FISHERY MANAGEMENT INVESTIGATIONS

IDAHO DEPARTMENT OF FISH AND GAME
FISHERY MANAGEMENT ANNUAL REPORT

Ed Schriever, Director

SOUTHWEST REGION - MCCALL
2020

Mike Thomas, Regional Fisheries Biologist
Josh Poole, Regional Fisheries Biologist
Isaac Fournier, Fisheries Technician
Steven Hughes, Fisheries Technician
Jordan Messner, Regional Fishery Manager

June 2023
IDFG 21-113

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

HIGH MOUNTAIN LAKE SURVEYS

ABSTRACT

The McCall sub-region of the Idaho Department of Fish and Game (IDFG) surveyed 20 high mountain lakes (HMLs) in 2020. Of these lakes, seven are managed with special regulations to provide opportunities for anglers to catch trophy-sized trout. We evaluated species composition, relative abundance, size structure, and amphibian presence or absence in all lakes (Big Hazard Lake, Blue Lake, Brush Lake, Crystal Lake, Cutthroat Lake, Fish Lake, Flossie Lake, Grassy Mountain Lakes #1 and #2, Hidden Lake, Lake Rock Lake, Long Lake, Lost Lake, Louie Lake, Raft Lake, Sheepeater Lake, Shirts Lake, Serene Lake, Skein Lake, and Tule Lake). Fish presence was documented in all HMLs except Shirts Lake, despite it being stocked with fingerlings in 2018. This survey information will be used to guide our management strategies for HMLs in the McCall sub-region.

Authors:

Mike Thomas,
Regional Fisheries Biologist

Isaac Fournier,
Fisheries Technician

Jordan Messner,
Regional Fisheries Manager

INTRODUCTION

High mountain lakes (HMLs) provide diverse opportunities for anglers to pursue trout in highly scenic environments. Angler satisfaction for these fisheries consistently ranks highly among Idaho anglers (IDFG 2018); second only to Idaho's popular stream fisheries. The McCall sub-region currently stocks 165 HMLs on one- to three-year rotations with Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* (WCT), Rainbow Trout *Oncorhynchus mykiss* (RBT), Golden Trout *Oncorhynchus aguabonita* (GNT), and Arctic Grayling *Thymallus arcticus* (GRA). Within the past 20 years, IDFG has transitioned the HML stocking program such that all WCT and RBT are putative triploids to reduce the potential for spawning with naturally occurring fish downstream. Historically, IDFG stocked Brook Trout *Salvelinus fontinalis* (BKT) in several HMLs, although this has been discontinued for several decades due to concerns of competition or hybridization with other native species. In recent years, however, several lakes have been stocked with YY-male BKT as part of a long-term research study to evaluate their use for suppression or elimination of naturally reproducing BKT populations.

The majority of HMLs in the McCall sub-region are managed with a statewide daily bag limit of six trout (BKT limit is 25). However, seven HMLs are currently managed with a special "trophy" regulation: permitting harvest of two trout, none under twenty inches, with barbless hooks and no bