due to easy access and high angling-use, we recommend managing this lake for high catch rates of BKT. Therefore, we recommend that managers discontinue stocking Lower Twin Lake with WCT. Fishery managers should also consider biological or chemical removal of BKT in Lower Twin Lake (see Hard Butte Lake in this chapter).

## Partridge Creek Lake

We did not capture any fish in the paired gill net set at Partridge Creek Lake in 2021. Additionally, two anglers fished with artificial flies for a combined effort of one h and did not catch or observe any fish. We recorded a maximum depth of 3.3 m and a small amount of suitable spawning substrate ( $\sim 10 \mathrm{~m}^{2}$ ). Columbia Spotted frogs were present (Table 4).

Partridge Creek Lake was last stocked in 1972. Partridge Creek Lake is relatively shallow (max depth $=3.3 \mathrm{~m}$ ) and likely experiences temporary anoxia during the winter season that results in winterkill. We do not recommend any changes to current management strategies for Partridge Creek Lake.

## Upper Twin Lake

We caught a total of 51 fish of two species ( $2 \%$ WCT and $98 \%$ BKT) in a paired gill net set at Upper Twin Lake in 2021 (CPUE = 51; Table 3). We caught a single WCT that was 291 mm with a relative weight of 91, and we caught 50 BKT that ranged in lengths from 120 to 252 mm (mean $=202 \mathrm{~mm}$ ) with a mean relative weight of 88 (range = 72 to 113; Table 3; Figure 8). Two anglers fished with artificial flies and spinning gear for a combined effort of 2 h and catch rates were 14 fish $/ \mathrm{h}$ and 4 fish $/ \mathrm{h}$, respectively. We recorded a maximum depth of 6.0 m and observed approximately seven $\mathrm{m}^{2}$ of suitable spawning substrate. Both Columbia Spotted frogs and Western Toads were observed (Table 4).

Upper Twin Lake has not been stocked in many decades, so natural reproduction is solely maintaining this fishery. The single WCT observed likely emigrated from nearby Hard Butte Lake. It appears that natural reproduction is occurring at a high rate in Upper Twin Lake, as evidenced by high catch rates for BKT. Fishery managers should consider biological or chemical removal of BKT in Upper Twin Lake (see Hard Butte Lake in this chapter).

## Warm Spring Creek Lake

We caught a total of 27 WCT in a paired gill net set at Warm Spring Creek Lake in 2021 (CPUE = 27; Table 3). Lengths of WCT ranged from 102 to 312 mm (mean = 208) and mean relative weight was 90 (range = 69 to 144; Table 3; Figure 8). Two anglers fished with artificial flies and spinning gear for a combined effort of 1.5 h . Catch rates with artificial flies was 15 fish $/ \mathrm{h}$ and 22 fish $/ \mathrm{h}$ with spinning gear. The lake was very shallow ( max depth $=1.8 \mathrm{~m}$ ) compared to other lakes surveyed in 2021 and contained a small amount ( $\sim 2 \mathrm{~m}^{2}$ ) of suitable spawning substrate along the shoreline. Columbia Spotted frogs were observed (Table 4).

Although Warm Spring Creek Lake is relatively small and shallow, a small geothermal seep likely allows fish to survive under the ice most years. The lake appears to receive very little use but provides excellent catch rates of WCT in good body condition (mean $W_{r}=90$ ). Therefore, we recommend maintaining the current stocking density and rotation.

## Middle Fork Salmon River Drainage

## Morehead Lake

We caught a total of five WCT in a single paired gill net set at Morehead Lake in 2021 (CPUE = 5; Table 3). Lengths of WCT ranged from 380 to 445 mm (mean = 396 mm ; Table 3; Figure 5). Unfortunately, we were unable to weigh four of the five fish collected due to issues with our spring scale. The lake is relatively deep ( $\max$ depth $=38.5 \mathrm{~m}$ ) and we did not observe any suitable spawning substrate. We did not observe any amphibians at Morehead Lake (Table 4).

Morehead Lake had not been sampled prior to our survey in 2021. Angling-use appears to be driven by hunting outfitters operating in the area. Morehead Lake provides anglers with an opportunity to catch very large WCT in a highly scenic area within the Middle Fork Salmon River drainage. We recommend that fishery managers consider collaborating fish stocking efforts with the hunting outfitters operating in the area to improve survival of fingerling WCT. However, we do not recommend any changes to current stocking density or rotation.

## North Fork Payette River Drainage

## Deep Lake

We caught a total of 26 BKT in a paired gill net set at Deep Lake in 2021 (CPUE = 26; Table 3). Lengths of BKT ranged from 105 to 253 (mean $=185 \mathrm{~mm}$ ) and mean relative weight was 76 (range = 59 to 92; Table 3; Figure 9). We did not conduct an angling survey at Deep Lake. We recorded a maximum depth of 30.7 m and observed a large amount ( $\sim 90 \mathrm{~m}^{2}$ ) of high-quality spawning substrate along the shoreline and within the inlet and outlet. Columbia Spotted frogs were observed (Table 4).

Natural reproduction appears to be occurring at a high rate in Deep Lake, evidenced by poor size structure (max length $=253 \mathrm{~mm}$ ) and body condition (mean $\mathrm{W}_{\mathrm{r}}=76$ ). Deep Lake also appears to receive relatively low angling-use even though it is relatively close ( $\sim 1.6 \mathrm{~km}$ ) to the trailhead. Therefore, we do not recommend any changes to current management strategies for Deep Lake.

## Ellis Lake

We caught a total of 14 WCT in a paired gill net set at Ellis Lake in 2021 (CPUE = 14; Table 3). Lengths of WCT ranged from 100 to 450 mm (mean $=163 \mathrm{~mm}$ ) and mean relative weight was 101 ( 90 to 111; Table 3; Figure 9). Three anglers fished with artificial flies for 1.75 h and did not catch any fish. The lake is relatively shallow ( 5.2 m ), and we did not observe any suitable spawning substrate. Columbia Spotted frogs were present (Table 4).

In our 2021 survey, we observed many fingerling WCT cruising the shoreline (stocked in previous year), indicating high overwinter survival in 2020. Based on lengths of fish collected, it appears that we caught two distinct year classes of fish (2017 and 2020), which suggests that Ellis Lake relies entirely on hatchery stocking. The lack of natural reproduction is likely the reason fish are able to reach such large size and body condition by approximately age-5. Based on these findings, we do not recommend any changes to current stocking density or rotation.

## Horton Lake

We did not capture a fish in the paired gill net set at Horton Lake in 2021. Two anglers also fished with artificial flies for a combined effort of 1.5 h and did not catch or observe a fish.

The lake was last stocked in 2019 and has been stocked with ~500 WCT fingerlings on a threeyear rotation. Prior to our survey, the most recent sampling in 2005 produced four small WCT.

Horton Lake is relatively shallow (max depth $=2.7 \mathrm{~m}$ ), receives little angling-use, and seems to winterkill often. We have never documented fish approaching quality size in this lake. Therefore, we recommend that fishery managers permanently discontinue stocking Horton Lake.

## Lower Granite Lake

We did not capture a fish in the paired gill net set at Lower Granite Lake in 2021. One angler fished with artificial flies for 0.5 h and did not catch or observe a fish either. The lake has not been stocked since 1974 and appears to be fishless. We recorded a maximum depth of 3.2 m and did not observe any spawning substrate. Columbia Spotted frogs were present (Table 4).

Lower Granite Lake is relatively shallow (max depth = 3.2 m ) and likely experiences temporary anoxia during the winter season that results in winterkill. The lake is currently not stocked, and we do not recommend any changes to current management strategies for Lower Granite Lake.

## South Fork Salmon River Drainage

## Bear Pete Lake

We caught a total of 43 BKT using a single sinking gill net set at Bear Pete Lake in 2021 (CPUE = 43; Table 3). Lengths ranged from 93 to 254 mm (mean $=173 \mathrm{~mm}$ ) and mean relative weight was 81 (range = 67 to 101; Table 3; Figure 10). One angler fished with artificial flies for 0.6 h and did not catch any fish. The lake is relatively deep (max depth $=18.2 \mathrm{~m}$ ) and contains a large amount ( $\sim 100 \mathrm{~m}^{2}$ ) of high-quality spawning substrate along the shoreline. Columbia Spotted frogs were present (Table 4).

Although the date and method of introduction is unknown, Bear Pete Lake supports an established BKT fishery. Due to expanses of high-quality spawning substrate along its shoreline, natural reproduction is likely occurring at a high rate. Currently, Bear Pete Lake is not stocked by IDFG, and we recommend no change to current management strategies.

## Creek Lake

We caught a total of 18 WCT in a paired gill net set at Creek Lake in 2021 (CPUE = 18; Table 3). WCT ranged in length from 97 to 380 mm (mean $=217 \mathrm{~mm}$ ) and mean relative weight was 99 (range = 85 to 121; Table 3; Figure 10). One angler fished with artificial flies for 0.5 h and did not catch a fish ( 0 fish $/ \mathrm{h}$ ). We recorded a maximum depth of 7.6 m and did not observe any suitable spawning substrate along the shoreline. Columbia Spotted frogs were present (Table 4).

Creek Lake is relatively accessible ( $<5 \mathrm{~km}$ ) and appears to support a quality fishing opportunity for WCT in terms of size structure (max length $=380 \mathrm{~mm}$ ) and body condition (mean $\mathrm{W}_{\mathrm{r}}=99$ ). We did not observe any spawning substrate along the shoreline that would support natural reproduction. Based on these observations, we do not recommend any changes to the current stocking density or rotation.

## North Lake

We caught a total of 20 WCT in a paired gill net set at North Lake in 2021 (CPUE = 20; Table 3). Lengths of WCT ranged from 60 to 335 mm (mean = 209 mm ) and mean relative weight was 110 (range = 74 to 135; Table 3; Figure 11). One angler fished with artificial flies for 2 h and
caught 1 fish ( 0.5 fish/h). The lake is relatively shallow (max depth $=4.7 \mathrm{~m}$ ), and we observed a small amount ( $\sim 1 \mathrm{~m} 2$ ) of high-quality spawning substrate along the shoreline. Both Columbia Spotted frogs and Western Toads were present (Table 4).

WCT collected at North Lake in 2021 were in excellent body condition (mean $\mathrm{W}_{\mathrm{r}}=110$ ). Although very little spawning substrate was observed, natural reproduction appears to be occurring at a low level, as evidenced by the presence of fingerlings in the lake (min length $=60$ mm ). North Lake does not appear to receive a lot of angling-use, so managing this lake for quality size rather than high catch rates seems appropriate. Therefore, we do not recommend any changes to stocking density and rotation.

## Shelly Ann's Lake

We did not capture any fish in the paired gill net set at Shelly Ann's Lake in 2021, and we did not conduct an angling survey. We recorded a maximum depth of 3.3 m and did not observe any suitable spawning substrate. Columbia Spotted frogs were observed (Table 4).

Shelly Ann's Lake was last stocked in 1999. Shelly Ann's Lake is relatively shallow (max depth $=3.3 \mathrm{~m}$ ) and likely experiences temporary anoxia during the winter season that results in winterkill. We do not recommend any changes to current management strategies for Shelly Ann's Lake.

## Summit Lake

We caught a total of 68 BKT in a paired gill net set at Summit Lake in 2021 (CPUE = 68; Table 3). Lengths of BKT ranged from 90 to 250 mm (mean $=173 \mathrm{~mm}$ ) and mean relative weight was 86 (range = 58 to 117; Table 3; Figure 11). Two anglers fished with artificial flies for a combined effort of 4 h and caught 15 fish ( 3.75 fish $/ \mathrm{h}$ ). We recorded a maximum depth of 20.7 m and approximately 65 m 2 of suitable spawning substrate along the shoreline. We did not observe any amphibians (Table 4).

Relative abundance of BKT in Summit Lake was the highest observed across all HMLs surveyed in 2021 (CPUE = 68). This appears to be negatively impacting the maximum size fish are able to attain, as we did not observe any BKT greater than 250 mm in our survey. Based on these observations, we recommend that fishery managers consider tools to improve fishing opportunity in Summit Lake. Reducing abundance of BKT in the lake would likely result in improving growth conditions and the overall size structure of the BKT population.

## Trail Lake

We caught a total of 21 BKT in a paired gill net set at Trail Lake in 2021 (CPUE $=21$; Table 3). Lengths of BKT ranged from 101 to 320 mm (mean $=227 \mathrm{~mm}$ ) and mean relative weight was 100 (range = 78 to 125; Table 3; Figure 12). Two anglers fished with artificial flies for a combined effort of 4.5 h and caught one fish ( 0.2 fish $/ \mathrm{h}$ ). The lake is relatively shallow (max depth $=3.7 \mathrm{~m}$ ), and we observed a large amount ( $\sim 60 \mathrm{~m} 2$ ) of high-quality spawning substrate. Both Columbia Spotted frogs and Western Toads were observed (Table 4).

Trail Lake has not been stocked since 1989 so the fishery is maintained solely through natural reproduction. Despite relatively easy access to the lake, it appears to receive very little angling-use. Due to high apparent rates of natural reproduction, low-use, and relatively high abundance of BKT, we do not recommend any changes to the current management strategy. This lake functions well as a high catch rate lake without the aid of stocking.

## Victor Lake

We caught a total of seven fish of three species ( $29 \%$ WCT, $57 \%$ RBT, and $14 \%$ RBTxWCT) in a paired gill net set at Victor Lake in 2021 (CPUE = 7; Table 3). We captured two WCT that were 325 mm and 450 mm , respectively. We captured four RBT that ranged in length from 105 to 335 mm (mean $=239 \mathrm{~mm}$ ) and mean relative weight was 97 (range = 87 to 102). We also caught a RBTxWCT hybrid that was 340 mm TL (Table 3; Figure 12). Two anglers fished with artificial flies for a combined effort of 4 h and caught 7 fish ( 1.75 fish $/ \mathrm{h}$ ). We recorded a maximum depth of 8.5 m and observed a large amount ( $\sim 105 \mathrm{~m} 2$ ) of high-quality spawning substrate. We did not observe any amphibians at Victor Lake (Table 4).

Although natural reproduction is occurring at Victor Lake, both size structure and body condition of fish are excellent. Based on these observations, Victor Lake currently supports good catch rates of quality-sized fish. Therefore, we do not recommend any changes to stocking density or rotation. However, since Victor Lake has received fewer stocked fish than requested over the last two stocking rotations, it is difficult evaluate the contribute stocking has had on fish community structure. We recommend that managers begin evaluating otolith thermal markings on stocked WCT to determine the contribution of naturally produced fish vs. hatchery stocked fish within age groups collected at Victor Lake.

## MANAGEMENT RECOMMENDATIONS

1. Continue to assess fish presence, species composition, relative abundance, and size structure in McCall sub-region HMLs.
2. We recommend that managers discontinue stocking Crystle Lake, French Creek Lake \#1, Horton Lake, Lower Twin Lake, and Twin Lake \#2.
3. We recommend that managers discontinue stocking GNT in Slab Butte Lake.
4. We recommend that managers change the current stocking rotation at Center Lake to plant 500 WCT every three years.
5. We recommend that managers consider stocking Tiger Muskie in Summit Lake to remove BKT and provide a unique fishing opportunity to anglers.
6. We recommend that managers evaluate the feasibility of using biological or chemical fish removal at Hard Butte Lake, Upper Twin Lake, and Lower Twin Lake to establish new, diverse fishing opportunities for anglers.
7. We recommend that managers evaluate the contribution of stocking (using otolith thermal marks) in select lakes that are both stocked and appear to support natural reproduction.

Table 1. Lake characteristics and general access considerations for high mountain lakes surveyed in the McCall Subregion in 2021.

| Lake | LLID | HUC6 | Trail (km) | Cross-Country (km) | Angler <br> Use |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Bear Pete Lake | 1159559453075 | 170602080501 | 6.4 | 1.6 | Low |
| Black Lake | 1165595451887 | 170602100401 | 0.0 | 0.0 | High |
| Buck Lake | 1162399452318 | 170602100502 | 0.0 | 3.2 | Moderate |
| Center Lake | 1160562452347 | 170602090102 | 6.4 | 1.6 | Low |
| Coffee Cup Lake | 1162174451706 | 170602100302 | 4.8 | 0.0 | Moderate |
| Creek Lake | 1159731453280 | 170602080501 | 0.0 | 8.0 | Low |
| Crystal Lake | 1165534452227 | 170602100401 | 9.7 | 1.6 | High |
| Deep Lake | 1159313451641 | 170501230101 | 1.6 | 0.0 | Low |
| Doe Lake | 1162441452395 | 170602100502 | 0.0 | 3.2 | Low |
| Eden Lake | 1162051452437 | 170602100302 | 8.0 | 0.0 | Low |
| Ellis Lake | 1160955451288 | 170501230103 | 0.0 | 1.6 | Moderate |
| French Creek Lake \#1 | 1160701451807 | 170602090102 | 8.0 | 0.0 | Low |
| Hard Butte Lake | 1162101452655 | 170602090202 | 4.8 | 0.0 | Moderate |
| Horton Lake | 1160863451289 | 170501230103 | 0.0 | 2.4 | Low |
| Kenneth Lake | 1161166452178 | 170602090101 | 0.4 | 0.0 | Low |
| Lower Granite Lake | 1160956451192 | 170501230103 | 0.0 | 1.2 | Low |
| Lower Twin Lake | 1162023452695 | 170602090202 | 4.8 | 0.0 | Low |
| Morehead Lake | 1153366445796 | 170602050406 | 11.3 | 0.8 | High |
| Morgan Lake | 1162438451737 | 170602100302 | 7.2 | 0.0 | Moderate |
| Neal Lake | 1161503450880 | 170602100104 | 0.0 | 3.2 | Low |
| North Lake | 1159150451473 | 170602080503 | 6.4 | 1.6 | Low |
| Partridge Creek Lake | 1161987452760 | 170602090202 | 5.6 | 0.0 | Low |
| Ruth Lake | 1165571452424 | 170602100403 | 15.3 | 0.0 | Low |
| Shelly Anns Lake | 1159685453469 | 170602080501 | 0.0 | 2.4 | Low |

Table 1. (continued)

| Lake | LLID | HUC6 | Trail (km) | Cross-Country (km) | Angler <br> Use |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Slab Butte Lake | 1161366450908 | 170501230103 | 0.0 | 4.8 | Low |
| Summit Lake | 1159139451712 | 170602080502 | 4.0 | 0.0 | Moderate |
| Trail Lake | 1159416451583 | 170501230101 | 4.4 | 0.8 | Low |
| Twin Lake \#2 | 1165205451544 | 170602100401 | 6.4 | 0.0 | Low |
| Upper Twin Lake | 1162078452682 | 170602090202 | 4.8 | 0.0 | High |
| Victor Lake | 1159005451487 | 170602080503 | 6.4 | 3.2 | Low |
| Warm Spring Creek Lake | 1161981452627 | 170602100302 | 4.0 | 0.0 | Low |
| Angler use (number of fire pits) |  |  |  |  |  |
| Low $=0-2$ |  |  |  |  |  |
| Moderate $=2-5$ |  |  |  |  |  |
| High $=>5$ |  |  |  |  |  |

Table 2. Stocking information, recent survey dates, and current fish community in high mountain lakes surveyed in the McCall Subregion in 2021.

| Lake | Last Surveyed | Last Stocked, Species | Stocking Rotation | Stocking Density (fish/ha) | Current Fish Observations |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Bear Pete Lake | 2020 | None | - | 0 | BKT |
| Black Lake | 2012 | 2020, RBT | A | 346 | RBT |
| Buck Lake | 1993 | 1993, RBT | - | 315 | BKT |
| Center Lake | 1991 | 2020, WCT | A | 833 | WCT |
| Coffee Cup Lake | 2003 | 2020, WCT | EV | 136 | WCT, GRA |
| Creek Lake | 2014 | 2020, WCT | A | 207 | WCT |
| Crystal Lake | 2006 | 2020, WCT | A | 82 | WCT, RBT, RBTxWCT |
| Deep Lake | 2019 | 1989, BT | - | 66.6 | BKT |
| Doe Lake | None | None | - | 0 | BKT |
| Eden Lake | 2006 | 2006, GRA | - | 7142 | None |
| Ellis Lake <br> French Creek Lake | 2005 | 2014, WCT | A | 333 | WCT |
| \#1 | 1998 | 1991, RBT | - | 364 | BKT |
| Hard Butte Lake | 2006 | 2020, WCT | EV | 57.1 | WCT |
| Horton Lake | 2005 | 2019, WCT | C | 333 | None |
| Kenneth Lake | 1990 | 2020, WCT | EV | 833 | WCT |
| Lower Granite Lake | 2005 | 1974, RBT | - | 686 | None |
| Lower Twin Lake | 2005 | None | - | 0 | BKT |
| Morehead Lake | None | 2019, WCT | C | 153 | WCT |
| Morgan Lake | 2003 | 2020, WCT | A | 400 | WCT |
| Neal Lake | 2014 | 1992, WCT | - | 385 | None |
| North Lake Partridge Creek | 2005 | 2020, WCT | A | 148 | WCT |
| Lake | 2006 | 1972, RBT | - | 735 | None |
| Ruth Lake | 2006 | 2006, RBT | - | 270 | BKT |

Table 2. (continued)

| Lake | Last Surveyed | Last Stocked, Species | Stocking Rotation | Stocking Density (fish/ha) | Current Fish Observations |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Shelly Anns Lake | 1997 | 1999, WCT | - | 0 | None |
| Slab Butte Lake | 2005 | 2020, WCT \& GDT | A | 1071 | WCT |
| Summit Lake | 2005 | 2009, RBT | - | 223 | BKT |
| Trail Lake | 2005 | 1989, BT | - | 157 | BKT |
| Twin Lake \#2 | 2007 | 2020, WCT | A | 117 | BKT |
| Upper Twin Lake | 2006 | None | - | 0 | BKT |
| Victor Lake | 1999 | 2020, WCT | A | 77 | WCT, RBT, RBTxWCT |
| Warm Spring Creek Lake | 2006 | 2020, WCT | A | 1351 | WCT |
| $A=2017,2020,2023$, etc. |  |  |  |  |  |
| $B=2018,2021,2024$, etc. |  |  |  |  |  |
| $C=2019,2022,2025$, etc. |  |  |  |  |  |
| $E V=$ even years |  |  |  |  |  |
| ODD = odd years |  |  |  |  |  |

Table 3. Fish species composition, size, and relative abundance (fish per paired gill net night) metrics for lakes surveyed in the McCall Subregion in 2021.

| Lake | Species | $N$ | Mean TL (range) | Mean $\mathrm{W}_{\mathrm{r}}$ (range) | CPUE |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Bear Pete Lake ${ }^{2}$ | BKT | 43 | 173 (93-254) | 81 (67-101) | 43 |
| Black Lake | RBT | 6 | 302 (120-400) | 55 (41-67) | 6 |
| Buck Lake | BKT | 17 | 259 (215-290) | 81 (66-100) | 17 |
| Center Lake | WCT | 13 | 186 (126-265) | 83 (76-91) | 13 |
| Coffee Cup Lake | WCT | 6 | 343 (308-370) | 83 (70-95) | 12 |
|  | GRA | 6 | 294 (286-303) | 79 (75-84) |  |
| Creek Lake | WCT | 18 | 217 (97-380) | 99 (85-121) | 18 |
| Crystle Lake | WCT | 3 | 350 (330-370) | 62 (47-76) | 20 |
|  | RBT | 7 | 297 (260-330) | 80 (70-89) |  |
|  | RBTxWCT | 10 | 195 (80-410) | - |  |
| Deep Lake | BKT | 26 | 185 (105-253) | 76 (59-92) | 26 |
| Doe Lake ${ }^{1}$ | BKT | 2 | - | - | 2 |
| Eden Lake | None | 0 | - | - | 0 |
| Ellis Lake | WCT | 14 | 163 (100-450) | 101 (90-111) | 14 |
| French Creek \#1 ${ }^{1}$ | BKT | 20 | 263 (245-277) | 84 (72-103) | 20 |
| Hard Butte Lake | WCT | 3 | 292 (290-293) | 97 (86-102) | 10 |
|  | BKT | 7 | 218 (107-260) | 83 (71-94) |  |
| Horton Lake | None | 0 | - | - | 0 |
| Kenneth Lake | WCT | 14 | 175 (123-334) | 97 (67-236) | 14 |
| Lower Granite Lake | None | 0 | - | - | 0 |
| Lower Twin Lake | WCT | 2 | 214 (210-217) | 86 (84-87) | 64 |
|  | BKT | 62 | 176 (110-240) | 83 (61-110) |  |
| Morehead Lake | WCT | 5 | 396 (380-445) | 92 (1 fish) | 5 |
| Morgan Lake | WCT | 5 | 343 (132-410) | 131 (85-151) | 5 |
| Neal Lake | None | 0 | - | - | 0 |
| North Lake | WCT | 20 | 209 (60-355) | 115 (74-175) | 20 |
| Partridge Creek Lake | None | 0 | - |  | 0 |
| Ruth Lake ${ }^{1}$ | BKT | 5 | 237 (215-284) | 81 (68-94) | 5 |
| Shelly Anns Lake | None | 0 | - | - | 0 |
| Slab Butte Lake | WCT | 5 | 288 (85-390) | 83 (63-105) | 5 |
| Summit Lake | BKT | 68 | 173 (90-250) | 86 (58-117) | 68 |
| Trail Lake | BKT | 21 | 227 (101-320) | 100 (78-125) | 21 |
| Twin Lake \#2 | BKT | 4 | 250 (240-260) | 71 (61-83) | 4 |
| Upper Twin Lake | BKT | 50 | 202 (120-252) | 88 (72-113) | 51 |
|  | WCT | 1 | 291 (1 fish) | 91 (1 fish) |  |
| Victor Lake | WCT | 2 | 388 (325-450) | 91 (1 fish) | 7 |
|  | RBT | 4 | 239 (105-335) | 97 (87-102) |  |
|  | RBTxWCT | 1 | 340 | - |  |
| Warm Spring Creek Lake | WCT | 27 | 208 (102-312) | 90 (69-144) | 27 |

[^0]Table 4. Lake, Total Spawning Area (meters squared), Spawning Suitability, Maximum Depth, and Amphibian Observations for high mountain lake surveys conducted in 2021.

| Lake | Total Spawning Area ( $\mathrm{m}^{2}$ ) | Spawning Suitability | Max Depth (m) | Amphibian Obs. |
| :---: | :---: | :---: | :---: | :---: |
| Bear Pete Lake | 100 | High | 18.2 | CSF |
| Black Lake | 85 | High | 38.1 | None |
| Buck Lake | 2 | Low | 17.1 | None |
| Center Lake | 0 | None | 8.2 | CSF |
| Coffee Cup Lake | 0 | None | 7.6 | CSF |
| Creek Lake | 0 | None | 7.6 | CSF |
| Crystal Lake | 20 | High | 9.8 | WT |
| Deep Lake | 89 | High | 30.7 | CSF |
| Doe Lake | 5 | Low | N/A | CSF \& WT |
| Eden Lake | 0 | None | 1.8 | CSF |
| Ellis Lake | 0 | None | 5.2 | CSF |
| French Creek Lake \#1 | 0 | Low | 17.3 | None |
| Hard Butte Lake | 52 | High | 3.8 | CSF |
| Horton Lake | 0 | None | 2.7 | CSF |
| Kenneth Lake | 0 | None | 7.6 | None |
| Lower Granite Lake | 0 | None | 3.2 | CSF |
| Lower Twin Lake | 75 | High | 3.8 | CSF \& WT |
| Morehead Lake | 0 | None | 38.5 | None |
| Morgan Lake | 0 | None | 13.7 | CSF |
| Neal Lake | 0 | None | 2.2 | CSF |
| North Lake | 1 | High | 4.7 | CSF \& WT |
| Partridge Creek Lake | 10 | High | 3.3 | CSF |
| Ruth Lake | 20 | High | 12.4 | CSF |
| Shelly Anns Lake | 0 | None | 3.3 | CSF |
| Slab Butte Lake | 30 | High | 3.4 | CSF \& WT |
| Summit Lake | 67 | High | 20.7 | None |

Table 4. (continued)

| Lake | Total Spawning Area (m2) | Spawning Suitability | Max Depth (m) | Amphibian Obs. |
| :--- | :---: | :---: | :---: | :---: |
| Trail Lake | 58 | High | 3.7 | CSF \& WT |
| Twin Lake \#2 | 22 | High | 10.5 | WT |
| Upper Twin Lake | 7 | Low | 6.0 | CSF \& WT |
| Victor Lake | 105 | High | 8.5 | None |
| Warm Spring Creek Lake | 2 | Low | 1.8 | CSF |
| CSF = Columbia Spotted Frog (Rana luteiventris) |  |  |  |  |
| WT = Western Toad (Anaxyrus boreas) |  |  |  |  |



Figure 1. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Black Lake and Buck Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 2. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Coffee Cup Lake and Crystle Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 3. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Morgan Lake and Ruth Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 4. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Slab Butte Lake and Twin Lake \#2 in 2021. Horizontal dashed line represents a relative weight of 100 , for reference.


Figure 5. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Morehead Lake and Center Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 6. Length-frequency histogram and relative weights of fish captured during gill netting surveys at French Creek Lake and Hard Butte Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 7. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Kenneth Lake and Lower Twin Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 8. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Upper Twin Lake and Warm Spring Creek Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 9. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Deep Lake and Ellis Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 10. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Bear Pete Lake and Creek Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 11. Length-frequency histogram and relative weights of fish captured during gill netting surveys at North Lake and Summit Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.


Figure 12. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Trail Lake and Victor Lake in 2021. Horizontal dashed line represents a relative weight of 100, for reference.

## GOOSE LAKE FISHERY SURVEY


#### Abstract

Goose Lake was surveyed on June 16, 2021, to determine fish species composition, relative abundance, and size structure. The lake is currently managed as a put-and-take Rainbow Trout (RBT) Oncorhynchus mykiss fishery. Previous gill netting surveys have shown that overwinter survival of stocked (holdover) RBT is low, likely due to seasonal draw down in the reservoir in late summer. Our survey was conducted prior to any stocking events in 2021. The survey consisted of two paired gill net sets, which captured a total of 31 fish ( $87 \%$ Brook Trout [BKT] Salvelinus fontinalis, 10\% Westsope Cutthroat Trout [WCT] O. clarki lewisi, and 3\% RBT, CPUE = 16 fish per paired net night). BKT ( $n=27$ ) ranged in length from 168 to 390 mm TL. We collected a single hatchery-holdover RBT that was $380 \mathrm{~mm}\left(\mathrm{~W}_{\mathrm{r}}=89\right)$. Although winter survival appears to be low for hatchery stocked catchable RBT, data suggests excellent return-to-creel rates (19\% 1-year adjusted exploitation) compared to other waterbodies in the McCall Subregion. We recommend managers continue to stock Goose Lake annually with catchable RBT to supplement the fishery. Stocking should occur as soon as the lake is accessible to provide opportunity after ice-off.


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## INTRODUCTION

Goose Lake ( $45.290970^{\circ} \mathrm{N},-116.173665^{\circ} \mathrm{W}$ ) is a 148.1 -ha subalpine reservoir that sits at an elevation of 1943 m in Adams County approximately 20 km northwest of McCall, ID. The reservoir is located within the Payette National Forest and water levels are managed by the Goose Lake Reservoir Company. There is one developed campground ("Grouse Campground") in addition to several dispersed camping areas with vault-toilets and fire rings around the perimeter of the lake adjacent to Goose Lake Road. Valley County currently lists Goose Lake as a "nowake" body of water.

Goose Lake has a very complex stocking history reaching as far back as 1930, when Cutthroat Trout (CTT) were first planted. Between 1930 and 2000, a variety of fish species and strains were stocked to establish a diverse sport fishery, which included: late- and early-spawning kokanee Oncorhynchus nerka, fine-spotted CTT, Henry's Lake CTT, Mt. Whitney RBT, Mt. Lassen RBT, domestic Kamloop RBT, Eagle Lake RBT, and troutlodge- and hayspur-strain RBT. There is no recorded history of stocking Brook Trout in Goose lake. Since 2000, Goose Lake has received on average 3,000 catchable (average 254 mm TL) RBT each year, managed as a put-and-take fishery. Hatchery surplus WCT were stocked in addition to RBT in 2019. The statewide fisheries management plan (2019-2024; IDFG 2019) directs fishery managers to supplement the fishery with catchable RBT to maintain an overall average catch rate of $0.5 \mathrm{fish} / \mathrm{h}$.

## OBJECTIVES

1. Monitor trends in species composition, relative abundance, and size structure to guide management actions.

## METHODS

We set two floating/sinking pairs of IDFG experimental gill nets ( $46 \mathrm{~m} \times 2 \mathrm{~m}$; 6 panels consisting of 19-, 25-, 32-, 38-, 51-, and 64-mm bar mesh; IDFG 2012). One pair was attached to the shore and fished perpendicular to the shoreline ( $45.074537^{\circ} \mathrm{N},-116.172356^{\circ} \mathrm{W}$ ), while the other was set offshore ( $45.069607^{\circ} \mathrm{N},-116.172677^{\circ} \mathrm{W}$ ). Catch-per-unit-effort (CPUE) was calculated as the average number of fish caught in a paired gill net set per net night. All fish were identified by species, enumerated, measured ( mm TL ), and weighed ( g ).

Condition of fish was assessed using relative weights $\left(W_{r}\right)$ for RBT (Simpkins and Hubert 1996), Brook Trout (Hyatt and Hubert 2001), and WCT (Kruse and Hubert 1997) larger than 130 mm TL. Relative weight was calculated by first using a standard weight $\left(\mathrm{W}_{\mathrm{s}}\right)$ equation for each species:

$$
\log _{10}\left(W_{s}\right)=a+b * \log _{10}(\text { total length }(\mathrm{mm}))
$$

where $a=$ the intercept value and $b=$ slope derived from Blackwell et al. (2000). The log value is then converted back to base 10 , and relative weight is then calculated using the equation:

$$
W_{r}=\left(\frac{\text { weight }(\mathrm{g})}{W_{s}}\right) * 100
$$

## RESULTS

We collected a total of 31 fish of 3 species ( $87 \%$ BKT, $10 \%$ WCT, $3 \%$ RBT) in Goose Lake during the 2021 survey (CPUE = 16; Table 5). We caught 27 BKT that ranged in length from 168 to 390 mm (mean $=337 \mathrm{~mm}$ ) with a mean relative weight of 89 (range = 69 to 104). We caught three WCT that ranged in length from 242 to 276 mm (mean $=264 \mathrm{~mm}$ ) with a mean relative weight of 96 (range $=94$ to 98). We also caught a single RBT that was 380 mm with a relative weight of 81 (Table 5; Figure 13).

## DISCUSSION

Goose Lake is a popular trout fishing destination for summer campers and day users because of its proximity to McCall, Idaho. Recent tagging studies in 2020 suggest that approximately $19 \%$ (adjusted for $48.3 \%$ reporting rate; Meyer et al. 2012) of stocked RBT return-to-creel (IDFG, unpublished data). Our 2021 survey suggests that over winter survival of stocked trout (both RBT and WCT) is low and that continued hatchery stocking will be necessary to maintain this popular trout fishery. Unfortunately, comparisons to previous surveys are limited due to timing of surveys relative to stocking events. All future gill netting surveys should be conducted prior to stocking events.

Moving forward, fishery managers should consider stocking "magnum"-sized ( $\sim 305 \mathrm{~mm}$ ) RBT in Goose Lake. Recent research suggests that reduced stocking densities of larger RBT can result in higher return-to-creel rates (Branigan et al. 2021). If stocking is changed, managers should evaluate if return-to-creel and catch rates improve at Goose Lake. The current statewide fisheries management plan (2019-2024) directs managers to maintain a 0.5 fish/h catch rate on stocked trout in Goose Lake. Moving forward, managers should develop a plan to estimate catch rates and determine if stocking densities and schedules should be adjusted to meet the current FMP goal.

## MANAGEMENT RECOMMENDATIONS

1. Continue monitoring trends in species composition, relative abundance, and size structure on a three-year rotation.
2. Work with hatchery staff to determine if stocking "magnum" RBT is feasible at Goose Lake, in place of catchable RBT. If so, evaluate return-to-creel to determine if angler-use improves.
3. Develop a plan to estimate angler catch rates at Goose Lake in 2023/2024.

Table 5. Total catch (Brook Trout [BKT], Rainbow Trout [RBT], Westslope Cutthroat Trout [WCT]), percent of total catch, mean lengths ( mm TL ), and relative weights ( $\mathrm{W}_{\mathrm{r}}$ ) from a gill net survey at Goose Lake on June 16 and 17, 2021.

| Species | Catch | \% of <br> Catch | Mean TL <br> (range) | Mean W <br> $\mathbf{r}$ |
| :---: | :---: | :---: | :---: | :---: |
| (range) |  |  |  |  |



Figure 13. Length-frequency histogram and relative weights of Brook Trout ( $n=27$ ), Rainbow Trout ( $n=1$ ), and Westslope Cutthroat Trout ( $n=3$ ) captured during a gill netting survey at Goose Lake on June 16 and 17, 2021.

## TRIPOD RESERVOIR FISHERY SURVEY

## ABSTRACT

Tripod Reservoir was surveyed on June 22, 2021, to determine species composition, relative abundance, and size structure of the fishery. The reservoir is currently managed as a put-and-take Rainbow Trout (RBT) Oncorhynchus mykiss fishery. Due to logistical constraints, our survey was conducted following hatchery stocking events. We sampled a total of 132 fish of two species ( $80 \%$ RBT, 20\% Brook Trout [BKT] Salvelinus fontinalis, CPUE = 66). Naturally reproducing BKT lengths ranged from 153 to 275 mm (mean $=189 \mathrm{~mm}$ ) with a mean relative weight of 96 (range = 79 to 116). We recommend that managers develop a plan to estimate catch rates at Tripod Reservoir and conduct a tagging study within the next three years to evaluate return-to-creel.

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## INTRODUCTION

Tripod Reservoir $\left(44.290970^{\circ} \mathrm{N},-116.100785^{\circ} \mathrm{W}\right.$ ) is a 2.1 -ha subalpine reservoir at an elevation of 1530 m in Valley County, approximately 70 km south of McCall in the Payette River drainage. The reservoir was first constructed in 1940 and was managed by the Southern Idaho Timber Protective Association (SITPA) until 1998, when the property was transferred to the Boise Cascade Corporation. Prior to the transfer, SITPA determined they had no need for the stored water but appreciated that the site had a long history of IDFG stocking trout and providing a popular fishery in the area. In 1997, the dam, which is located on State of Idaho land, breached due to a collapsed outlet pipe that allowed the reservoir to completely drain through a hole that developed downstream of the outlet gate. IDFG offered to repair the damaged pipe and restabilize the dam embankment in exchange for a long-term recreational lease with IDL for the site, which all parties agreed to. All erosion control measures, as well as installation of a new outhouse and handicap-accessible fishing dock were completed in the summer of 1998.

The IDFG first stocked Tripod Reservoir in 1939 with Rainbow Trout [RBT] Oncorhynchus mykiss. Since 1953, the reservoir has been stocked annually with exclusively RBT (triploid RBT since 2001). Although Bull Trout Salvelinus confluentus were observed in a 1997 survey, only Brook Trout (BKT) Salvelinus fontinalis and RBT have been observed since (2016 and 2021). The current statewide fisheries management plan (2019 - 2024; IDFG 2019) outlines a target objective of maintaining minimum catch rates of 0.5 fish per hour.

## OBJECTIVES

1. Monitor trends in species composition, relative abundance, and size structure to guide management actions.

## METHODS

We set two sinking/floating pairs of IDFG experimental gill nets (i.e., $46 \mathrm{~m} \times 2 \mathrm{~m}$; 6 panels consisting of 19-, 25-, 32-, 38-, 51-, and 64-mm bar mesh; IDFG 2012). One pair was attached to the shore and fished perpendicular to the shoreline, while the other was set offshore. We did not record GPS locations of gill net sites due to the reservoirs small size (2.1 ha). Catch-per-uniteffort (CPUE) was calculated as the average number of fish caught in a paired gill net set per net night. All fish were identified to species, enumerated, measured ( mm ; TL ), and weighed ( g ).

Condition of fish was assessed using relative weights $\left(W_{r}\right)$ for RBT (Simpkins and Hubert 1996), Brook Trout (Hyatt and Hubert 2001), and WCT (Kruse and Hubert 1997) larger than 130 mm TL. Relative weight was calculated by first using a standard weight $\left(\mathrm{W}_{\mathrm{s}}\right)$ equation for each species:

$$
\log _{10}\left(W_{s}\right)=a+b * \log _{10}(\text { total length }(\mathrm{mm}))
$$

where $a=$ the intercept value and $b=$ slope derived from Blackwell et al. (2000). The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$
W_{r}=\left(\frac{\text { weight }(\mathrm{g})}{W_{s}}\right) * 100
$$

## RESULTS

We collected a total of 132 fish of two species ( $80 \%$ RBT, $20 \%$ BKT) in Tripod Reservoir during the 2021 survey (CPUE = 66; Table 6). We caught 106 RBT that ranged in length from 122 to 395 mm (mean $=252 \mathrm{~mm}$ ) with a mean relative weight of 88 (range $=63$ to 131). We also caught 26 BKT that ranged in length from 153 to 275 mm (mean $=189 \mathrm{~mm}$ ) with a mean relative weight of 96 (range = 79 to 116; Table 6; Figure 14).

## DISCUSSION

Tripod Reservoir is a very small (2.1 ha) subalpine reservoir that is easily accessible by vehicle. Similar to our most recent survey in 2016, the fish community is comprised of hatchery RBT and naturally reproducing BKT. To continue to provide fishing opportunity at this reservoir, we recommend that managers continue managing Tripod Reservoir as a put-and-take RBT fishery. The naturally reproducing Brook Trout population does not appear to be abundant enough to sustain catch rates of 0.5 fish $/ \mathrm{h}$ on its own.

In future years, fishery managers should consider stocking "magnum"-sized ( $\sim 305 \mathrm{~mm}$ ) RBT catchables in Tripod Reservoir. Recent research suggests that stocking fewer, but larger RBT can result in higher return-to-creel rates (Branigan et al. 2021). If stocking is changed, managers should evaluate if return-to-creel and catch rates improve at Tripod Reservoir. The current statewide fisheries management plan (2019-2024; "FMP") directs managers to maintain a 0.5 fish/h catch rate on stocked trout in Tripod Reservoir. In order to evaluate whether this objective is being met, managers should develop a plan to estimate catch rates and determine if stocking densities and schedules should be adjusted.

## MANAGEMENT RECOMMENDATIONS

1. Continue managing Tripod Reservoir as a put-and-take RBT fishery.
2. Work with hatchery staff to determine if stocking "magnum" RBT is feasible at Tripod Reservoir, in place of catchable RBT. If so, evaluate return-to-creel to determine if angleruse improves.
3. Develop a study to estimate angler catch rates at Tripod Reservoir in 2023/2024.

Table 6. Total catch (Brook Trout [BKT], Rainbow Trout [RBT]), percent of total catch, mean lengths ( mm TL ), and relative weights ( $\mathrm{W}_{\mathrm{r}}$ ) from a gill net survey at Tripod Reservoir on June 22, 2021.

| Species | Catch | \% of <br> Catch | Mean TL <br> (range) | Mean W <br> r |
| :---: | :---: | :---: | :---: | :---: |
| (range) |  |  |  |  |



Figure 14. Length-frequency histogram and relative weights of Brook Trout ( $n=26$ ), Rainbow Trout ( $n=106$ ) captured during a gill netting survey at Tripod Reservoir on June 22, 2021.

## GRANITE LAKE FISHERY SURVEY


#### Abstract

Granite Lake was surveyed on June 16, 2021, prior to stocking for the year, to determine species composition, relative abundance, and size structure of the fishery. The lake is currently managed as a put-and-take Rainbow Trout (RBT) Oncorhynchus mykiss fishery, and tiger trout (TIG) Salmo trutta X Salvelinus fontinalis have been stocked annually since 2020 to reduce Redside Shiner [RSS] Richardsonius balteatus abundance and increase fishery quality and diversity. The survey consisted of two paired gill net sets, which collected 15 fish of 3 species ( $60 \%$ TIG, $33 \%$ RSS, $7 \%$ RBT; CPUE = 7.5). Lengths of TIG ranged from 287 to 375 mm (mean $=323 \mathrm{~mm}$ ). The single RBT captured was 475 mm and $>1 \mathrm{~kg}$ and RSS were observed in high abundance along the shoreline. Our results confirm that over-winter survival is occurring for stocked TIG and RBT in Granite Lake, but abundance is relatively low. Stocking catchable Rainbow Trout (average 254 mm TL) annually is necessary for providing higher catch rates during the summer months. Although TIG body condition did not suggest high predation rates on RSS, we recommend that managers continue stocking TIG in addition to RBT in Granite Lake for the diversity they provide. We also recommend conducting return-to-creel evaluations on stocked fish in Granite Lake to maximize efficiency and effectiveness of the stocking program.


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## INTRODUCTION

Granite Lake $\left(45.104252^{\circ} \mathrm{N},-116.075444^{\circ} \mathrm{W}\right)$ is a 75.9 -ha subalpine reservoir that sits at an elevation of $2,058 \mathrm{~m}$ in the North Fork Payette River drainage, 22 km north of McCall, Idaho. The East Fork of Lake Creek forms the inlet and outlet of Granite Reservoir. The outlet joins Fisher Creek before draining into the North Fork of the Payette River. The Payette National Forest maintains several dispersed camping areas with vault-toilets, fire rings, and picnic tables at Granite Lake.

The Idaho Department of Fish and Game (IDFG) first stocked Granite Lake in 1925 with Rainbow Trout (RBT) Oncorhynchus mykiss and have since managed the lake as a put-and-take fishery receiving $\sim 4,000$ catchable RBT ( $\sim 250 \mathrm{~mm}$ ) each year. In 2020, IDFG introduced tiger trout (TIG) Salmo trutta X Salvelinus fontinalis to reduce Redside Shiner (RSS) Richardsonius balteatus abundance and convert RSS biomass into sportfish biomass (see Janssen et al. 2020 for details). The region currently has an annual stocking request for 2,000 TIG in late-July/early August at an average size of 280 mm .

## OBJECTIVES

1. Determine species composition, relative abundance, and size structure prior to stocking for the year to assess winter holdover rates.
2. Determine if TIG are utilizing RSS biomass to increase size quality.

## METHODS

We set two sinking and two floating IDFG experimental gill nets (i.e., $46 \mathrm{~m} \times 2 \mathrm{~m}$; 6 panels consisting of 19-, 25-, 32-, 38-, 51-, and 64-mm bar mesh; IDFG 2012). One paired set was attached to the shore and fished perpendicular to the shoreline (45.100375 ${ }^{\circ} \mathrm{N},-116.078851^{\circ} \mathrm{W}$ ), while the other was set offshore ( $45.069607^{\circ} \mathrm{N},-116.172677^{\circ} \mathrm{W}$ ). Catch-per-unit-effort (CPUE) was calculated as the average number of fish caught in a paired gill net set per net night. All fish were identified by species, enumerated, measured ( mm TL ), and weighed ( g ).

The condition of fish was assessed using relative weights $\left(W_{r}\right)$ for RBT (Simpkins and Hubert 1996) and TIG (assumed similar to lentic Brown Trout; Hyatt and Hubert 2000) larger than 130 mm TL and 140 mm TL, respectively. Relative weight was calculated by first using a standard weight $\left(W_{s}\right)$ equation for each species:

$$
\log _{10}\left(W_{s}\right)=a+b * \log _{10}(\text { total length }(\mathrm{mm}))
$$

where $a=$ the intercept value and $b=$ slope derived from Blackwell et al. (2000). The log value is then converted back to base 10, and relative weight is then calculated using the equation:

$$
W_{r}=\left(\frac{\text { weight }(\mathrm{g})}{W_{s}}\right) * 100
$$

## RESULTS

We captured a total of 15 fish of 3 species ( $60 \%$ TIG, $33 \%$ RSS, $7 \%$ RBT) in Granite Lake during the 2021 survey (CPUE = 7.5; Table 7). We caught nine TIG that ranged in length from 287 to 375 mm (mean $=323 \mathrm{~mm}$ ) with a mean $\mathrm{W}_{\mathrm{r}}$ of 63 (range $=52-73$; Figure 15). In addition to five RSS (not measured), we captured a single RBT that measured 475 mm and $>1 \mathrm{~kg}$. RSS were also observed in high abundance along the shoreline.

## DISCUSSION

The results of our 2021 survey suggest that TIG are outperforming RBT in terms of overwinter survival and size structure. However, we did not observe RSS in gut contents while processing TIG and overall body condition of TIG was poor ( $\mathrm{W}_{\mathrm{r}}=63$ ), which suggests that RSS are not being fully utilized as a prey base for TIG in Granite Lake. The reason for this is unclear but could be due to differences in seasonal habitat use and availability. Constructing a bathymetric map of Granite Lake, to evaluate amounts of littoral and deep habitat available throughout the year, could help fishery managers determine when to stock TIG to maximize availability of littoraloriented RSS and improve growth conditions.

Tagging studies from 2020 and 2021 indicate that few TIG and RBT are returning-to-creel ( $<3 \%$; adjusted for non-reporting rate) at Granite Lake, even though angler visitation appears to be high during the summer months. The Fisheries Management Plan does not list specific objectives for Granite Lake, but our objectives should be considered similar to that of Tripod Reservoir and Goose Lake - maintain a minimum catch rate of 0.5 fish/hr with catchable trout. In future years, fishery managers should consider stocking "magnum"-sized ( $\sim 305 \mathrm{~mm}$ ) RBT in Tripod Reservoir. Recent research suggests that stocking fewer, but larger RBT can result in higher return-to-creel rates (Branigan et al. 2021). If stocking is changed, managers should evaluate if return-to-creel and catch rates improve at Tripod Reservoir. Moving forward, managers should develop a plan to estimate catch rates and determine if stocking densities and schedules should be adjusted.

## MANAGEMENT RECOMMENDATIONS

1. Continue managing Granite Lake as a put-and-take fishery by stocking RBT and Tiger Trout annually.
2. Conduct a creel survey at Granite Lake to gather angler preferences and estimate catch rates to determine if FMP goals are being met.
3. Work with hatchery staff to determine if stocking "magnum" RBT is feasible at Granite Lake, in place of catchable RBT. If so, evaluate return-to-creel to determine if angler-use improves.
4. Construct bathymetric map of Granite Lake to evaluate amount of littoral and deep habitat available, seasonally. Use this information to evaluate if changes in stocking dates are warranted to maximize habitat overlap of TIG and RSS at Granite Lake.

Table 7. Total catch (Tiger Trout [TIG], Rainbow Trout [RBT] and Redside Shiner [RSS]), percent of total catch, mean lengths ( mm TL) , and relative weights $\left(\mathrm{W}_{\mathrm{r}}\right)$ from a gill net survey at Granite Lake on June 16, 2021.

| Species | Catch | \% of Catch | Mean TL (range) | Mean Wr (range) |
| :--- | :--- | :--- | :--- | :--- |
| TIG | 9 | 60 | $327(287-375)$ | $63(52-73)$ |
| RBT | 1 | 7 | $475(1$ fish $)$ | -- |
| RSS | 5 | 33 | -- | -- |
| Total: | 15 | 100 |  |  |



Figure 15. Length-frequency histogram of tiger trout $(n=9)$ and Rainbow Trout $(n=1)$ captured during a gill netting survey at Granite Lake on June 16, 2021.

## WARM LAKE KOKANEE SALMON INVESTIGATIONS

## ABSTRACT

Warm Lake was surveyed on October 11, 2021, to characterize the relative abundance, size-, age-, and genetic structure of the kokanee (KOK) Oncorhynchus nerka population. This was the first time Warm Lake has ever been surveyed with kokanee-specific gill nets. All previously conducted surveys employed the use of standard experimental nets, thus comparing results from year to year is difficult. The lake is currently managed as a put-and-take Rainbow Trout (RBT) O. mykiss and put-grow-take kokanee fishery. The 2021 survey consisted of four paired pelagic gill net sets, which collected 333 fish of 3 species ( $98 \%$ KOK, 1\% RBT, 1\% Bull Trout [BUT] Salvelinus confluentus, CPUE = 83). Lengths of KOK ranged from 94 to 265 mm ( mean = 235) with a mean relative weight of 82 (range = 69-101). We caught two RBT that were $332\left(\mathrm{~W}_{\mathrm{r}}=76\right)$ and $342\left(\mathrm{~W}_{\mathrm{r}}=71\right)$ and two BUT that were $368\left(\mathrm{~W}_{\mathrm{r}}=96\right)$ and $408\left(\mathrm{~W}_{\mathrm{r}}=72\right)$.

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## INTRODUCTION

Warm Lake $\left(44.645528^{\circ} \mathrm{N},-115.670432^{\circ} \mathrm{W}\right)$ is a 260 -ha natural lake that sits at an elevation of $1,615 \mathrm{~m}$ in the South Fork Salmon River drainage approximately 42 km east of Cascade, Idaho. Warm Lake is the largest natural lake within the Boise National Forest. In 1935, a dam was constructed that raised the water level by 0.4 m . Many private homes, as well as two lodges, have been constructed along the northern and western shoreline of the lake.

Warm Lake is thought to have historically supported endemic Sockeye Salmon Oncorhynchus nerka and kokanee (KOK) populations (Chapman et al. 1990). Currently, the lake supports a late-spawning KOK population. Based on genetic samples from this KOK population, Waples et al. (1997) concluded that, "the distinctiveness and the low level of genetic variability found in this sample are consistent with the hypothesis that it represents a native gene pool that has been isolated and has experienced severe and/or prolonged bottlenecks in the past". These findings were surprising, as Warm Lake has been stocked with many different stocks of both kokanee and Sockeye Salmon. It has been hypothesized that the lack of evidence for genetic introgression from non-native stocks is due to the lack of suitable tributary spawning habitat for introduced stream early- spawning kokanee (Waples et al. 1997).

Warm Lake is currently managed as a put-and-take Rainbow Trout (RBT) O. mykiss and put-grow-take KOK (triploid) fishery. Since 2007, approximately 15,000 catchable RBT (> 150 mm ) and 30,000 to 40,000 KOK fingerlings ( $<150 \mathrm{~mm}$ ) have been stocked annually. All KOK stocked in Warm Lake since 1990 have been either triploid late-spawning stock from Cabinet Gorge Hatchery (Whatcom stock) or diploid early-spawning kokanee from Mackay Hatchery (Deadwood stock), in an attempt to reduce the risk of genetic mixing with the endemic latespawning stock. One exception was in 2017, when 10,000 diploid late-spawning kokanee were stocked - this was an oversight. The last survey of Warm Lake, in 1997, observed RBT, Brook Trout Salvelinus fontinalis, Bull Trout (BUT) Salvelinus confluentus Bull Trout x Brook Trout hybrids, Mountain Whitefish Prosopium williamsoni, Mountain Sucker Catostomus platyrhynchus, and Redside Shiner Richardsonius balteatus. The previous survey in 1991 documented Lake Trout Salvelinus namaycush in low abundance as well.

## OBJECTIVES

1. Monitor trends in species composition, relative abundance, and size structure to guide management actions.
2. Evaluate genetic composition of KOK population to determine if changes to current stocking strategies are warranted.

## METHODS

Gill nets used in 2021 were built to the specifications outlined by Klein et al. (2019). We set four paired gill nets that were 48.8 m long and 6 m deep and constructed of clear monofilament. Each net consisted of 16 panels, measuring 3.0 m in length and 6.0 m deep, and 8 different mesh sizes (12.7-, 19.0-, 25.4-, 38.1-, 50.8-, 63.5-, 76.2-, 101.6-mm stretch measure) with two panels of each mesh size randomly positioned across the net. Gill nets were set for
approximately 18-24 h and retrieved the following day. Sites were selected to maximize catch in open water areas, offshore.

All netted KOK were enumerated and measured (mm; TL). We recorded weights ( g ) from five fish of each $10-\mathrm{mm}$ TL group caught during the gill netting survey. Catch-per-unit-effort (CPUE = mean number of fish per paired gill net) was calculated to describe relative abundance. We used relative selectivity estimates provided by Klein et al. 2019 to adjust our catch estimates for describing size structure with relative-frequency histograms. Relative weight ( $\mathrm{W}_{\mathrm{r}}$ ) was calculated as an index of body condition using length and weight data (Blackwell et al. 2000; Hyatt and Hubert 2000).

We collected sagittal otoliths from five fish of each $10-\mathrm{mm}$ TL group caught during the gill netting survey. To prepare otoliths for sectioning, whole otoliths were mounted in bullet molds (Ted Pella, Inc., Redding, CA, USA) using epoxy and cross-sectioned using an Isomet low-speed saw (Buehler Inc., Lake Bluff, IL, USA) to approximately $0.58-\mathrm{mm}$ thickness. Resulting crosssections were viewed using a compound microscope and image analysis system (Leica Application Suite, Leica Microsystems, Buffalo Grove, IL, USA).

We used age estimates to develop an age length key for kokanee in Warm Lake, which we used to assign ages to unaged fish after incorporating relative selectivity estimates for catch provided by Klein et al. 2019. To estimate growth, a von Bertalanffy (VB) growth function was used

$$
L_{t}=L_{\infty}\left[1-e^{-K\left(t-t_{0}\right)}\right]
$$

where $L_{t}$ is the mean length at age of capture, $L_{\infty}$ is the theoretical maximum length, $K$ is the growth coefficient, and $t_{0}$ is the theoretical age when length equals 0 mm (von Betalanffy 1938). A best-fit model was constructed using nonlinear regression and bootstrapping techniques in Program R (nlstools package, Baty et al. 2015; R Development Core Team 2020; FSA package, Ogle et al. 2021).

We collected genetic samples from the lower portion of the caudal fin on a subsample of kokanee from Warm Lake. Samples were placed on Whatman sheets and provided to the Idaho Department of Fish and Game's Eagle Fish Genetics Lab for genetic stock identification.

## RESULTS

We captured a total of 333 fish of 3 species ( $98 \%$ KOK, $1 \%$ RBT, $1 \%$ BUT) with four paired net nights of effort in Warm Lake during the 2021 survey (CPUE = 83; Table 8; Figure 16). We caught 329 KOK (CPUE = 82.5) that ranged in length from 94 to $265 \mathrm{~mm}($ mean $=235)$ with a mean relative weight of 82 (range $=69-101$; Figure 17). We also caught two RBT (CPUE $=0.5$ ) that were $332\left(\mathrm{~W}_{\mathrm{r}}=76\right)$ and $342\left(\mathrm{~W}_{\mathrm{r}}=71\right)$ and two BUT $(\mathrm{CPUE}=0.5)$ that were $368\left(\mathrm{~W}_{\mathrm{r}}=96\right)$ and $408\left(\mathrm{~W}_{\mathrm{r}}=72\right.$; Table 8).

We collected and processed 52 otoliths and developed an age length key to estimate ages of kokanee in Warm Lake ( $n=38$; Table 9). Estimated ages ranged from one to five and the majority of kokanee were estimated to be age-4 in this survey (Figure 18). Mean length-at-age-at-capture (MLAA) for age-3 and -4 kokanee was 216 and 242 mm TL, respectively (Table 9;

Figure 19). Estimated von Bertalanffy growth parameters for unexpanded kokanee were: $\mathrm{L}_{\text {inf }}=$ 255.9, $\mathrm{K}=0.3$, and $\mathrm{t}_{0}=-0.8$ (Figure 19).

The Eagle Fish Genetics Lab processed 72 kokanee samples from Warm Lake in 2021, of which 67 assigned to the Warm Lake endemic stock, two assigned to the Whatcom stock (hatchery-origin; triploid), and three did not genotype (genotyping rate $=95.8 \%$ ).

## DISCUSSION

The results of our 2021 gill netting survey suggest that Warm Lake currently supports a high density, natural-origin kokanee population that is predominately comprised of native-strain fish (> 97\%). In previous surveys, very few kokanee were caught. In 1997 for example, kokanee only made up $0.2 \%$ of the total species composition caught during the survey (Janssen et al. 2000). However, all previous surveys used standard experimental gill nets, while the 2021 survey used kokanee-specific gill nets to specifically learn more about the kokanee population in Warm Lake. Therefore, 2021 results are not directly comparable with previous surveys. Relative abundance of kokanee was very high in our 2021 survey (CPUE $=82.5$ ). At several sites, gear saturation of the gill nets may have contributed to our lack of age-2 and -3 kokanee observed in the survey. Such high abundance likely limits growth rates of kokanee in Warm Lake, as evidenced by a maximum length of $\sim 260 \mathrm{~mm}$ (Figure 19). Although we were sampling in the pelagic zone to minimize bycatch, we still observed two BUT in our survey. Managers should continue to consider potential impacts to BUT while developing surveys of the Warm Lake fishery.

Although IDFG has been stocking 30,000 to 40,000 kokanee fingerlings in Warm Lake since 2007, stocked fish were not represented in our 2021 gill net catch. Abundance of naturalorigin, native-strain kokanee in Warm Lake is very high, thus continued hatchery supplementation of kokanee is not warranted to sustain the fishery. We recommend that managers discontinue stocking kokanee fingerlings in Warm Lake. The fishery should be surveyed within the next three to five years to evaluate the effect that discontinued stocking has on the fishery, if any.

## MANAGEMENT RECOMMENDATIONS

1. Continue to monitor the Warm Lake kokanee fishery on a 3-to-5-year rotation with other lowland lakes in the subregion.
2. Fishery managers should discontinue stocking kokanee fingerlings in Warm Lake.
3. Fishery managers should develop a plan to evaluate angler catch rates and preferences at Warm Lake in 2023 or 2024.

Table 8. Species composition and size characteristics of fish captured during a gill netting survey of Warm Lake in 2021.

| Species | Catch | \% of <br> Catch | Mean TL <br> (range) | Mean W <br> r <br> (range) |
| :---: | :---: | :---: | :---: | :---: |
| BUT | 2 | 1 | $332,342(2$ fish $)$ | $72,96(2$ fish $)$ |
| KOK | 329 | 98 | $235(94-265)$ | $82(69-101)$ |
| RBT | 2 | 1 | $368,408(2$ fish $)$ | $71,76(2$ fish $)$ |
|  | Total: | 333 | 100 |  |

Table 9. Age-length key developed for kokanee salmon sampled at Warm Lake in 2021. Age estimates obtained from $n=38$ kokanee otoliths to develop key. Includes estimated age in years, number of kokanee assigned to each age category ( $n$ ), mean length (mm; total length), and one standard error of the mean.

| Age | $\boldsymbol{n}$ | mean TL | SE |
| :---: | :---: | :---: | :---: |
| 1 | 2 | 96 | 2 |
| 2 | 12 | 187 | 2 |
| 3 | 9 | 216 | 3 |
| 4 | 12 | 242 | 2 |
| 5 | 3 | 257 | 5 |



Figure 16. Map of kokanee gill netting sites $(n=4)$ on Warm Lake, ID, in October 2021. Each site consisted of a paired gill net set.


Figure 17. Relative length-frequency histogram of adjusted gill net catch of kokanee collected in Warm Lake, Idaho in October 2021.


Figure 18. Relative estimated age-frequency histogram of adjusted gill net catch of kokanee collected in Warm Lake, Idaho in October 2021.


Figure 19. Von Bertalanffy growth curve plotted against estimated length-at-age-at-capture for kokanee collected at Warm Lake, Idaho in October, 2021.

# LAKE CASCADE JUVENILE YELLOW PERCH GEAR COMPARISON STUDY 


#### Abstract

Quantitative measures of recruitment and survival are vital to understanding the factors that influence a fishery. However, results can vary based on the selectivity of gear used to capture fish. Therefore, it is important to understand the effectiveness and limitations of specific gears when monitoring these fisheries. To better understand the most effective technique to monitor juvenile Yellow Perch Perca flavescens on Lake Cascade, fisheries managers evaluated differences in catch between common sampling gears. We sought to compare catch, precision (coefficient of variation; CV), and relative efficiency ( n workdays [replicates * mean operational time / 8 h ] to detect $20 \%$ change in mean catch) of five sampling gears using catch of young-ofyear (YOY) and age-1 perch. Currently, fishery managers use benthic otter trawls to monitor trends in relative abundance of YOY and age-1 perch. In this study, mini-fyke nets, cloverleaf traps, and micro-mesh gillnets were used to monitor perch abundance as well. Across all gears, very few age-1 perch ( $n=22$ ) were caught in our study. For YOY perch ( $n=37,865$ ), preliminary results suggest that micro-mesh gillnets were the most precise (CV = 52) and efficient gear (11 days). Cloverleaf traps with cyalume glow stick attractants were more precise ( $C V=101$ ) and efficient (22 days) than cloverleaf traps baited with chicken livers (CV = 106; 24 days), benthic otter trawls (CV = 134; 74 days), and mini-fyke nets (CV = 290; 344 days). While average operational time was similar between micro-mesh gill nets and benthic otter trawls ( $\sim 25$ min per set), the latter accounted for $\sim 95 \%$ of all perch collected in this study ( $\mathrm{n}=35,783$ ). Regarding these findings, we recommend that fishery managers at Lake Cascade continue using benthic otter trawls to monitor trends in juvenile perch abundance.


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## INTRODUCTION

Recruitment is one of the most important parameters affecting fish population abundance and size structure. For several species, including Yellow Perch (YLP) Perca flavescens, a variety of factors can influence recruitment and sources of variation are poorly understood. Although numerous biotic and abiotic interactions have been proposed to explain variation in perch recruitment, little research has been conducted to evaluate relative differences in catch between common sampling gears. Currently, fishery managers at Lake Cascade, Idaho use benthic otter trawls to monitor trends in relative abundance of young-of-year (YOY) and age-1 YLP (see Lake Cascade Juvenile Perch Trawling chapter in this report). However, several different gears (i.e., mini-fyke nets, cloverleaf traps, micro-mesh gill nets) have been used for monitoring YLP across their range (Mangan et al. 2005; Sullivan et al. 2019).

## OBJECTIVES

1. Determine relative precision and workload for five different sampling gears (benthic otter trawl, micro-mesh gill net, baited and non-baited cloverleaf trap, mini-fyke net) and develop a management recommendation for which gear-type to utilize as a recruitment index monitoring tool in the future.

## METHODS

This study was conducted in late summer when juvenile YLP are known to occupy nearshore habitat (Griswold and Bjornn 1992). We allocated effort evenly across available shoreline and selected sites based on suitable habitats for each sampling gear (avoided dense macrophyte beds, steep drop offs). At each site ( $n=15$ ), we set each gear approximately 50 m apart to fish overnight, so that individual gears did not compete with others. We included benthic otter trawl data from our August survey (see Lake Cascade Juvenile Perch Trawling chapter in this report) for the comparisons.

Mini-fyke nets were constructed with a $0.6 \times 1.2 \mathrm{~m}$ frame and two 0.6 m diameter hoops using 0.64 cm knotless nylon netting. Leads were 15.2 m long $\times 0.6 \mathrm{~m}$ deep with 0.64 cm knotless nylon netting. The benthic otter trawl dimensions were $2.16 \mathrm{~m} \times 4.5 \mathrm{~m}$ and 9 m long, constructed with 39 mm stretch-measure mesh in the body and 13 mm mesh in the cod end. The trawl included weighted otter doors to ensure the net remained open while in use (Hayes et al. 1996). The trawl had a 15 m bridle attached to a rope and was towed at approximately $4.0 \mathrm{~km} / \mathrm{h}$ in a zig-zag pattern. Micro-mesh nets were constructed of three different stretch-mesh sizes (1.27-, 1.91-, 2.54-cm) and 30.5 m long. Cloverleaf traps were three-lobe construction, measuring 71.1 cm wide by 38.1 cm tall. The gap between lobes measured 1.27 cm across to accommodate the entrance of small perch. Cloverleaf traps were "baited" with two different items: 15 cm cyalume glowsticks and chicken livers, placed or attached in the center of the trap.

To evaluate differences in catch among gears, we compared precision of mean catch-per-unit-effort (CPUE) using coefficient of variation (CV),

$$
C V=\left(\frac{s d}{\text { mean }}\right) * 100
$$

where $s d$ is the standard deviation around the mean and mean is the average CPUE of each gear. In addition to comparing precision, we sought to evaluate the relative efficiency of using each sampling method. To do this, we recorded the amount of time required to deploy each gear and process catch and calculated the average operational time per replicate. We then estimated the number of replicates required to detect a $20 \%$ change in the mean CPUE for each gear (Campbell et al. 1995). By multiplying the number of replicates required by the average operational time for each gear, and dividing by eight (hours in workday), we estimated the amount of effort required to achieve our target precision ( $n$ workdays).

All fish collected were measured (mm; TL) and weighed ( g ). If catch exceeded 90 fish, batch weights were estimated. For example, if less than 90 fish were collected; we measured each fish to the nearest mm . If more than 90 fish were collected, we measured lengths of three random batches of 30 fish. We then obtained an average weight across the three batches to estimate the total number of fish in the haul. Additionally, we measured all YLP that appeared to be age-1 or older in each haul.

## RESULTS

## Micro-mesh Gill Net

We caught a total of 25 YOY YLP and 12 age-1 YLP across 4 net nights of effort in 2021 (Table 10). Mean CPUE of YOY YLP was 10 (Figure 20; CV = 53) and on average, each set required 24 minutes of operational time to deploy, and process catch. We estimate that it would require 11 work days to achieve the level of precision required to detect a $20 \%$ change in mean CPUE using this gear (Table 11; Figures 21 and 22).

## Cloverleaf Trap with Cyalume Glowsticks

We caught a total of 914 YOY YLP and 1 age-1 YLP across 12 trap nights of effort in 2021 (Table 10). Mean CPUE of YOY YLP was 77 (Figure 20; CV = 102) and on average, each set required 13 minutes of operational time to deploy, and process catch. We estimate that it would require 22 work days to achieve the level of precision required to detect a $20 \%$ change in mean CPUE using this gear (Table 11; Figures 21 and 22).

## Cloverleaf Trap with Chicken Liver

We caught a total of 160 YOY YLP and 2 age-1 YLP across 8 trap nights of effort in 2021 (Table 10). Mean CPUE of YOY YLP was 20 (Figure 20; CV = 107) and on average, each set required 13 minutes of operational time to deploy, and process catch. We estimate that it would require 24 workdays to achieve the level of precision required to detect a $20 \%$ change in mean CPUE using this gear (Table 11; Figures 21 and 22).

## Benthic Otter Trawl

We caught a total of 35,783 YOY YLP across 21 hauls (5 min duration) in August 2021 (Table 10). See Lake Cascade Juvenile Yellow Perch Trawling chapter in this report for more detail. Mean CPUE of YOY YLP was 1704 (Figure 20; CV = 134) and on average, each set required 25 minutes of operational time to deploy, and process catch. We estimate that it would
require 74 workdays to achieve the level of precision required to detect a $20 \%$ change in mean CPUE using this gear (Table 11; Figures 21 and 22).

## Mini-Fyke Net

We caught a total of 943 YOY YLP and 2 age-1 YLP across 12 trap nights of effort in 2021 (Table 10). Mean CPUE of YOY YLP was 79 (Figure 20; CV = 290) and on average, each set required 25 minutes of operational time to deploy, and process catch. We estimate that it would require 344 workdays to achieve the level of precision required to detect a $20 \%$ change in mean CPUE using this gear (Table 11; Figures 21 and 22).

## DISCUSSION

In this study, we compared catch, precision, and relative efficiency of five different sampling gears to document changes in relative abundance of YOY and age-1 perch. The benthic otter trawl produced the highest catch of any gear, by orders of magnitude; accounting for ~95\% of all perch collected in this study $(n=35,783)$. Although it was not the most precise gear, it required the second fewest replicates to detect a $20 \%$ change in mean CPUE of age-1 perch. Micro-mesh gill nets were the most precise (CV = 52) and efficient gear (11 workdays) compared to all other gears for sampling YOY and age-1 perch. However, sample sizes were extremely low (CPUE < 10) and would likely limit the ability to effectively monitor juvenile perch in Lake Cascade. Although mini-fyke nets produced the second highest average catch of both age classes, they were the least precise and efficient of the five compared. Cloverleaf traps were the most efficient gear in terms of average operational time but caught fewer fish and were less precise than the benthic otter trawl at capturing age- 1 perch.

Benthic otter trawls have been used to survey the perch community in Lake Cascade since 2001 (see Lake Cascade Trawling chapter in this report) and has historically revealed shifts in juvenile perch survival and abundance. We recommend that fishery managers continue using benthic otter trawls to build upon existing trend datasets for monitoring perch production (relative abundance of YOY perch). In addition, we recommend that managers evaluate any potential relationships between recruitment estimates from annual gill netting surveys (see Lake Cascade Fall Annual Survey chapter in this report) and YOY production trends from benthic otter trawls.

## MANAGEMENT RECOMMENDATIONS

1. Continue using benthic otter trawls to build upon existing datasets for monitoring juvenile YLP production in Lake Cascade.
2. Determine if relationship exists between benthic otter trawl and fall gill net survey data to evaluate factors influencing juvenile perch abundance and survival in Lake Cascade.

Table 10. Number of sets $(N)$, mean catch-per-unit-effort (CPUE), coefficient of variation (CV), and mean operational time (minutes) across five gears at Lake Cascade, Idaho in 2021.

| Gear | $\boldsymbol{N}$ | CPUE | CV | Operational Time |
| :---: | :---: | :---: | :---: | :---: |
| Micro-mesh Gillnet | 4 | 10 | 53 | 24 |
| Cloverleaf Light | 12 | 77 | 102 | 13 |
| Cloverleaf Liver | 8 | 20 | 107 | 13 |
| Trawl | 21 | 1704 | 134 | 25 |
| Mini-Fyke Net | 12 | 79 | 290 | 25 |

Table 11. Minimum number of workdays required to detect a 10, 20, or $40 \%$ change in mean young-of-year catch-per-unit-effort between five gears at Lake Cascade, Idaho in 2021.

| \% Change | Micro-mesh <br> Gillnet | Cloverleaf <br> Light | Cloverleaf <br> Liver | Trawl | Mini-Fyke <br> Net |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 10 | 44 | 88 | 96 | 294 | 1377 |
| 20 | 11 | 22 | 24 | 74 | 344 |
| 40 | 3 | 5 | 6 | 18 | 86 |



Figure 20. Mean catch-per-unit-effort across five sampling gears used in Lake Cascade, Idaho in 2021.


Figure 21. The number of workdays required to detect a given change in mean young-of-year Yellow Perch catch-per-unit-effort (CPUE) collected in Lake Cascade, Idaho in 2021.

.... Micro-mesh Gilllnet- - Trawl —Cloverleaf Liver— .Cloverleaf Light— 'Mini Fyke Net

Figure 22. The number of workdays required to detect a given change in mean estimated age-1 Yellow Perch catch-per-unit-effort (CPUE) collected in Lake Cascade, Idaho in 2021.

## LAKE CASCADE JUVENILE YELLOW PERCH TRAWLING

## ABSTRACT

Bottom trawl surveys have been employed at various times throughout the management history of Lake Cascade (1998-2011 and 2019-2021) to monitor trends in relative abundance and sizes of juvenile Yellow Perch (YLP) Perca flavescens. In August 2021, we conducted trawls across 21 historic sites (i.e., 3 lake divisions; 7 transects each). In total, we collected 35,783 juvenile YLP ( $\sim 97 \%$ estimated age-0). Mean lengths of young-of-year YLP were 37 mm (range = 25-60) in August. In the future, we will continue monitoring juvenile YLP production using August trawl surveys unless at some point it is determined to not be an accurate index of fishery recruitment.

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## INTRODUCTION

A bottom trawl was utilized from 1998 through 2011 to monitor the Yellow Perch (YLP) Perca flavescens population in Lake Cascade, ID before being discontinued in 2012 in lieu of standardized gill netting surveys. Recent post hoc analysis of historic trawl data (Thomas et al. 2021) revealed a relationship between numbers of young-of-year (YOY) YLP and recruitment of harvestable-sized YLP to the fishery four to five years later (in gill net catch). Trawling was reinstated in 2019 and 2020 to explore this approach for indexing recruitment of YLP in Lake Cascade. Trawling data appears effective at monitoring trends in YOY, and to a lesser degree, age-1 YLP abundance in Lake Cascade. Combined with annual gill netting survey data, this approach could allow managers to evaluate factors influencing juvenile recruitment and identify strong year classes to forecast future fishery quality in Lake Cascade.

See Thomas et al. (2021) for a comprehensive review of historic trawling activities in Lake Cascade.

## OBJECTIVES

1. Determine 2021 YLP YOY relative abundance and mean size compared to previous years, utilizing bottom trawl surveys.

## METHODS

We used the same lake area divisions (i.e., east, west, and south), effort, and transect sites developed in 1998 and 1999, described by Janssen et al. (2003). We sampled all trawl sites ( $n=21$ ) in August 2021. Each lake area division contained seven trawl sites. Trawls were conducted as close as possible to established sites, although slight modifications were made to avoid dense macrophyte beds that could foul the trawl in some areas. Upon completing each trawl, we counted all YLP either individually or with pound counts of YOY fish (depending on numbers caught). For example, if less than 100 fish were collected; we measured each fish to the nearest mm TL. If more than 100 fish were collected, we measured lengths of three random batches of 30 fish. We then obtained an average weight $(\mathrm{g})$ across the three batches to estimate the total number of fish in the haul. Additionally, we measured all YLP that appeared to be age-1 or older in each haul. Visual analysis of length-frequency histograms were then used to estimate the minimum length of age-1 fish caught and to calculate mean lengths of YOY separately from YLP > age-1.

## RESULTS

In total, we completed 21 trawl hauls (effort = 105 min ) and collected 35,783 YLP (mean catch $=1,703$ fish per trawl) in 2021 (Table 12). Overall catch of YOY YLP increased in 2021 and was the highest observed since 2009 (Table 13; Figure 23). Similar to 2020, catch was highest in the east section ( $n=16,217$ ) compared to the south ( $n=11,574$ ), and west ( $n=7,992$ ) sections (Table 12; Figure 24). Using length-frequency histograms, we estimated the lengths of YOY YLP to be between 25 and 60 mm (mean $=37 \mathrm{~mm}$ TL; Table 13; Figure 25). Average length of YOY
fish in 2021 were the second lowest on record and were only lower in 2008 when one of the largest cohorts in Lake Cascade was produced following fishery restoration efforts. We estimated the lengths of age-1 YLP to be between 61 and 150 mm TL. Of fish measured, we estimated that $96.7 \%$ of our trawl catch were YOY YLP in 2021 ( $n=1,466$ YOY and $n=52$ age-1).

## DISCUSSION

In 2021, catch rates of juvenile YLP was the second highest observed across all years trawling has been conducted in Lake Cascade (Table 13; Figure 26). Greater numbers of juvenile YLP were collected only during 2008, a strong year-class that recruited to the fishery increasing the quality of the sport fishery in recent years (Thomas et al. 2021; Figure 26). Although catch has been high in recent years, we have not observed very many age-1 YLP in our trawl catch, which may indicate high over-winter mortality of YOY YLP in Lake Cascade. In contrast, the 2008 cohort was dominant as age-1 fish in trawling surveys in 2009 - indicating excellent survival from fall 2008 through summer 2009. Previous research has shown high mortality rates of YOY YLP during their first over-winter period may be associated with high levels of predation (Fitzgerald et al. 2006). In Lake Cascade and similar waterbodies, predation of YOY YLP by Northern Pikeminnow (NPM) Ptychocheilus oregonensis (Bennett et al. 2004), adult YLP (Janssen et al. 2020; Thomas et al. 2021), and Smallmouth Bass (SMB) Micropterus dolomieu (Dembkowski et al. 2015) is common and cursory examination of stomach contents have often revealed several YOY per stomach; however, it is not clear if total predation is driving year class strength or under what conditions.

Currently, it is unclear when year class strength is set in Lake Cascade, which limits our ability to effectively index YLP recruitment and forecast fishery quality (Dembkowski et al. 2022). However, through post hoc analysis of historic trawl data in 2020, we observed a possible relationship between mean August trawl catch of YOY and numbers of harvestable-sized YLP (age-4 and -5) in gill net catch four to five years later (Figure 26; Thomas et al. 2021). Therefore, we will continue monitoring juvenile YLP production using August trawl surveys until we are able to evaluate its efficacy as an index of fishery recruitment (i.e., 2020 trawl catch will be compared to 2024 gill net catch, and so on). YOY growth also appears to be density-dependent and managers should continue to report average lengths of juvenile perch so that this relationship can also be evaluated in future years (Table 13; Figure 27). If a strong relationship exists that isn't related to environmental factors, then less trawling could be required to obtain a relatively precise average length measurement that could be used to monitor juvenile perch production, growth conditions, and survival. In the meantime, we will work closely with University of Idaho researchers on Lake Cascade in 2022-2023 to evaluate the relative influences of predation from NPM, YLP, and SMB to determine if, or when, juvenile YLP bottlenecks occur in Lake Cascade. This information will provide a solid foundation for addressing questions related to fish community interactions and predation in Lake Cascade.

## MANAGEMENT RECOMMENDATIONS

1. Continue monitoring juvenile YLP production using August trawl surveys.
2. Continue to evaluate relationship between trawl catch, mean lengths, and gill net catch to determine if juvenile perch abundance, growth, and survival can be monitored through trawling and gill netting each year on Lake Cascade.

Table 12. Trawl catch (total and mean), average length (mm) and range, proportion of young-of-year to estimated age-1 Yellow Perch (\%), by lake section (i.e., East, West, South) in Lake Cascade, Idaho in August 2021.

| Lake Division | $\boldsymbol{n}$ | Total Catch | Mean CPUE | Mean <br> Length | Range | $\%$ <br> YOY |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: |
| East | 7 | 16,217 | $2,317 \pm 946$ | 37 | $26-58$ | 98.9 |
| West | 7 | 7,992 | $1,142 \pm 502$ | 36 | $25-57$ | 98.8 |
| South | 7 | 11,574 | $1,653 \pm 943$ | 39 | $26-60$ | 97.5 |

Table 13. August Trawl catch (total and mean) and average total length of young-of-year Yellow Perch (mm) between 2003-2011 and 2020-2021 in Lake Cascade, Idaho.

| Year | Total Catch | Mean Catch | YOY TL |
| :--- | ---: | ---: | ---: |
| 2003 | 33 | 2 | -- |
| 2004 | 1,259 | 57 | -- |
| 2005 | 7,278 | 347 | -- |
| 2006 | 15,110 | 720 | 44.2 |
| 2007 | 25,945 | 1,235 | 41.1 |
| 2008 | 63,691 | 3,032 | 33.6 |
| 2009 | 34,718 | 1,736 | $51.9^{1}$ |
| 2010 | 2,332 | 111 | 45.6 |
| 2011 | 15,910 | 758 | 46.3 |
|  | -- discontinued -- |  |  |
| 2020 | 22,627 | 1,078 | 39.4 |
| 2021 | 35,783 | 1,703 | 36.8 |

${ }^{1}$ Possibly influenced by abundant, relatively small age-1 perch.


Figure 23. Mean August trawl catch of juvenile Yellow Perch with $90 \%$ confidence intervals collected with bottom trawl in Lake Cascade, Idaho from 2003 through 2021.


Figure 24. Relative length-frequency histogram of YOY Yellow Perch collected by lake division (i.e., East, West, South) with a bottom trawl in Lake Cascade, Idaho in August 2021.


Figure 25. Relative length-frequency histogram of Yellow Perch YOY collected with a bottom trawl in Lake Cascade, Idaho in August 2021.


Figure 26. Linear relationship between mean August trawl catch (2007-2011) of juvenile Yellow Perch and subsequent gill net catch four to five years later (i.e., 2012-2016) in Lake Cascade, Idaho.


Figure 27. August trawl catch and mean total length (mm) of juvenile Yellow Perch collected with a bottom trawl in Lake Cascade, Idaho from 2003 to 2021.

## LAKE CASCADE YELLOW PERCH EXPLOITATION STUDY

## ABSTRACT

To index trends in angler harvest (exploitation) of Yellow Perch (YLP) Perca flavescens in Lake Cascade, we have utilized the Tag-You're-It program since 2009. We collected and tagged $n=1,019$ YLP from April 21 to May 5, 2021, ranging in size from 180 to 404 mm (mean length = 291 mm ) with non-reward tags. We had 59 non-reward tags returned through March, 2022. We estimate an adjusted exploitation and use (catch and release) rate of $10 \%$ and $12 \%$, respectively, in 2021. Fishing mortality on adult perch in Lake Cascade is low, and many fish are reaching maximum age and dying of old age before being harvested by anglers. The data gathered through this tagging and exploitation study indicate that harvest restrictions for YLP on Lake Cascade are not warranted biologically.

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## INTRODUCTION

Lake Cascade is a world-class Yellow Perch (YLP) Perca flavescens fishery that attracts anglers from Idaho, surrounding states, the Midwest, and Canada. As the fishery improved in years following YLP restoration efforts (See Janssen et al. 2020), angling effort has increased (see Lake Cascade Holiday Angler Counts section, this report). Current fishing regulations at Lake Cascade do not restrict harvest of YLP (i.e., no bag, size, or possession limits). As such, during informal scoping of the fishery, several anglers commonly express concerns that overharvest of YLP is a threat to the future quality of the sport fishery. To index angler harvest (exploitation), we have utilized the Tag-You're-IT program (Meyer et al. 2012) since 2009 to monitor trends in exploitation through time. These data assist managers with determining whether harvest restrictions could improve the fishery. See Janssen et al. 2020 for a comprehensive review of past YLP tagging studies at Lake Cascade.

## OBJECTIVES

1. Evaluate current YLP exploitation and use rates to determine if angling harvest can negatively impact the quality of the fishery.

## METHODS

We used standard Idaho Department of Fish and Game (IDFG) trap nets described in IDFG 2012 set at various locations throughout the lake in the spring, shortly after ice-out, to collect spawning YLP large enough to be vulnerable to harvest (> 250 mm TL). Trap net locations were dispersed over a variety of habitats and locations throughout the lake. Trap nets were attached to, or very near shoreline at locations with a gradual slope such that depths were equal to, or slightly exceeded the height of the trap frame ( 1.8 m ). Trap nets were set in water depths less than 5 m . All YLP captured were measured to the nearest mm and tagged with a bright orange Tbar anchor tag (FLOY, Inc) between the vertebral skeleton and the dorsal fin base. Each unique tag number was entered into the "Tag-You're-lt" database, along with the length of each fish. Methods used to estimate exploitation and use rates of tagged fish are presented in Meyer et al. (2012).

To estimate single-year exploitation in 2021, we included all tag returns reported through March 2022, using an estimated tag loss rate of $1.2 \%$ and an angler reporting rate of $58.5 \%$ (Meyer et al. 2012). For all previous years reported, we estimated single-year exploitation using the same adjusted rates.

## RESULTS

We collected and tagged 1,019 YLP between April 21 and May 5, 2021 (Table 14). Lengths of tagged fish ranged from 180 to 404 mm (mean = 291 mm ; Figure 28). Anglers reported 59 tags in 2021, which corresponds with an adjusted exploitation estimate of $10 \%$ and use (caught and released) estimate of $12 \%$. Annual exploitation rates in Lake Cascade since 2009 have
ranged from a low of $7 \%$ (2015) to a high of $16 \%$ (2009), with an overall mean through 2021 of 12\% (Table 14).

## DISCUSSION

Isermann et al. (2005) reported that little information is available in the literature regarding YLP exploitation rates in recreational fisheries, but that rates are generally less than $30 \%$ and may occasionally exceed 60\%. In Lake Cascade, YLP exploitation rates are much lower than these reported values, averaging 12\% across all years through 2021. These results suggest that fishing mortality likely has little impact on YLP abundance and size structure in Lake Cascade (see Thomas et al. 2021 for additional information). In the future, we recommend that managers consider using reward tags (\$50) in addition to non-reward tags, so that a lake-specific reporting rate can be estimated which could improve our ability to monitor trends in angler exploitation and use through time. We also recommend that managers conduct annual tagging surveys to estimate annual fishing mortality rates in Lake Cascade. We do not recommend any changes to current harvest regulations at Lake Cascade.

## MANAGEMENT RECOMMENDATIONS

1. Continue monitoring trends in exploitation and use by tagging YLP in the spring following ice-out.
2. Include reward tags in the 2022 tagging study to estimate a lake-specific angler reporting rate.
3. Explore opportunities to utilize tagging data to develop models of fishing mortality.

Table 14. Number of Yellow Perch released with tags ( $n$ Tagged), adjusted exploitation rate and use estimates based on tagging studies conducted between 2009 and 2021 in Lake Cascade, Idaho.

| Year | $\boldsymbol{n}$ Tagged | Exploitation (\%) | Use (\%) |
| :---: | :---: | :---: | :---: |
| 2009 | 379 | 16 | 20 |
| 2013 | 493 | 15 | 17 |
| 2015 | 445 | 7 | 7 |
| 2018 | 370 | 10 | 10 |
| 2019 | 99 | 12 | 12 |
| 2021 | 1,019 | 10 | 12 |
|  | Average: | 12 | 13 |



Figure 28. Length-frequency histogram of Yellow Perch tagged between April 21 and May 5, 2021, in Lake Cascade, Idaho.

## LAKE CASCADE HOLIDAY ANGLER COUNT INDEX

## ABSTRACT

Holiday angler counts have been conducted annually at Lake Cascade since 1996 as an index of trends in angling effort. We count shore anglers and fishing boats on Lake Cascade each year on Memorial Day, Independence Day, and Labor Day, to assess trends in angling effort relative to previous years. In 2021, we conducted angler counts on Memorial Day and Independence Day. We counted four shore anglers and 22 fishing boats on Memorial Day, and 3 shore anglers and 35 fishing boats on Independence Day. Mean holiday index counts in 2021 for shore anglers and number of fishing boats was 4 and 29, respectively for a combined index count of 33 .

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## INTRODUCTION

We have conducted annual shore angler and fishing boat counts on Memorial Day, Independence Day, and Labor Day each year since 1996 to monitor long-term trends in angling effort on Lake Cascade.. These holiday angler counts started just prior to the collapse of the Yellow Perch (YLP) Perca flavescens fishery in the early 2000s (see Janssen et al. 2020 for historical background on the fishery) and have provided managers with a relatively inexpensive tool to monitor relative changes in angling effort over the past 25 years. We completed holiday angler counts again in 2020 to add to the long-term trend dataset.

## OBJECTIVES

1. Conduct holiday counts in 2021 to assess trends in angling effort trends on Lake Cascade.

## METHODS

The total number of shore anglers and fishing boats (boats - not boat anglers) were enumerated on Memorial Day and Independence Day on Lake Cascade in 2021. Each day, a single count was conducted beginning at 10:00 AM and ending at approximately 1:00 PM, or after the entire lake was surveyed. We used a motorized boat to travel the perimeter of the entire lake. We averaged the counts of shore anglers and fishing boats across both surveys to derive an index count for 2021, identical to previous years. In addition to the count data, we also recorded weather conditions on each holiday (e.g., air temperature and quality, atmospheric conditions).

## RESULTS

On Memorial Day in 2021, we counted four shore anglers and 22 fishing boats. On Independence Day we counted three shore anglers and 35 fishing boats. Mean index counts for shore anglers and fishing boats were four and 29, respectively, for a combined mean index total of 33 (Table 15; Figure 29). Although our mean index count was lower than 2020, it remained higher than the pre-restoration period (2000-2004). In general, angler counts have increased since fishery restoration efforts in 2004 through 2006 (Table 16; Figure 29).

## DISCUSSION

In general, angler counts have increased since the Yellow Perch restoration project (20042006). A comprehensive creel survey will be conducted between 2021 and 2022 and fishery managers should evaluate the relationship between creel estimates (1982, 1992, 2009, 2016) and holiday counts to ensure that these index data remain a useful method for monitoring trends in angling use on Lake Cascade. Moving forward, fishery managers should evaluate the feasibility of using electro-magnetic car counters to monitor trends in angling use at Lake Cascade and determine if a relationship exists between the car counter data and the holiday count trend dataset.

## MANAGEMENT RECOMMENDATIONS

1. Continue holiday index counts to monitor trends in angler effort at Lake Cascade.
2. Continue to work with fisheries biometrician to develop repeatable methodology (electro-magnetic car counters) for monitoring trends in angling use and harvest on an annual or semi-annual basis at Lake Cascade. Determine whether it is appropriate to replace holiday counts with this method of monitoring effort.

Table 15. Weather conditions and total counts of shore anglers and fishing boats conducted on Memorial Day and Independence Day on Lake Cascade, Idaho in 2021.

| Holiday | Shore Anglers | Fishing Boats | Weather |
| :--- | :---: | :---: | :---: |
| Memorial | 4 | 22 | Good $^{1}$ |
| Independence | 3 | 35 | Good $^{1}$ |
| Labor | -- | -- | NA |
| Mean: | 4 | 29 |  |
| ${ }^{1}$ Sunny and low winds |  |  |  |

Table 16. Mean boat and shore angler counts on Lake Cascade, Idaho on three major holidays including Memorial Day, July $4^{\text {th }}$, and Labor Day, in 1982, 1991, 1992, 1996-2010, and 2014-2021 with corresponding intensive creel survey angler hour estimates for 1982, 1992, 2009, and 2016.

| Year | Holiday counts |  |  | Creel surveyed angler hours |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Fishing Boats | Shore Anglers | total | Boat anglers | Shore anglers | $\begin{gathered} \hline \text { Ice } \\ \text { anglers } \\ \hline \end{gathered}$ | Total Pressure |
| $1968{ }^{1}$ | -- | -- | 0 | 32.3 | 27.4 | na | 59.7 |
| $1969{ }^{1}$ | -- | -- | 0 | 38.7 | 27.9 | na | 66.6 |
| $1970{ }^{1}$ | -- | -- | 0 | 53.3 | 24.8 | na | 81.3 |
| 1982 | 154 | 85 | 239 | 254.6 | 119.9 | 39.8 | 414.2 |
| 1986 | na | na | 0 | 212.8 | 128.2 | 50.8 | 391.8 |
| 1991 | 42 | 32 | 74 | 135.2 | 102 | 13.8 | 237.2 |
| 1992 | 52.5 | 28 | 80.5 | 144.2 | 177.3 | 61.7 | 321.5 |
| 1996 | 35 | 27 | 62 | -- | -- | -- | -- |
| 1997 | 37 | 19 | 56 | -- | -- | -- | -- |
| 1998 | 58 | 40 | 98 | -- | -- | -- | -- |
| 1999 | 27 | 31 | 58 | -- | -- | -- | -- |
| 2000 | 15 | 12 | 27 | -- | -- | -- | -- |
| 2001 | 11 | 12 | 23 | -- | -- | -- | -- |
| 2002 | 17 | 12 | 29 | -- | -- | -- | -- |
| 2003 | 17 | 6 | 23 | -- | -- | -- | -- |
| 2004 | 23 | 9 | 32 | -- | -- | -- | -- |
| 2005 | 28 | 13 | 41 | -- | -- | -- | -- |
| 2006 | 25 | 23 | 48 | - | - | -- | - |
| 2007 | 24 | 28 | 52 | - | _ | -- |  |
| 2008 | 34 | 37 | 71 | - |  | -- | -- |
| 2009 | 29 | 29 | 58 | 29.2 | 23.1 | 17.9 | 70.6 |
| 2010 | 23 | 22 | 45 | -- | -- | -- | -- |
| 2014 | 63 | 54 | 117 | -- | -- | -- | -- |
| 2015 | 44 | 42 | 86 | -- | -- | -- | -- |
| 2016 | 22 | 16 | 38 | 31.8 | 22.1 | 11.1 | 65 |
| 2017 | 36 | 24 | 60 | -- | -- | -- | -- |
| 2018 | 52 | 23 | 75 | -- | -- | -- | -- |
| 2019 | 38 | 41 | 79 | -- | -- | -- | -- |
| 2020 | 57 | 40 | 97 | -- | -- | -- | -- |
| $2021{ }^{4}$ | 29 | 4 | 33 |  |  |  |  |
| ${ }^{1}$ Creel survey from mid-April thru late October 1968, 1969, 1970 <br> ${ }^{2}$ Creel survey from May 15, 2009 thru May 30, 2010 <br> ${ }^{3}$ Creel survey from May 1, 2016 thru March 31, 2017 <br> ${ }^{4}$ Counts not conducted on Labor Day in 2021 |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |



Figure 29. Mean index counts of shore anglers and number of fishing boats on Lake Cascade, Idaho on Memorial Day, Independence Day, and Labor Day, 2000-2021. Note: Counts were not conducted on Labor Day in 2021.

## LAKE CASCADE ANNUAL FALL GILL NETTING SURVEY


#### Abstract

Annual gill netting surveys are conducted in Lake Cascade each October to monitor changes in abundance and size structure of the fish community. In 2021, we collected 1,330 fish of 13 species. Yellow Perch (YLP) Perca flavescens comprised 23.8\% of the catch ( $n=317$ ), Smallmouth Bass Micropterus dolomeiu comprised 11.7\% of the catch ( $n=156$ ), and Rainbow Trout Oncorhynchus mykiss comprised $1.9 \%$ of the catch ( $n=25$ ). Northern Pikeminnow (NPM) Ptychocheilus oregonensis, Largescale Sucker Catostomus macrocheilus, and Black Bullhead Ameiurus melas comprised $28.1 \%(n=374)$, $18.0 \%(n=239)$, and $8.9 \%(n=119)$ of the catch, respectively. Relatively few Mountain Whitefish Prosopium williamsoni ( $n=19,1.4 \%$ ), kokanee O. nerka ( $n=8,0.6 \%$ ), Pumpkinseed Lepomis gibbosus ( $n=30$, 2.3\%), Largemouth Bass Micropterus salmoides ( $n=27,2.0 \%$ ), Coho Salmon Oncorhynchus kisutch ( $n=12,0.9 \%$ ), Black Crappie Pomoxis nigromaculatus ( $n=2,0.2 \%$ ), and Bridgelip Sucker Catostomus columbianus ( $n=2,0.2 \%$ ) were collected. Total catch, catch-per-unit-effort (CPUE) and CPUE $>250 \mathrm{~mm}$ of YLP were the highest observed since 2016. CPUE of NPM increased significantly in 2021 (25 fish per site $\pm 9$ ) from $2020(11 \pm 3)$ while CPUE of NPM greater than 350 mm has remained stable since 2016 ( $5 \pm 2$ in 2021).


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## INTRODUCTION

Lake Cascade is a very popular and economically important recreational fishery in Idaho. Gill netting surveys are conducted every October in Lake Cascade to monitor changes in abundance and size structure of the fish community. Since 2012, these surveys have been standardized to occur on or near the same dates, at the same sites, and with the same amount of effort and gear type. These data are used to assess fishery quality and determine what, if any, management intervention is needed to improve the sport fishery.

See Janssen et al. 2020 for a comprehensive review of past fisheries management activities in Lake Cascade.

## OBJECTIVES

1. Monitor trends in abundance, size structure, and condition of the fish community to guide management actions.

## METHODS

A total of 15 gill net sites (described by Janssen et al. 2014) were sampled between October 5 and 9, 2021. Each site was sampled once with paired (i.e., one floating and one sinking) IDFG standard experimental gill nets ( $46 \mathrm{~m} \times 2 \mathrm{~m}$; 6 panels of 19-, 25-, 32-, 38-, 51-, and 64-mm bar mesh). Sinking gill nets were attached to shore at littoral sites or in at least one meter of water in low-slope, shallow off-shore sites. Floating gill nets were set as close to the sinking net as possible (often directly attached), in at least three meters of water. All nets were set overnight and pulled the following day. Catch-per-unit-effort (CPUE = mean number of fish per pair of gill nets at a site; $\pm 90 \%$ confidence intervals) was calculated to compare relative abundance between years. Significant differences in CPUE between years were revealed when $90 \%$ confidence intervals did not overlap.

All fish were identified to species, measured for total length (mm), and weighed (g). Length- or relative-frequency histograms were made to show size structure of species sampled. Proportional stock density (PSD-Q) and incremental relative stock density (RSD) for Yellow Perch (YLP) Perca flavescens (stock length $=130 \mathrm{~mm}$, quality length $=200 \mathrm{~mm}$ ) and Smallmouth Bass (SMB) Micropterus dolomieu (stock length $=180 \mathrm{~mm}$, quality length $=300 \mathrm{~mm}$ ) were calculated to summarize and compare size structure between years (Gabelhouse 1984; Neumann et al. 2012). Relative weight ( $\mathrm{W}_{\mathrm{r}}$ ) was calculated as an index of body condition using length and weight data (Blackwell et al. 2000; Kolander et al. 1993; Willis et al. 1991).

## RESULTS

We caught a total of 1,330 fish of 13 species in Lake Cascade during the 2021 annual survey (Table 17). YLP comprised $23.8 \%$ of the catch ( $n=317$ ), SMB comprised $11.7 \%$ of the catch ( $n=156$ ), and Rainbow Trout (RBT) Oncorhynchus mykiss comprised 1.9\% of the catch ( $n$
= 25). Northern Pikeminnow (NPM) Ptychocheilus oregonensis, Largescale Sucker Catostomus macrocheilus, and Black Bullhead Ameiurus melas comprised 28.1\% ( $n=374$ ), 18.0\% ( $n=239$ ), and $8.9 \%(n=119)$ of the catch, respectively. Relatively few Mountain Whitefish Prosopium williamsoni ( $n=19,1.4 \%$ ), kokanee O. nerka ( $n=8,0.6 \%$ ), Pumpkinseed Lepomis gibbosus ( $n$ = 30, 2.3\%), Largemouth Bass Micropterus salmoides ( $n=27,2.0 \%$ ), Coho Salmon (COH) O. kisutch ( $n=12,0.9 \%$ ), Black Crappie Pomoxis nigromaculatus ( $n=2,0.2 \%$ ), and Bridgelip Sucker Catostomus columbianus ( $n=2,0.2 \%$ ) were collected (Table 17). Relative length-frequencies of all fish caught (except Black Crappie and Bridgelip Sucker) in 2021, by species, are shown in Figure 30.

In our 2021 survey, relative abundance (mean CPUE $\pm 90 \% \mathrm{CI}$ ) of YLP ( $21 \pm 8$ ) remained similar to $2020(20 \pm 6)$, while mean CPUE of YLP > 250 mm increased from $11 \pm 5$ to $16 \pm 6$ (Figures 31 and 32). The increase in catch of YLP > 250 was expected (Thomas et al. 2021), following increased catch of YLP between 200 and 250 mm in 2020. While relative abundance remains lower than the first five years of standardized monitoring, catch rates have improved since 2017 and remained stable since 2019 (Figure 31). In 2021, lengths of YLP ranged from 135 to 400 mm (mean $=285 \mathrm{~mm}$ ) and mean $\mathrm{W}_{\mathrm{r}}$ was 86 (Table 17; Figure 35). PSD-Q was 93 and RSD-250, -300 , and -380 were 75,40 , and 3 , respectively (Table 18).

Overall catch of NPM more than doubled in $2021(n=374)$ compared to $2020(n=166)$, which is concerning (Janssen et al. 2020). Mean CPUE was the highest observed since standardized monitoring began in 2012 (Figure 33). While overall catch increased in 2021, mean CPUE of NPM > $350 \mathrm{~mm}(5 \pm 2)$ has remained relatively low and stable since 2016 (Figure 34). Lengths of NPM ranged from 91 to 576 mm (mean $=301 \mathrm{~mm}$; Table 17; Figure 36).

We sampled 25 RBT in 2021, of which 15 appeared to be of natural origin (Tables 17 and 20). These natural-origin RBT ranged in length from 180 to 548 mm , with a mean relative weight of 83 (Tables 17 and 20; Figure 30). Hatchery origin RBT ranged in length from 332 to 505 mm , with a mean relative weight of 88 (Tables 17 and 20; Figure 30). We also collected 12 COH in our survey, which indicates recent stocking efforts (2020) were successful. These fish appear to be growing rapidly based on the average length of COH caught in our survey (mean length at age-2 $=355 \mathrm{~mm}$ TL; Table 17; Figure 30).

We collected 156 SMB in 2021 ranging between 150 and 532 mm (mean $=367 \mathrm{~mm}$ ) and mean relative weight was $W_{r}=92$ (Table 17; Figure 30). Mean catch per site was $10 \pm 6$ and PSD-Q, RSD-400, and RSD-480 were 98, 27, and 3, respectively (Table 21). Total catch, CPUE, and PSD-Q were the highest observed since standardized monitoring began in 2012 (Table 21).

Although total catch of Black Bullhead was high ( $n=119$ ), it remained highly variable (mean CPUE $=8 \pm 5$ ) in $2021(90 \% \mathrm{Cl}$ in $2020=19)$. With the exception of Largescale Sucker, which has remained stable in abundance over the last three years (mean CPUE $=16 \pm 4$; CPUE $=15 \pm 4$ in 2020), the remaining species (i.e., Largemouth Bass, Mountain Whitefish, Black Crappie, Pumpkinseed, Bridgelip Sucker) captured in our survey appear to be either low in relative abundance or inadequately sampled by our gill nets (Table 17; Figure 30).

## DISCUSSION

In 2021, NPM were the most common species collected in our gill net survey (28\%). Overall mean abundance of NPM increased from 11 fish per site in 2020, to 25 fish per site in

2021, whereas mean CPUE of NPM > 350 mm has remained relatively low and stable (since 2016; Figures 6 and 7). This increase is concerning because previous research (Bennett 2004) has indicated that NPM predation and competition can negatively affect the quality of the sport fishery (Janssen et al. 2020). However, NPM catch in 2021 did not exceed the action thresholds outlined in IDFG's 2019-2024 Fisheries Management Plan (FMP; IDFG 2019). The FMP specifies that adult NPM abundance should be aggressively reduced if mean CPUE of NPM > 350 mm reaches or exceeds 10 ( $5 \pm 1$ in 2021), and the proportion of NPM > 350 mm reaches or exceeds $75 \%$ during fall-gillnetting ( $20 \%$ in 2021). Therefore, no direct management interventions are warranted to control NPM abundance at this time, according to current FMP action thresholds.

Fortunately, overall catch of YLP has improved since 2019 and remained stable, while catch of YLP > 250 mm has increased in recent years (Figures 31 and 32). Although mean CPUE of YLP has improved in recent years, the overall trend is concerning. Relative abundance of YLP remains lower than the first five years of standardized monitoring (2012-2016), and we have not observed any substantial increases in recruitment of harvestable-sized YLP (i.e., > age-4) since 2013 (Thomas et al. 2021; Figure 37). See Thomas et al. (2021) for a discussion of factors that could be limiting recruitment of YLP in Lake Cascade. To address these concerns, we will be conducting a graduate research study on Lake Cascade beginning in 2022 to evaluate seasonal patterns in growth, body condition, and food habits of three dominant fish species: YLP, NPM, and SMB. Additionally, the study will evaluate the relative impact of predation on juvenile YLP using a combination of bioenergetics and age-structured population models. Ultimately, these data will provide insight on factors affecting recruitment and survival of juvenile YLP, which will be used to direct management actions and provide a more consistent YLP fishery.

RBT are also an important component of the sport fishery in Lake Cascade. Unfortunately, gill net catch for RBT can vary greatly from year to year due to timing of stocking events and challenges associated with sampling pelagic areas in Lake Cascade. Natural-origin RBT remain an important component of this popular fishery ( $60 \%$ of catch), although little is known about these fish. Evaluations of spawning tributaries should be conducted (juvenile abundance, survival, and entrainment) to determine if management actions can improve productivity of natural-origin RBT in Lake Cascade.

Additionally, we observed COH in our gill net catch (following a single stocking event in 2020) in 2021. This is encouraging because COH have not been stocked in Lake Cascade since 2011 and have historically contributed to a large component of the sport fishery. In addition to stream monitoring (see Thomas et al. 2021), we will incorporate pelagic gill nets set in combination with our standard gill netting effort to begin monitoring trends in RBT, KOK, and COH population characteristics in Lake Cascade.

While bass are another important component of the sport fishery at Lake Cascade, Iow water conductivity ( $15-20 \mu \mathrm{~S}$ ) precludes the use of electrofishing, and gill nets are typically not set in ideal bass habitat due to logistical constraints. Exploitation tagging investigations, in addition to monitoring growth by collecting ageing structures during annual netting surveys, may be the best option for identifying trends in the SMB population over time in the reservoir. Our standard monitoring efforts indicate that relative abundance and size structure has remained stable since standardized monitoring began in 2012 (Table 21).

## MANAGEMENT RECOMMENDATIONS

1. Continue standard annual monitoring of the Lake Cascade fishery as a status index.
2. Incorporate pilot pelagic netting efforts in 2022 to monitor RBT, KOK, and COH .
3. Conduct evaluations of RBT spawning tributaries to determine if productivity of natural origin RBT can be increased.
4. Assist Lake Cascade graduate student with evaluation of seasonal patterns in growth, body condition, and food habits of YLP, NPM, and SMB.

Table 17. Total numbers of fish caught, relative weights, mean catch-per-unit-effort (CPUE $\pm 90 \% \mathrm{Cl}$ ), and total length (TL) by species collected with gill nets in Lake Cascade in October 2021.

| Species | Total <br> Catch | Mean <br> CPUE $\pm \mathbf{C l}$ | Mean <br> $\mathbf{W}_{\mathbf{r}}$ | Mean <br> TL | Min TL | Max TL |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Yellow Perch | 317 | $21 \pm 8$ | 86 | 285 | 135 | 400 |
| Northern Pikeminnow | 374 | $25 \pm 9$ | -- | 301 | 91 | 576 |
| Smallmouth Bass | 156 | $10 \pm 6$ | 92 | 367 | 150 | 532 |
| Rainbow Trout (Natural) | 15 | $1 \pm 1$ | 83 | 438 | 180 | 548 |
| Rainbow Trout (Hatchery) | 10 | $1 \pm 1$ | 88 | 437 | 332 | 505 |
| Kokanee salmon | 8 | $1 \pm 1$ | 104 | 329 | 260 | 395 |
| Coho Salmon | 12 | $1 \pm 1$ | -- | 355 | 314 | 430 |
| Largemouth Bass | 27 | $2 \pm 1$ | 117 | 205 | 132 | 450 |
| Largescale Sucker | 239 | $16 \pm 3$ | -- | 496 | 170 | 655 |
| Bridgelip Sucker | 2 | $0.1 \pm 0.1$ | -- | -- | 355 | 409 |
| Black Crappie | 2 | $0.1 \pm 0.2$ | 105 | -- | 295 | 296 |
| Mountain Whitefish | 19 | $1 \pm 1$ | 100 | 326 | 223 | 415 |
| Pumpkinseed | 30 | $2 \pm 1$ | -- | 139 | 95 | 189 |
| Black Bullhead | 119 | $8 \pm 5$ | 83 | 291 | 200 | 395 |
| Grand Total: | $\mathbf{1 3 3 0}$ |  |  |  |  |  |

Table 18. Proportional (PSD) and incremental Relative Stock Densities** (RSD) for 250-, 300-, and $380-\mathrm{mm}$ Yellow Perch (total length) collected annually with gill nets in Lake Cascade in October 2012 through 2021.

| Year | PSD | RSD-250 | RSD-300 | RSD-380 |
| :--- | :---: | :---: | :---: | :---: |
| 2012 | 69 | 45 | 27 | 1 |
| 2013 | 66 | 27 | 13 | 1 |
| 2014 | 89 | 65 | 32 | 1 |
| 2015 | 57 | 47 | 27 | 2 |
| 2016 | 78 | 63 | 42 | 3 |
| 2017 | 83 | 77 | 58 | 4 |
| 2018 | 72 | 56 | 46 | $0(1$ fish $)$ |
| 2019 | 80 | 59 | 48 | 3 |
| 2020 | 88 | 57 | 33 | 3 |
| 2021 | 93 | 75 | 40 | 3 |

Table 19. Total catch and mean catch-per-unit-effort (CPUE) with $90 \%$ confidence intervals of Yellow Perch, Northern Pikeminnow, Yellow Perch greater than 250 mm , and Northern Pikeminnow greater than 350 mm total length collected in Lake Cascade in 1991, 2003, 2005, 2008 and annually in October from 2012 through 2021 by McCall subregion staff.

| Yellow Perch |  |  |  |  | Northern Pikeminnow |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Year | Total Catch | mean CPUE | $\begin{aligned} & \text { CPUE } \\ & >250 \mathrm{~mm} \end{aligned}$ | $\begin{aligned} & \%> \\ & 250 \\ & \mathrm{~mm} \end{aligned}$ | Total Catch | mean CPUE | Total Catch > 350 mm | $\begin{aligned} & \text { CPUE > } \\ & 350 \mathrm{~mm} \end{aligned}$ | $\begin{aligned} & \%> \\ & 350 \\ & m \\ & m \end{aligned}$ |
| $1991{ }^{1}$ | 1,361 | 109 | -- | 60 | 795 | 31 | 673 |  | 85 |
| $2003{ }^{2}$ |  | 1.2 | 0.3 | 25 |  |  | 651 | 9.9 <br> sink/3.3 <br> float | 96 |
| Yellow Perch Restoration Project (2004-2006) |  |  |  |  |  |  |  |  |  |
| $2005{ }^{3}$ | -- | 7 | -- | 15 | -- | -- | -- | -- | 7 |
| $2008{ }^{4}$ | -- | 27 | 18 | 66 | -- | 5 | -- | 1 | 11 |
| $2012^{5}$ | 608 | $40 \pm 11$ | $18 \pm 4$ | 45 | 351 | $23 \pm 10$ | 110 | $7 \pm 3$ | 31 |
| 2013 | 739 | $49 \pm 28$ | $13.5 \pm 23$ | 28 | 213 | $14 \pm 7$ | 70 | $5 \pm 2$ | 33 |
| 2014 | 441 | $29 \pm 10$ | $19 \pm 32$ | 66 | 335 | $22 \pm 10$ | 122 | $8 \pm 4$ | 36 |
| 2015 | 465 | $31 \pm 10$ | $14.5 \pm 5.5$ | 47 | 275 | $18 \pm 6$ | 118 | $8 \pm 4$ | 43 |
| 2016 | 400 | $27 \pm 8$ | $17 \pm 7$ | 63 | 243 | $16 \pm 6$ | 58 | $4 \pm 2$ | 24 |
| 2017 | 188 | $12.5 \pm 4$ | $10 \pm 5$ | 58 | 139 | $9 \pm 6$ | 65 | $4 \pm 2$ | 47 |
| 2018 | 183 | $12 \pm 3$ | $7 \pm 3$ | 60 | 239 | $16 \pm 6$ | 64 | $4 \pm 2$ | 27 |
| 2019 | 194 | $13 \pm 4$ | $8 \pm 2.5$ | 59 | 227 | $15 \pm 6$ | 65 | $4 \pm 2.5$ | 29 |
| 2020 | 294 | $19.6 \pm 6$ | $11.2 \pm 5$ | 59 | 166 | $11.1 \pm 3$ | 73 | $5.2 \pm 2.2$ | 44 |
| 2021 | 317 | $21 \pm 8$ | $16 \pm 6$ | 75 | 374 | $25 \pm 9$ | 76 | $5 \pm 1.4$ | 20 |

${ }^{1} 15$ sinking experimental nets, 11 floating experimental nets, one net per site.
${ }^{2} 80$ experimental floating and sinking gill nets, one net per site.
${ }^{3} 17$ sinking IDFG experimental nets, one net per site.
${ }^{4} 9$ experimental nets; three floating and six sinking, one net per site.
${ }^{5}$ Catch per site, 15 sites, one floating and one sinking net/site (2012 through 2021).

Table 20. Total catch, mean and range of total lengths of hatchery holdover (> 399 mm ) and natural origin Rainbow Trout collected from Lake Cascade annually during fall fish surveys ( 15 sites per year) in October 2014 through 2021.

| Year | Holdover/Natural | Mean TL | Holdover TL Range | Natural TL Range |
| :--- | :---: | :---: | :---: | :---: |
| 2014 | $26 / 6$ | $455 / 522$ | $405-515$ | $485-555$ |
| 2015 | $27 / 4$ | $479 / 437$ | $405-565$ | $385-485$ |
| 2016 | $23 / 31$ | $452 / 460$ | $405-545$ | $305-745$ |
| 2017 | $8 / 11$ | $458 / 360$ | $405-525$ | $170-490$ |
| 2018 | $28 / 15$ | $464 / 464$ | $405-535$ | $345-635$ |
| 2019 | $20 / 36$ | $441 / 420.5$ | $405-535$ | $168-585$ |
| 2020 | $6 / 22$ | $500 / 431$ | $424-585$ | $176-572$ |
| 2021 | $7 / 15$ | $474 / 438$ | $455-505$ | $180-548$ |

Table 21. Smallmouth Bass total catch, mean catch-per-unit-effort (CPUE), proportional stock densities (PSD) and incremental Relative Stock Densities* (RSD-400 and 480 mm ) of Smallmouth Bass collected with gill nets in Lake Cascade in October 2012 through 2021.

| Year | Total Catch | Mean CPUE $\mathbf{\pm}$ <br> Cl | PSD | RSD-400 | RSD-480 |
| :--- | :---: | :---: | :---: | :---: | :---: |
| 2012 | 64 | $5 \pm 3$ | 69 | 32 | 2 |
| 2013 | 38 | $2.5 \pm 5$ | 95 | 53 | 3 |
| 2014 | 67 | $4.5 \pm 3$ | 72 | 27 | 0 |
| 2015 | 142 | $9.5 \pm 5$ | 83 | 22 | 1 |
| 2016 | 65 | $4 \pm 3$ | 93 | 36 | 0 |
| 2017 | 41 | $3 \pm 2$ | 88 | 46 | 5 |
| 2018 | 59 | $4 \pm 3$ | 75 | 17 | 0 |
| 2019 | 80 | $5 \pm 3$ | 87 | 37 | 6 |
| 2020 | 101 | $6.7 \pm 4$ | 91 | 28 | 1 |
| 2021 | 156 | $10.4 \pm 6$ | 98 | 27 | 3 |



Figure 30. Relative length-frequency histograms of fish species collected during fall gill net survey at Lake Cascade, ID in 2021.


Figure 30. Cont'd. Relative length-frequency histograms of fish species collected during the fall gill net survey at Lake Cascade, ID in 2021.


Figure 30. Cont'd. Relative length-frequency histograms of fish species collected during the fall gill net survey at Lake Cascade, ID in 2021.


Figure 31. Mean catch-per-unit-effort (CPUE) with 90\% confidence intervals for Yellow Perch collected with gill nets in Lake Cascade from October 2012 through 2021.


Figure 32. Mean catch-per-unit-effort (CPUE) with $90 \%$ confidence intervals for Yellow Perch greater than 250 mm total length collected with gill nets in Lake Cascade from October 2012 through 2021.


Figure 33. Mean catch-per-unit-effort (CPUE) with $90 \%$ confidence intervals for Northern Pikeminnow collected with gill nets in Lake Cascade from October 2012 through 2021.


Figure 34. Mean catch-per-unit-effort (CPUE) with $90 \%$ confidence intervals for Northern Pikeminnow greater than 350 mm total length collected with gill nets in Lake Cascade from October 2012 through 2021. The dashed-line represents the action threshold outlined in the FMP (IDFG, 2019).


Figure 35. Length-frequency histogram of Yellow Perch captured during a fall gill netting survey at Lake Cascade, ID in 2021.


Figure 36. Length-frequency histogram of Northern Pikeminnow captured during a fall gill netting survey at Lake Cascade, ID in 2021.


Figure 37. Smoothed relative-density histograms of Yellow Perch lengths collected with gill nets in Lake Cascade from 2012 through 2021.

## PAYETTE LAKE FISHERY RESTORATION - LAKE TROUT STUDIES


#### Abstract

The primary objective for management of Payette Lake is to reduce Lake Trout Salvelinus namaycush abundance and predation to the point at which kokanee Oncorhynchus nerka kennerlyi survival increases. Since 2014, biologists have removed 2,537 Lake Trout from Payette Lake. Beginning in 2021, we tagged and live-released all Lake Trout greater than 760 mm TL to monitor angler-use and maintain a trophy component of the fishery. A standardized summer profundal index netting (SPIN) survey was initiated in 2021 to serve as an index to monitor trends in Lake Trout population characteristics moving forward. Results from our SPIN survey corroborate conclusions from recent removal efforts that Lake Trout in Payette Lake are currently present at a relatively low density (CPUE = 1.4; RSE $=0.14$ ), comprised primarily of four- to 10 -year-old fish. In the future, these data will be used in combination with kokanee-specific gill netting and escapement surveys to evaluate the status and efficacy of restoring a balanced sport fishery in Payette Lake.


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## INTRODUCTION

The Idaho Department of Fish and Game's current statewide Fisheries Management Plan (IDFG 2019) directs regional staff to reduce Lake Trout Salvelinus namaycush abundance and predation through suppression gill netting to improve kokanee Oncorhynchus nerka kennerlyi survival and abundance. Since 2014, 2,537 Lake Trout have been removed from Payette Lake. In that period, relative abundance of Lake Trout has declined. In 2021 we continued our suppression efforts and initiated a standardized summer profundal index netting survey (SPIN; Sandstrom and Lester 2009) to evaluate trends in Lake Trout population characteristics (relative abundance, size- and age-structure) in the future. The primary objective of the SPIN survey was to obtain a spatially and biologically representative sample of Lake Trout to develop a trend dataset for Lake Trout in Payette Lake

See Janssen et al. 2020 for a comprehensive review of past fisheries management activities in Payette Lake.

## OBJECTIVES

1. Continue reducing Lake Trout abundance through suppression gill netting.
2. Evaluate angler use and exploitation on the Lake Trout population using tagging and angler reporting.
3. Develop a standardized survey to index changes in Lake Trout relative abundance, size structure, and body condition to determine effectiveness of suppression efforts.

## METHODS

## Lake Trout Removal Efforts

Gillnets used in 2021 were sinking-style, $91.5-\mathrm{m}$ long, and constructed of clear monofilament. Nets consisted of three mesh sizes each: 38-, 51-, and 64-mm stretched. Nets were typically set in gangs of two to four $91.5-\mathrm{m}$ nets tied together. Netting sites were subjectively chosen to maximize catch efficiency and were dispersed throughout the west, east, and north basins. Nets were typically set on flats and ridges, in water no less than 12 m in depth to avoid catching large numbers of Northern Pikeminnow Ptychocheilus oregonensis and Largescale Suckers Catostomus macrocheilus. Nets were set mid-day, fished all night and pulled the following morning. Effort (expressed as number of net-nights) was recorded as number of 91.5m nets fished per night. Catch-per-unit-effort (CPUE) was calculated as the number of fish caught per net-night.

All netted Lake Trout were enumerated, measured (mm, TL). Non-target fish were not measured or enumerated. All Lake Trout greater than 760 mm TL were live-released with spaghetti tags to preserve the trophy component of the fishery and estimate exploitation on that trophy component of the fishery (i.e., \$50 reward tags, non-reward tags; FLOY). Sex and maturity (immature/mature/ripe) were recorded for all euthanized fish.

## Lake Trout SPIN Survey

Gillnets were built by Hickey Brothers Research to specifications provided by Sandstrom and Lester (2009). Nets were sinking-style and set in random orientation across seven depth strata ( $2-10 \mathrm{~m}, 10-20 \mathrm{~m}, 20-30 \mathrm{~m}, 30-40 \mathrm{~m}, 40-60 \mathrm{~m}, 60-80 \mathrm{~m},>80 \mathrm{~m}$ ) in each of three basins (West, North, East; Figure 3). Within each basin, sampling sites were chosen randomly based on available depth strata. We estimated our target sample size by using the formula:

$$
\text { No.of Sets }=0.008(>10 \mathrm{~m} \text { Area, ha })+6
$$

provided by Sandstrom and Lester (2009). We used image analysis software (ImageJ; National Institute of Health) to calculate lake area by depth strata. We estimated the area $>10 \mathrm{~m}$ in Payette Lake to be 1,799 ha, which resulted in a target effort of approximately 21 net nights. However, our priority was to maximize the number of sets to minimize error in our estimates of catch-per-unit-effort (CPUE). For this, Sandstrom and Lester (2009) recommended attaining a relative standard error (RSE; SE of estimate/estimate) of $0.15 \pm 0.05$. Based on Lake Trout removal netting CPUE, we assumed relative abundance to be low in Payette Lake. Therefore, we combined two 64 m gill nets into a paired-net and set a total of 27 paired-net nights ( 54 net nights). CPUE was calculated as the average catch per net night (not per paired-net night).

All netted Lake Trout were enumerated, measured (mm, TL), and weighed ( g ). All Lake Trout greater than 760 mm TL were measured for length, not weighed, and live released with spaghetti tags (FLOY). Each unique tag number was entered into the "Tag-You're-lt" database, along with the length of each fish. Methods used to estimate exploitation and use rates of tagged fish are presented in Meyer et al. (2010). Body condition of Lake Trout was evaluated using relative weight (Blackwell et al. 2000). Since all Lake Trout greater than 760 mm TL were not weighed, we calculated relative weight for two length categories; stock to quality length ( 300 to 599 mm TL ) and quality to preferred length ( $500-650 \mathrm{~mm}$; Gabelhouse 1984a; Piccolo et al. 1994). For each euthanized fish, we recorded diet content under four categories: empty, invertebrate, fish, or other. When possible, we identified each fish present in stomach contents to the species level. We also recorded sex and maturity of each euthanized fish to estimate male-to-female ratio and proportion of mature individuals in the gill net catch. We also recorded secchi depth (m) and surface water temperature $\left({ }^{\circ} \mathrm{C}\right)$ each day.

## RESULTS

## Lake Trout Removal Netting

The removal-netting period in 2021 spanned 12 weeks, from June 7 to August 24. In total, 185 Lake Trout were captured during 114 net nights and 164 were euthanized. Mean CPUE across all sizes of mesh was 2.0 (Figure 38). All nets in poor condition (e.g., numerous large holes) at time of setting were excluded from CPUE calculations ( $n=80$ ). Overall, CPUE remained lower than the first two years of netting.

In 2021, captured Lake Trout ranged in length from 180 to $1,030 \mathrm{~mm} \mathrm{TL}$ (mean $=492 \mathrm{~mm}$, SE = 14; Figure 39). We released 21 Lake Trout > $760 \mathrm{~mm} \mathrm{TL} ; 10$ of which were tagged with $\$ 50$ reward tags and 11 were tagged with non-reward tags and entered into the IDFG Tag-You're-It Program. The sex ratio of Lake Trout captured through removal netting was 1.25 males to females; sex was undetermined for 45 fish.

## Lake Trout SPIN Survey

The SPIN survey was conducted between August 30 and September 8. We captured 80 Lake Trout during 27 paired net nights of effort ( 54 net nights). Effort was allocated evenly across Payette Lake (Figure 40). Mean CPUE was 1.4 Lake Trout per net night (RSE = 0.14) and similar across basins, ranging from 1.0 in the North basin to 1.8 in the East basin (1.7 in West basin). CPUE by depth was highest within the core strata (i.e., $10-40 \mathrm{~m}$; Figures 41 and 42) and ranged from zero to 3.5. We did not capture any Lake Trout in depths less than 10 m or greater than 80 m.

Lake Trout ranged in length from 240 to 975 mm TL (mean $=484 \mathrm{~mm}$, $\mathrm{SE}=18$; Figure 43). Mean relative weight of stock to quality length fish was 80 (range $=65-98$ ) and 77 (range $=$ $65-109$ ) for quality to preferred length fish. The sex ratio of Lake Trout captured in our SPIN survey was 1:1 males to females; sex was undetermined for 10 fish.

All Lake Trout caught greater than 760 mm TL were either tooth-hooked or entangled at time of capture. All fish that appeared to be in good condition at time of capture were then livereleased ( $n=6$ ) with spaghetti tags (FLOY). Four Lake Trout were released with $\$ 50$ reward tags, and two were released with non-reward tags and entered into the IDFG Tag-You're-It Program. We euthanized 74 Lake Trout, bringing the total number removed In Payette Lake since 2014 to 2,537 fish.

We applied an age-length key developed in 2019 to our SPIN catch data in 2021 (Table 22; Figure 45). Age estimates ranged from four to 31 years old (Figure 44). The majority of our catch ( $60 \%$ ) was between the ages of four and $10(\sim 300-600 \mathrm{~mm} \mathrm{TL})$. For both, male and female Lake Trout, we estimated the age at first maturity to be 6 years old. At time of capture, $70 \%$ of males appeared to be sexually mature, whereas $36 \%$ of females appeared to be sexually mature.

We observed the stomach contents of 74 Lake Trout, of which 30 (40\%) had empty stomachs at time of capture. Of Lake Trout with stomach contents, we observed 13 that contained fish, 26 contained various invertebrates, and 5 contained other or unknown items (e.g., lures, birds, digested matter). Of the 13 Lake Trout stomachs that contained fish, 8 were identifiable by species and 7 of these were juvenile kokanee salmon, while one was a juvenile Yellow Perch Perca flavescens. Weather was stable during our study period, with water temperatures ranging between 18 and $19^{\circ} \mathrm{C}$. Secchi depth was consistent at 6.5 m .

## DISCUSSION

The SPIN survey in 2021 established a repeatable study design for quantifying changes in Lake Trout population characteristics through time. In addition, a secondary benefit was removing Lake Trout ( $n=74$ ) in addition to our routine removal netting efforts ( $n=164$ ). The results of the SPIN survey suggest that Lake Trout densities are relatively low in Payette Lake (CPUE $=1.4$ ) and that the population is largely comprised of relatively young fish (i.e., $60 \%$ of catch < age-10; Figure 43). Although direct comparisons to removal netting data are limited, our results appear to support previous observations that Lake Trout removal efforts have reduced the abundance of Lake Trout in Payette Lake (Janssen et al. 2020).

The SPIN methodology provides a standardized, representative sample of Lake Trout across lake area and depths that can be compared across years (Sandstrom and Lester 2009).

Whereas, in contrast, inference from past removal netting has been limited by non-random site selection, fewer depths sampled, and inconsistent sampling dates (between May and September). Further, previous research has identified various density-dependent responses to removal efforts at the population level (Schoen et al. 2012; Ng et al. 2016), making it challenging to predict the effects of continued removal efforts on population characteristics (i.e., abundance and size- or age-structure). In the future, we will continue to remove Lake Trout as directed by the current fisheries management plan (2019-2024; IDFG 2018) and will utilize annual or semiannual SPIN surveys to closely monitor responses in the Lake Trout population to kokanee salmon stocking and gill net removal efforts.

The SPIN methodology also allows managers to directly estimate the density of harvestable-sized Lake Trout in a waterbody by using "short-sets" (i.e., 2 h ) and adjusting catch based on previously estimated catchability coefficients with known populations of fish (Sandstrom and Lester 2009). While both methods can be used concurrently, we chose to utilize overnight sets because: 1) mortality is not an issue in Payette Lake, 2) our study area is relatively large ( $\sim 1,799 \mathrm{ha}$ ) with high water clarity (Secchi depth $=6.5 \mathrm{~m}$ ) and 3) catch rates are typically 4-6 times higher using overnight sets compared to short sets (Sandstrom and Lester 2009). Based on catch rates from removal netting efforts and communication with other agency biologists, we suspected that densities of adult Lake Trout in Payette Lake were low. Our results confirm that densities of adult Lake Trout in Payette Lake are relatively low and that the population is largely comprised of small-bodied, relatively young (age-4 to -9) fish. For example, in Priest Lake, ID, managers conducted a similar SPIN survey in 2021 and relative abundance was much higher (mean CPUE $=6.4, \mathrm{SD}=3.3$ ) compared to our study (Rob Ryan, personal communication).

Previous research evaluating Lake Trout removal efforts to meet kokanee recovery objectives recommend that managers focus removal efforts on small-bodied (age-4 to -9) Lake Trout (Pate et al. 2014). Fortunately, our results suggest that mesh sizes used in removal netting efforts since 2014 have primarily targeted these smaller-bodied Lake Trout (Figure 39). Additionally, mesh sizes used in 2021 (both surveys) do not appear selective for larger-bodied Lake Trout. Therefore, although relative densities appear low, removal efforts should continue to reduce abundance of small-bodied Lake Trout to improve conditions for juvenile kokanee salmon survival throughout the current fishery management period.

In 2021, we live-released 27 Lake Trout greater than 760 mm TL with spaghetti tags to monitor angler-use. Across all netting efforts in 2021, these fish comprised approximately $10 \%$ of total catch. Moving forward, we will continue to release all Lake Trout greater than 760 mm TL with spaghetti tags to monitor angler-use and preserve a trophy component of the Lake Trout fishery in Payette Lake. These large Lake Trout were primarily caught in depths < 25 m (Figure 42). Most Lake Trout were captured in depths between 12 and 50 m (Figure 41). No Lake Trout were caught in depths less than 10 m and these areas had high bycatch (mostly Northern Pikeminnow and Largescale Suckers). Future SPIN surveys should exclude overnight sets in depths $<10 \mathrm{~m}$ and $>80 \mathrm{~m}$ to minimize bycatch and overall operational time.

Among observed stomach contents in 2021, invertebrates and fish comprised the majority of recorded diet items. The high number of invertebrates observed can be attributed to a large Diptera spp. hatch during our study period. Among fish observed in stomach contents, juvenile kokanee were most prevalent (7 of 8), all of which appeared to be age-0 or -1 . Future studies should continue to record observed stomach contents throughout the removal netting period to monitor trends in diet composition throughout the open-water period on Payette Lake.

## MANAGEMENT RECOMMENDATIONS

1. Continue with suppression efforts to reduce Lake Trout abundance through the current FMP period (2019-2024)
2. Continue monitoring Lake Trout population responses to removal netting with SPIN methodologies on an annual or semi-annual basis

Table 22. Age-length key developed for Lake Trout sampled at Payette Lake in 2019. Age estimates obtained from $n=281$ Lake Trout otoliths to develop key. Includes estimated age in years, number of Lake Trout assigned to each age category ( $n$ ), mean length (mm), and one standard error of the mean.

| Age | $n$ | Mean length | SE |
| :---: | :---: | :---: | :---: |
| 2 | 9 | 190.4 | 6.6 |
| 3 | 5 | 217.2 | 6.9 |
| 4 | 9 | 250.1 | 12.2 |
| 5 | 20 | 279.2 | 7.6 |
| 6 | 18 | 350.1 | 15.2 |
| 7 | 29 | 388.2 | 12.6 |
| 8 | 20 | 431.4 | 16.4 |
| 9 | 15 | 442.9 | 19.2 |
| 10 | 12 | 487.8 | 20.7 |
| 11 | 8 | 475.3 | 27.3 |
| 12 | 14 | 514.4 | 23.4 |
| 13 | 4 | 586.5 | 32.8 |
| 14 | 5 | 566.2 | 15.6 |
| 15 | 6 | 611.8 | 33.9 |
| 16 | 9 | 643.0 | 42.5 |
| 17 | 9 | 727.3 | 38.4 |
| 18 | 5 | 642.0 | 43.6 |
| 19 | 7 | 702.6 | 30.6 |
| 20 | 9 | 776.1 | 34.7 |
| 21 | 13 | 760.3 | 26.5 |
| 22 | 13 | 832.3 | 33.6 |
| 23 | 6 | 871.7 | 53.3 |
| 24 | 12 | 811.4 | 23.7 |
| 25 | 3 | 809.0 | 1.0 |
| 26 | 1 | 826.0 | - |
| 27 | 6 | 907.3 | 35.7 |
| 28 | 3 | 862.0 | 53.6 |
| 29 | 2 | 918.0 | 70.0 |
| 30 | 1 | 1000.0 | - |
| 31 | 2 | 922.5 | 53.5 |
| 32 | 2 | 806.0 | 50.0 |
| 33 | 1 | 928.0 | - |
| 38 | 1 | 940.0 | - |
| 40 | 1 | 898.0 | - |
| 42 | 1 | 884.0 | - |



Figure 38. Lake Trout catch-per-unit-effort (CPUE; fish per 91.5 m net-night) in Payette Lake, ID, 1994 through 2021.


Figure 39. Length-frequency histograms for all Lake Trout captured during removal netting efforts in Payette Lake across 2018, 2019, 2020, and 2021. Note: different mesh sizes were used in 2018.


Figure 40. Map of SPIN survey sites $(n=27)$ on Payette Lake, ID, in 2021. Numbers at each gill net site correspond to specific depth strata.


Figure 41. Plot of catch-per-unit-effort (CPUE) across depths (m) sampled during a 2021 SPIN survey in Payette Lake, ID.


Figure 42. Lengths (mm) of Lake Trout by depth (m) collected during the Summer Profundal Index Netting survey on Payette Lake, Idaho in 2021.


Figure 43. Relative length-frequency histogram of Lake Trout collected during the 2021 SPIN survey at Payette Lake, ID.


Figure 44. Estimated age-frequency histogram for Lake Trout collected during a SPIN survey at Payette Lake, ID, in 2021.


Figure 45. Estimated length-at-age-at-capture for Lake Trout collected during the Summer Profundal Index Netting survey on Payette Lake, Idaho in 2021. Ages estimated using age-length key developed in 2019.

## PAYETTE LAKE KOKANEE SALMON INVESTIGATIONS

## ABSTRACT

Since 2014, nearly 2,500 Lake Trout Salvelinus namaycush have been removed in efforts to improve kokanee salmon Oncorhynchus nerka kennerlyi survival and growth in Payette Lake. Following observed declines in Lake Trout catch-per-unit-effort (CPUE), the department resumed annual plantings of approximately 400,000 late-spawning kokanee fingerlings (< 330 mm ). To monitor the effectiveness of Lake Trout suppression efforts, we implemented a pilot gill netting survey in 2021 to evaluate population characteristics (relative abundance, growth) of kokanee. Our findings in 2021 were encouraging: approximately $61 \%$ of age-1 and -2 kokanee were hatchery-origin based on observed thermal markings and kokanee spawner abundance in the index transect of the North Fork Payette River (NFPR) was the highest observed since 2008 ( $n=$ 3,818). Moving forward, we will combine similar gill netting efforts with NFPR spawner count estimates to monitor the effectiveness of kokanee stocking and Lake Trout suppression efforts and guide our future management efforts in Payette Lake.

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## INTRODUCTION

Following observed declines in Lake Trout Salvelinus namaycush gill net catch, the department resumed annual plantings of approximately 400,000 late-spawning kokanee salmon Oncorhynchus nerka kennerlyi. The current statewide Fisheries Management Plan (FMP; 2019 2024; IDFG 2018) directs regional staff to evaluate the success of stocking and to monitor kokanee numbers both in the lake and while spawning in the North Fork Payette River (NFPR) above Payette Lake. To do this, we implemented a new annual kokanee-specific gill netting survey to monitor relative abundance and survival of stocked kokanee. These data from this pilot survey can be used in combination with spawner index counts in the NFPR to develop models of kokanee population characteristics and inform management decisions in Payette Lake moving forward.

See Janssen et al. 2020 for a comprehensive review of past fisheries management activities in Payette Lake.

## OBJECTIVES

1. Implement new annual gill netting survey to track relative abundance and survival of stocked kokanee.
2. Estimate kokanee spawner abundance in the NFPR as an index of effectiveness of suppression efforts on Lake Trout.

## METHODS

Gill nets used in 2021 were built to the specifications outlined by Klein et al. (2019). Nets were 48.8 m long and 6 m in depth and constructed of clear monofilament. Each net consisted of 16 panels, measuring 3.0 m in length, and 8 different mesh sizes (12.7-, 19.0-, 25.4-, 38.1-, 50.8, 63.5-, 76.2-, 101.6-mm stretch measure) with two panels of each mesh size randomly positioned across the net. Gill nets were set for approximately $18-24 \mathrm{~h}$ before retrieving the following day. Sampling was conducted during thermal stratification within 7-days of the dark phase of the moon in an effort to maximize catch of kokanee (Klein et al. 2019). Sites were selected to maximize catch in each basin of Payette Lake (West, North, East; Figure 1). Prior to sampling, the vertical distribution of kokanee was determined by visiting areas within each basin at night and using an electronic fish finder to locate areas and depths with the highest densities of kokanee (Zach Klein, personal communication).

All netted kokanee salmon were enumerated, measured (mm, TL), and weighed (g). Catch-per-unit-effort (CPUE = mean number of fish per pair of gill nets at a site) was calculated to describe relative abundance. We used relative selectivity estimates provided by Klein et al. 2019 to adjust our catch estimates for describing size structure with relative-frequency histograms. Relative weight $\left(\mathrm{W}_{\mathrm{r}}\right)$ was calculated as an index of body condition using length and weight data (Blackwell et al. 2000; Hyatt and Hubert 2000).

We collected sagittal otoliths from five fish of each 10-mm TL group caught during the gill netting survey. To prepare otoliths for sectioning, whole otoliths were mounted in bullet molds
(Ted Pella, Inc., Redding, CA, USA) using epoxy and cross-sectioned using an Isomet low-speed saw (Buehler Inc., Lake Bluff, IL, USA) to approximately $0.58-\mathrm{mm}$ thickness. Resulting crosssections were viewed using a compound microscope and image analysis system (Leica Application Suite, Leica Microsystems, Buffalo Grove, IL, USA). All kokanee assigned ages < 2 were evaluated for thermal markings following IDFG protocol (IDFG, unpublished) to determine the proportion hatchery vs natural-origin kokanee in the catch.

We used age estimates to develop an age length key for kokanee in Payette Lake, which we used to assign ages to unaged fish after incorporating relative selectivity estimates for catch provided by Klein et al. 2019. Age frequencies were developed separate from growth models. Since growth rates could differ between hatchery and natural-origin kokanee, growth models were developed using only natural-origin fish (no observed thermal markings). To estimate growth, a von Bertalanffy (VB) growth function was used,

$$
L_{t}=L_{\infty}\left[1-e^{-K\left(t-t_{0}\right)}\right]
$$

where $L_{t}$ is the mean length at age of capture, $L_{\infty}$ is the theoretical maximum length, $K$ is the growth coefficient, and $t_{0}$ is the theoretical age when length equals 0 mm (von Betalanffy 1938). A best-fit model was constructed using nonlinear regression and bootstrapping techniques in Program R (nlstools package, Baty et al. 2015; R Development Core Team 2020; FSA package, Ogle et al. 2021). Catch curves were developed for natural-origin kokanee and weighted regression was used to estimate instantaneous and total annual mortality rates (Sammons and Betolli 1998)

The North Fork Payette River (NFPR; above Payette Lake) was walked twice weekly during the kokanee spawning run from the mouth of Fisher Creek (W 45.037496 N -116.057979) downstream approximately $3,400 \mathrm{~m}$ (W $45.021131 \mathrm{~N}-116.062573$ ) All live spawners were counted during walks. The total run estimate was made by multiplying the largest daily count by 1.73 (Frost and Bennett 1994). Samples of dead post-spawn kokanee that still had an intact tail were measured for total length.

## RESULTS

A total of 67 kokanee salmon were captured across 12 paired net nights between September 9 and 13 (Figure 46). Mean CPUE across all sites was 5.6 ( $\mathrm{SE}=1.3$ ) and was highest in the northern basin (mean CPUE $=10, \mathrm{SE}=1.6$ ) compared to the western (mean CPUE $=3.3$, $\mathrm{SE}=2.6$ ) and eastern (mean CPUE $=3.5, \mathrm{SE}=1.3$ ) basins. Lengths ranged from 125 to 490 mm TL (mean $=284 \mathrm{~mm}$; Figure 47) and relative weights ranged between 60 and 105 ( mean = 87).

We collected and processed 62 otoliths and developed an age length key to estimate ages of the expanded catch estimate ( $n=90$; Table 23). Estimated ages ranged from one to six and the majority ( $47 \%$ ) were age-2 (Figure 48). Thermal markings were observed on 17 of 28 (62\%) kokanee estimated to be age-1 or -2. Of age-2 kokanee, $68 \%$ (17/25) were hatcheryorigin. Of these fish, mean-length-at-age-at-capture for age-2 kokanee was $212 \pm 7 \mathrm{~mm}$ compared to $220 \pm 10 \mathrm{~mm}$ for natural-origin age-2 kokanee. Mean length-at-age-at-capture for age-3 and -4 (natural-origin) kokanee was 297- and 344-mm TL, respectively (Table 23, Figure 49). Estimated von Bertalanffy growth parameters for unexpanded, natural-origin kokanee were:
$\mathrm{L}_{\text {inf }}=579.5, \mathrm{~K}=0.2$, and $\mathrm{t}_{0}=-0.14$ (Figure 49). Based on weighted catch curve estimates, the total annual survival rate of natural-origin kokanee was approximately $58 \%$ (Figure 50).

We completed seven kokanee spawner counts on the NFPR in 2021. The first count was made on August 24 and the last on September 8. The peak count ( $n=2207$ ) was made on August 30. The total spawning run estimate in 2021 was 3,818 (2,207*1.73) fish (Table 24; Figure 51). Spawning fish ranged in length from 350 to 520 mm TL (mean $=414 \mathrm{~mm}$ ) based on a random sample of carcasses $(n=13)$. Of these randomly sampled carcasses, four were female (length range $=365$ to 380 mm ) and nine were male (length range $=350$ to 520 mm ).

## DISCUSSION

Results of our 2021 surveys were encouraging: approximately $61 \%$ of estimated age-1 and -2 kokanee appeared to be hatchery-origin based on observed thermal markings and kokanee spawner abundance in the index transect of the NFPR was the highest observed since 2008 ( $n=3,818$; Table 24). Our netting efforts captured a wide range of lengths ( 125 to 490 mm TL ) and ages ( 1 to 6 ) of kokanee and fish appeared to be in relatively good body condition (mean $\mathrm{W}_{\mathrm{r}}=87$ ). Although it remains too early to estimate hatchery-origin survival rates (recruit to gill nets at age-2), our results suggest that the current kokanee population is dominated by age-2 fish ( $47 \%$ of total catch); of which, approximately $68 \%$ are hatchery-origin (i.e., 2020 hatchery plants; Figure 48).

By removing known, hatchery-origin kokanee from our catch we were able to estimate survival and growth of natural-origin kokanee in Payette Lake. Mean length-at-age-at-capture ranged from 129 mm (age-1) to 431 mm (age-6) and annual survival was approximately $58 \%$. Based on these findings, we estimate the spawning ages of natural, early-strain kokanee in Payette Lake to be between four and seven years old. These data will provide a useful baseline as hatchery stocking and lake trout removal efforts continue.

Due to recent reductions in availability of early-spawning kokanee (the dominant lifehistory in Payette Lake), late-spawning kokanee have been stocked annually since 2020. Based on observed increases in natural, early-spawning adult kokanee numbers during spawning counts in the NFPR, we will work closely with McCall hatchery staff to assist with construction and implementation of a weir to collect broodstock to supplement stocking efforts in Payette Lake moving forward. Previous research (Bennett 1992) suggests that adult (mean length $=414 \mathrm{~mm}$ ) spawners can produce up to 800 eggs per female. We will work with hatchery staff to determine how many adult spawners will be needed for broodstock collection and will develop a minimum escapement goal to preserve a natural-spawning component of the fishery.

In 2022, we will repeat a similar gill netting survey in July or August, prior to the earlystrain kokanee spawning run in the NFPR (typically late-August), so that we can include prespawn adults in our gill net catch and population estimates. We will continue to monitor trends in adult spawner counts in the NFPR to build upon our 34-year dataset. These data will be a critical monitoring tool for evaluating the efficacy of fishery restoration efforts in Payette Lake moving forward.

## MANAGEMENT RECOMMENDATIONS

1. Continue annually stocking $\sim 400,000$ thermally marked kokanee in Payette Lake.
2. Conduct a similar gill netting survey prior to the NFPR spawning run to gather information on spawning age classes.
3. Work closely with McCall Fish Hatchery staff to implement a weir in the NFPR and to collect sufficient numbers of early-spawning kokanee to supplement stocking efforts.
4. Continue monitoring early-strain kokanee spawner abundances in the NFPR.

Table 23. Age-length key developed for kokanee salmon sampled at Payette Lake in 2021. Age estimates obtained from $n=50$ kokanee otoliths to develop key. Includes estimated age in years, number of kokanee assigned to each age category ( $n$ ), mean length (mm), and one standard error of the mean.

| Age | $\boldsymbol{n}$ | Length | SE |
| :---: | :---: | :---: | :---: |
| 1 | 7 | 125.0 | 0.0 |
| 2 | 42 | 214.3 | 4.4 |
| 3 | 16 | 296.9 | 4.9 |
| 4 | 16 | 343.8 | 4.8 |
| 6 | 6 | 375.0 | 4.5 |

Table 24. Payette Lake kokanee salmon spawner counts and estimated spawning run size and biomass from 1988 through 2021 in the North Fork Payette River.

| Year | Peak count | Estimated spawner numbers | Number/lake ha ${ }^{1}$ | Average spawner weight (g) | Average spawner TL (mm) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1988 | 13,200 | 22,800 | 13.3 | 346 | -- |
| 1989 | 8,400 | 14,500 | 8.4 | 349 | -- |
| 1990 | 9,642 | 16,700 | 9.7 | 358 | -- |
| 1991 | 10,400 | 18,000 | 10.5 | 505 | 365 |
| 1992 | 16,945 | 29,300 | 17.1 | 377 |  |
| $1993{ }^{\text {a }}$ | 34,994 | 59,310 | 34.6 | 245 | -- |
| 1994 | 25,550 | 44,200 | 25.8 | 214 | -- |
| 1995 | 32,050 | 55,450 | 32.3 | 147 | 260 |
| 1996 | 35,090 | 60,707 | 35.4 | $162{ }^{\text {c }}$ | -- |
| 1997 | $36,300^{\text {e }}$ | 64,891 ${ }^{\text {d }}$ | 37.8 | 148 | 265 |
| 1998 | 14,585 | 25,232 | 14.7 | 143 | 254 |
| 1999 | 15,590 | 26,971 | 15.7 | 184 | 276 |
| 2000 | 15,520 | 26,850 | 15.6 | 188 | 286 |
| $2001{ }^{\text {f }}$ | 15,690 ${ }^{\text {g }}$ | 30,144 | 17.6 | $250{ }^{\text {b }}$ | -- |
| 2002 | 9,430 | 16,314 | 9.5 | -- | -- |
| 2003 | 5,430 | 9,394 | 5.5 | 279 | -- |
| 2004 | 11,290 | 19,532 | 11.4 | -- | -- |
| 2005 | 11,780 | 20,780 | 12.1 | -- | -- |
| 2006 | 5,580 | 9,650 | 5.6 | -- | 317 |
| 2007 | 3,925 | 6,790 | 4.0 | 401 | 340 |
| 2008 | 2,425 | 4,195 | 2.4 | -- | 336 |
| 2009 | 1,290 | 2,232 | 1.3 | -- | 405 |
| 2010 | 610 | 1,055 | 0.6 | -- | 416 |
| 2011 | 435 | 753 | 0.4 | -- | 390 |
| 2012 | 852 | 1,475 | 0.8 | -- | $376 / 440^{\text {h }}$ |
| 2013 | 304 | 526 | 0.3 | -- | 384/458 ${ }^{\text {h }}$ |
| 2014 | 245 | 424 | 0.3 | -- | - |
| 2015 | 185 | 320 | 0.2 | -- | 455 |
| 2016 | 364 | 630 | 0.4 | -- | 404 |
| 2017 | 583 | 1,008 | 0.6 | -- | $383 / 451^{\text {h }}$ |
| 2018 | 420 | 727 | 0.4 | -- | $442 / 519^{\text {h }}$ |
| 2019 | 1,955 | 3,382 | 2.0 | -- | 424 |
| 2020 | 1,076 | 1,862 | 1.1 | -- | 459 |
| 2021 | 2,207 | 3,818 | 2.2 | -- | 414 |

11,717 ha usable kokanee habitat in Payette Lake (Area with depth greater than 40 feet).
${ }^{\text {a }}$ Estimate made from stream and weir counts (Frost and Bennett, 1994)
${ }^{\mathrm{b}}$ From gill net data of captured spawners in Payette Lake during lake survey.
${ }^{\text {c }}$ From trawling collections made in September 1996.
${ }^{\text {d }}$ Includes 2,092 fish spawned and removed by Nampa Fish Hatchery.
${ }^{\text {e }}$ Does not include 2,092 fish spawned and removed by Nampa Fish Hatchery.
${ }^{\dagger}$ Includes 3,000 fish spawned and removed by Nampa Fish Hatchery.
${ }^{9}$ Does not include 3,000 fish spawned and removed by Nampa Fish Hatchery.
${ }^{\mathrm{h}}$ Two distinct age classe


Figure 46. Map of kokanee gill netting sites $(\mathrm{n}=6)$ on Payette Lake, ID, in 2021. Each site consisted of a paired gill net set.


Figure 47. Adjusted relative-frequency histogram of kokanee salmon collected during the 2021 pilot gill netting survey at Payette Lake, ID.


Figure 48. Adjusted estimated age-frequency histogram for kokanee salmon collected during the 2021 pilot gill netting survey at Payette Lake, ID.


Figure 49. Von Bertalanffy growth curve for natural-origin kokanee salmon ( $n=50$ ) in Payette Lake plotted against estimated length-at-age-at-capture data for kokanee collected in 2021.


Figure 50. Natural log of catch at estimated ages for natural-origin kokanee salmon ( $n=50$ ) collected in Payette Lake including a best-fit line fit to ages 3-6. Instantaneous total mortality rate ( $Z$ ) and total annual mortality rate (A) estimated using weighted regression (catch curve) methods.


Figure 51. Spawning run size estimates (adjusted spawner count) and mean length of carcasses (mm) for kokanee salmon in the North Fork Payette River from 1988 through 2021.

## LAKE CASCADE TRIBUTARY SNORKEL INVESTIGATIONS

## ABSTRACT

The three major tributaries to Lake Cascade, the North Fork of the Payette River (NFPR), Lake Fork Creek (LFC), and the Gold Fork River (GFR), provide important spawning habitat for natural origin, adfluvial Rainbow Trout (RBT) Oncorhynchus mykiss. Currently, a paucity of information exists about factors limiting RBT productivity in these systems. In 2021, we conducted snorkel surveys at four NFPR sites, three LFC sites, and five GFR sites to evaluate relative abundance of RBT, species composition, water temperature, and habitat characteristics. RBT densities ranged from 0.07 fish $/ 100 \mathrm{~m}^{2}$ in the GFR to 0.93 fish $/ 100 \mathrm{~m}^{2}$ in LFC ( $0.57 \mathrm{fish} / \mathrm{m}^{2}$ in NFPR). RBT were observed at nearly every site (83\%) snorkeled in 2021. Fishery managers should consider developing a study to estimate RBT production and entrainment in NFPR, LFC, and GFR in 2023 and 2024. Fishery managers should also monitor temperature and flow in each tributary to gather baseline water quality data in each system.

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## INTRODUCTION

The three major tributaries to Lake Cascade, the North Fork of the Payette River (NFPR), Lake Fork Creek (LFC), and the Gold Fork River (GFR), provide a unique fishing opportunity for trout anglers in the McCall area. Large-bodied (often between 400 to 610 mm ) adfluvial Rainbow Trout (RBT) Oncorhynchus mykiss migrate from Lake Cascade into these tributaries to spawn each spring and can be sight-fished from the bank or small boats. Although this provides an opportunity to target trophy-sized trout, anecdotal evidence and creel surveys suggest this fishery does not receive heavy angling pressure, likely due to relatively low fish numbers and poor public access (Janssen et al. 2014).

For several decades, fisheries managers have been exploring methods to improve RBT productivity in these tributaries (e.g., Anderson and Robertson 1985b; Janssen and Anderson 1994). The current Statewide Fisheries Management Plan (FMP) makes several references to this objective: 1) improve [Cascade] tributary habitat condition and access for natural trout production, 2) improve natural trout production in [Gold Fork River], and 3) assess fish losses occurring in Lake Irrigation District canals and laterals (IDFG 2018). At present, a paucity of information exists about relative abundance, productivity, distribution, and movement of RBT in these tributaries. Baseline data is needed to identify factors (biotic or abiotic) that may be influencing the current level of productivity, compare future surveys to, and to assess the effect of any future management actions aimed at increasing RBT productivity in these systems.

Lake Cascade tributaries are challenging to sample with most conventional fisheries survey techniques: electrofishing is ineffective due to extremely low conductivity levels (< 10 $\mu \mathrm{S} / \mathrm{cm}$; Janssen et al. 2006), angler surveys are limited due to low fishing pressure (Janssen et al. 2013), and weirs used to collect fish have been damaged by extreme flows due to heavy snow melt (Janssen et al. 2006). Fortunately, snorkel surveys have been conducted in these tributaries with some success, resulting in several hundred fish of interest being observed (Janssen and Anderson 1992, Janssen et al. 2002, Janssen et al. 2009). Snorkel surveys are relatively simple to conduct, cost-efficient, and low impact to the resource. These surveys can provide the repeatable study design necessary for managers to evaluate factors that could be limiting RBT production in Lake Cascade tributaries.

In 2021, we conducted 12 snorkel surveys in the three major tributaries of Lake Cascade between to evaluate RBT presence (adult and fry), abundance, species composition, and habitat characteristics (temperature and flow) between June 18 and 20.

## OBJECTIVES

1. Establish snorkel survey sites on each major Lake Cascade tributary to develop a trend dataset for monitoring RBT production.
2. Evaluate RBT presence in Lake Cascade tributaries in the early-summer and estimate densities of adults and fry at multiple locations in each tributary.
3. Describe habitat (\% pool, riffle, run, pocket water) at each site and determine species composition, water temperature, and flow in each major Lake Cascade tributary.

## METHODS

Twelve index sites were snorkeled in three Lake Cascade tributaries between June 18 and June 20, 2021 (Table 25). Five sites were completed in the GFR, three in LFC, and four in the NFPR. Methods for conducting fish abundance surveys by snorkeling are detailed in Apperson et al. (2015). All sites were conducted through corridor snorkels, where the transect is surveyed by floating from the upstream boundary to the downstream boundary. Snorkelers were spaced such that the entire width of the stream could be observed. All observed fish were identified to the species. Salmonids were tallied and visually measured and presence/absence was noted for all other species.

The length of each transect was measured for each site along with five widths, which were averaged to obtain a mean width. The mean width was multiplied by the transect length to get the total area that was surveyed. The area of each transect was divided by number of fish observed over 100 m to obtain fish densities in fish $/ 100 \mathrm{~m}^{2}$. Temperature, conductivity, underwater visibility, and percent habitat type were each measured and recorded. Additionally, water velocities were estimated using the method described in Chapter 5 of A Citizen's Guide to Understanding and Monitoring Lakes and Streams (J.P. Michaud 1991).

Transects were chosen based on accessibility, due to poor public access. The crew accessed the river at public access points and from private land where permission could be obtained. After accessing the river, crews were instructed to identify a snorkel site that was roughly 100 m in length and had multiple habitat types (e.g., pool, riffle, run, and pocket water). Care was taken not to disturb the site prior to snorkel surveys and all stream measurements were conducted after the snorkel survey occurred.

## RESULTS

## North Fork Payette River

In 2021, we surveyed four sites in the NFPR (Table 25). Mean RBT density was 0.57 fish/100 $\mathrm{m}^{2}(\mathrm{SE}=0.08$; Table 26) and RBT as well as trout fry were observed at all four sites. Mean density of trout fry was $1.44 / 100 \mathrm{~m}^{2}$ ( $\mathrm{SE}=1.00$; Table 26). Brook Trout (BKT) Salvelinus fontinalis were observed at two of the sites (mean density $=0.08$ fish $/ 100 \mathrm{~m}^{2}$; SE $=0.05$; Table 26). Mountain Whitefish (MWF) Prosopium williamsoni were also observed (mean density $=8.00$ fish $/ 100 \mathrm{~m}^{2}$; SE = 1.48; Table 26) at all four sites. In the NFPR, we also observed Redside Shiner (RSS) Richardsonius balteatus, Largescale Sucker (LSS) Catostomus macrocheilus, Northern Pikeminnow (NPM) Ptychocheilus oregonensis, and Dace Rhinichthys spp. Mean temperature at all four sites was $18.1^{\circ} \mathrm{C}$, a mean conductivity of $18 \mu \mathrm{~S} / \mathrm{cm}$ and a mean flow of 490.1 cubic feet per second (CFS; Table 26).

## Lake Fork Creek

We surveyed three sites in LFC (Table 25). Mean RBT density was 0.93 fish $/ 100 \mathrm{~m}^{2}$ (SE $=0.46$; Table 27) and RBT were observed at all three sites. Mean density of trout fry was 0.36 fish/ $100 \mathrm{~m}^{2}$ (SE = 0.31; Table 27) and trout fry were observed at two of the three sites. BKT were observed (mean density $=0.38$ fish $/ 100 \mathrm{~m}^{2} ; \mathrm{SE}=0.28$; Table 27) at two sites and MWF were
observed (mean density $=3.39$ fish $/ 100 \mathrm{~m}^{2}$; SE $=3.11$; Table 27) at one site. We also observed RSS, LSS, NPM, Cottidae spp., Yellow Perch (YLP) Perca flavescens, and Dace Rhinichthys spp. Mean temperature at all three sites was $17.4^{\circ} \mathrm{C}$, mean conductivity was $19 \mu \mathrm{~S} / \mathrm{cm}$ and a mean flow of 182.7 CFS (Table 27).

## Gold Fork River

We surveyed five sites in the GFR (Table 25). Mean RBT density was 0.07 fish/ $100 \mathrm{~m}^{2}$ (SE = 0.04; Table 28) and RBT were observed at three sites. Mean density of trout fry was 0.04 fish $/ 100 \mathrm{~m}^{2}(\mathrm{SE}=0.04$; Table 28) and trout fry were observed at two of the six sites. MWF were observed ( $0.42 \mathrm{fish} / 100 \mathrm{~m}^{2}$; SE $=0.26$; Table 28) at two of the six sites. We also observed RSS, LSS, NPM, and Cottidae spp. Mean temperature was $14.3^{\circ} \mathrm{C}$, mean conductivity was $22 \mu \mathrm{~S} / \mathrm{cm}$, and mean flow was 199.6 CFS (Table 28).

## DISCUSSION

The results of our 2021 survey suggest that RBT are broadly distributed across the major Lake Cascade tributaries, occupying each tributary and nearly every site surveyed (83\%). However, densities of RBT and trout fry were generally low compared to other streams that are snorkeled in the McCall subregion (IDFG unpublished data). In the future, snorkel surveys should be used to assess how abundance of RBT changes over time, thus, repeating these same sites in subsequent years will provide the best data for comparison. Unfortunately, comparisons with past surveys (Janssen and Anderson 1992, Anderson et al. 1998, Janssen et al. 2002) are limited due to differences in survey methodologies and site locations.

## North Fork Payette River

The North Fork Payette River (largest tributary of Lake Cascade) supported the highest densities of trout fry observed in our survey. Unfortunately, very little is known about RBT production and abundance in the NFPR below Payette Lake. Therefore, snorkeling (and possibly redd surveys) should be conducted annually to track RBT production in the NFPR. This section of river below Payette Lake is significantly impacted by high water temperatures, sedimentation, and poor water quality. Monitoring data from the Department of Environmental Quality (DEQ) in the NFPR has shown water temperatures that exceed the thresholds necessary to support coldwater aquatic life (DEQ 2019). As the area surrounding the NFPR below Payette Lake continues to develop, overall water-use demands on the system will also increase. Fishery managers should continue to work closely with irrigators and water users to find collaborative solutions for improving water quantity and quality and decreasing summer water temperatures in the NFPR.

## Lake Fork Creek

Lake Fork Creek faces similar challenges as the NFPR (i.e., development, irrigation diversions, warm-water source). Between the outlet of Little Payette Lake and the mouth of LFC, a series of irrigation diversions (i.e., Lake Fork Irrigation District canals) have been previously shown to entrain adult and juvenile RBT and act as migration barriers that restrict fish passage. In 1989, snorkeling revealed high densities of RBT ( 2.67 fish/100 m²) in the Lake Fork Irrigation District system, a major RBT production loss. Additionally, irrigation diversions can act as
migration barriers in the LFC, which was first observed in the LFC at a diversion approximately 1 km below Little Payette in 1992 (Janssen and Anderson 1992). While screens are available to block salmonid loss to irrigation diversions and have been widely employed across Idaho (Hovanisian 1997), maintenance and associated costs can be a challenge. The Mahala Ditch on LFC was screened in 1999 but abandoned by 2002 (Hightree 2002). Moving forward, fishery managers should develop a study to estimate RBT production and entrainment in the upper LFC irrigation diversions below Little Payette Lake. If substantial losses are observed, managers should work closely with the Lake Fork Irrigation District to find collaborative solutions for reducing entrainment of juvenile RBT in LFC.

## Gold Fork River

In 2021, the GFR had particularly low densities of RBT and trout fry ( $<0.1$ fish $/ 100 \mathrm{~m}^{2}$ ). Our findings are similar to surveys conducted in 1998 and 2002 that described the GFR as "virtually fishless" (Anderson et al. 1998, Janssen et al. 2002). Approximately 6.4 km upstream from the mouth of the GFR is a 5.5 m tall irrigation diversion dam that does not provide fish passage and serves to provide water for irrigation in the lower GFC drainage. A large amount of spawning and rearing habitat exists upstream of the dam that has potential to greatly improve production of natural-origin RBT in Lake Cascade. Anderson and Robertson (1985b) surveyed the GFR drainage in 1985 and estimated 30 km of quality spawning habitat and 58 km of quality rearing habitat in the GFR drainage. Unfortunately, adfluvial RBT from Lake Cascade are currently unable to access these habitats in the GFR, which would significantly increase natural production of RBT. In fact, the 1985 survey suggested that enough spawning and rearing habitat exists to support up to 11,000 adfluvial RBT, which could contribute up to 250 k catchable RBT for Lake Cascade, annually (Anderson and Robertson 1985b).

Fishery managers should develop a study to evaluate fish losses in the Gold Fork Irrigation diversion and gather additional flow and water temperature data from both above and below the diversion on the mainstem GFR. These data will assist managers with determining if screening of the diversion, broodstock introductions (e.g., egg boxes), and fish passage projects can be implemented to increase RBT production in the GFR.

## MANAGEMENT RECOMMENDATIONS

1. Continue conducting annual snorkel surveys at each trend site established in 2021 to monitor trends in fish abundance and changes in water quality and habitat.
2. On the NFPR, work to improve water quality, quantity, and temperatures by communicating survey findings with water users and other stakeholders.
3. On LFC, develop a study to evaluate production of RBT and entrainment in the Lake Fork Irrigation District.
4. On GFC, develop a study to evaluate entrainment in the Gold Fork Irrigation diversion and gather flow and water temperature data from both above and below the diversion on the mainstem GFR.

Table 25. Stream, Site Name, Lat/Long, number of snorkelers, transect length ( $m$ ), and site description of snorkel sites conducted in Lake Cascade tributaries between June 18 and 20, 2021.
\(\left.$$
\begin{array}{cccccc}\hline \text { Stream } & \text { Site Name } & \text { Latitude } & \text { Longitude } & \begin{array}{c}\text { \# } \\
\text { Snorkelers }\end{array}
$$ \& \begin{array}{c}Transect <br>
Length <br>

(m)\end{array}\end{array} $$
\begin{array}{c}\text { Site Description }\end{array}
$$\right]\)| Start site just above island |
| :---: |
| where channel splits into |
| two. End site at bottom of |
| riffle where river narrows, |
| just above large pool. |
| Start site just below dam |
| at narrowing of two large |
| boulders. End site at large |
| boulder on river right. |

Table 25. (continued)

\begin{tabular}{|c|c|c|c|c|c|c|}
\hline Stream \& Site Name \& Latitude \& Longitude \& \# Snorkelers \& Transect Length \& Site Description <br>
\hline Lake Fork \& Lower Bridge \& 44.774375 \& -116.083657

-116.076608 \& 4

3 \& 117

92 \& Start site at the narrowest section of the river, just upstream of a large downed tree. End site around the bend at the start of the riffle, where there is a downed tree to river right. Start site just above large downed tree with a gravel bar on snorkel <br>
\hline Lake Fork \& Lake Fork Creek Road \& 44.832052 \& -116.076608 \& 3 \& 92 \& left. End site at bottom of riffle upstream of bridge, where gravel bar begins on river left. Walk out from campground site and start snorkel at the <br>

\hline Lake Fork \& Rolands Pond \& 44.916828 \& -116.007349 \& 5 \& 77 \& | largest rock in the center of the river. End site at a downed tree on river right. |
| :--- |
| Walk upstream of parking spot $\sim 50 \mathrm{ft}$, site starts at narrows above | <br>

\hline North Fork Payette River \& Smylie Lane Bridge \& 44.790868 \& -116.143052 \& 6 \& 165 \& a gravel bar that splits the river into multiple channels. End site at top of sand bar on river right. <br>
\hline
\end{tabular}

Table 25. (continued)
\(\left.$$
\begin{array}{cccccc}\hline \text { Stream } & \text { Site Name } & \text { Latitude } & \text { Longitude } & \begin{array}{c}\text { \# } \\
\text { Snorkelers }\end{array} & \begin{array}{c}\text { Transect } \\
\text { Length }\end{array}
$$ <br>

\hline North Fork Payette River \& Big Hole \& 44.888364 \& -116.112475 \& 7 \& 100\end{array} $$
\begin{array}{c}\text { Site Description }\end{array}
$$\right]\)| Start site at end of |
| :---: |
| riffle/beginning of back |
| eddy. End site at narrow |
| section where pool turns |
| into run and then riffle |
| Start of site is just below |
| riffle/above a gravel bar |
| on the river left. End site |
| at top of island that splits |
| channel in two. |

Table 26. Abiotic variables and densities (fish/100 $\mathrm{m}^{2}$ ) of salmonids observed in the North Fork of the Payette River (NFPR) at the four core transects. Rainbow Trout fry = all trout $<50 \mathrm{~mm}$.

| Density (fish/100m²) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Stream | Transect | Survey <br> Date | Rainbo w Trout Fry | Rainbo w Trout | $\begin{gathered} \text { Broo } \\ \mathbf{k} \\ \text { Trout } \end{gathered}$ | Whitefis h | Visibilit $y$ (m) | $\begin{aligned} & \text { Tem } \\ & \mathrm{p}(\mathrm{C}) \end{aligned}$ | $\begin{gathered} \text { Conductivit } \\ \mathbf{y} \\ (\mu \mathrm{S} / \mathrm{cm}) \end{gathered}$ | Flow (cfs) |
| NFPR | Smylie Ln Bridge | $\begin{aligned} & \text { 6/18/202 } \\ & 1 \end{aligned}$ | 0.28 | 0.80 | 0.00 | 7.81 | 2.2 | 18.0 | 21 | 698.38 |
| NFPR | Sheep Bridge Hole | $\begin{aligned} & 6 / 20 / 202 \\ & 1 \end{aligned}$ | 0.82 | 0.53 | 0.00 | 3.94 | 1.8 | 17.3 | 17 | 356.48 |
| NFPR | Sheep Bridge Hole 2 | $\begin{aligned} & 6 / 20 / 202 \\ & 1 \end{aligned}$ | 0.26 | 0.47 | 0.13 | 9.46 | 2.3 | 17.8 | 18 | 177.27 |
| NFPR | Big Hole | $\begin{aligned} & 6 / 20 / 202 \\ & 1 \end{aligned}$ | 4.40 | 0.49 | 0.20 | 10.79 | 3.4 | 19.4 | 14 | 728.31 |
|  | MeanStandard Error |  | 1.44 | 0.57 | 0.08 | 8.00 | 2.4 | 18.1 | 17.5 | 490.1 |
|  |  |  | 1.00 | 0.08 | 0.05 | 1.48 | 0.3 | 0.4 | 1.4 | 134.1 |
|  | Proportion Occupied |  | 1.0 | 1.0 | 0.5 | 1.0 |  |  |  |  |

Table 27. Abiotic variables and densities (fish/100 m2) of salmonids observed in Lake Fork Creek (LFC) at the three core transects. Rainbow Trout fry = all trout $<50 \mathrm{~mm}$.

| Density (fish/100m²) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Strea <br> m | Transect | Survey Date | Rainbo w Trout Fry | Rainbow Trout | $\begin{gathered} \text { Broo } \\ \mathbf{k} \\ \text { Trout } \end{gathered}$ | Whitefis h | Visibilit $y(m)$ | $\begin{aligned} & \text { Tem } \\ & \mathrm{p}(\mathrm{C}) \end{aligned}$ | $\begin{gathered} \text { Conductivit } \\ y \\ (\mu \mathrm{~S} / \mathrm{cm}) \end{gathered}$ | Flow (cfs) |
| LFC | Rolands Pond | 6/18/2021 | 0.00 | 0.07 | 0.00 | 0.00 | 2.5 | 14.3 | 12 | 347.63 |
| LFC | LFC Rd | 6/18/2021 | 0.98 | 1.63 | 1.14 | 0.57 | 1.4 | 21.0 | 14 | 113.71 |
| LFC | Lower Bridge | 6/18/2021 | 0.10 | 1.10 | 0.00 | 9.60 | 2.2 | 16.8 | 30 | 86.85 |
| Mean |  |  | 0.36 | 0.93 | 0.38 | 3.39 | 2.0 | 17.3 | 18.6 | 182.7 |
| Standard Error |  |  | 0.31 | 0.46 | 0.38 | 3.11 | 0.3 | 1.9 | 5.7 | 82.8 |
| Proportion Occupied |  |  | 0.67 | 1.00 | 0.33 | 0.67 |  |  |  |  |

Table 28. Abiotic variables and densities (fish/100 $\mathrm{m}^{2}$ ) of salmonids observed in the Gold Fork River (GFR) at the five core transects. Rainbow Trout fry = all trout $<50 \mathrm{~mm}$.

| Density (fish/100m²) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Stream | Transect | Survey Date | Rainbow Trout Fry | $\begin{aligned} & \text { Rainbow } \\ & \text { Trout } \\ & \hline \end{aligned}$ | Brook Trout | Whitefish | $\begin{gathered} \text { Visibility } \\ (\mathrm{m}) \end{gathered}$ | Temp (C) | Conductivity ( $\mu \mathrm{S} / \mathrm{cm}$ ) | Flow (cfs) |
| GFR | Pasture Site | 6/19/2021 | 0.00 | 0.00 | 0.00 | 0.00 | 3.1 | 16.3 | 21 | 80.66 |
| GFR | Plunge Pool | 6/19/2021 | 0.00 | 0.19 | 0.00 | 1.08 | 1.3 | 14.0 | 23 | 373.29 |
| GFR | Bridge <br> Access <br> Below Gold | 6/19/2021 | 0.00 | 0.07 | 0.00 | 0.00 | 1.9 | 12.2 | 23 | 158.74 |
| GFR | Fork Hot Springs | 6/19/2021 | 0.12 | 0.00 | 0.00 | 0.00 | 1.7 | 15.2 | 18 | 126.18 |
| GFR | Bridge Site | 6/19/2021 | 0.07 | 0.09 | 0.00 | 1.03 | 1.4 | 14.0 | 23 | 259.23 |
|  |  | Mean | 0.04 | 0.07 | 0.00 | 0.42 | 1.9 | 14.3 | 21.6 | 199.6 |
|  |  | dard Error | 0.02 | 0.04 | 0.00 | 0.26 | 0.3 | 0.7 | 1.0 | 52.4 |
|  | Proportio | Occupied | 0.40 | 0.60 | 0.00 | 0.40 |  |  |  |  |

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[^0]:    ${ }^{1}$ angling survey
    ${ }^{2}$ sinking gillnet only

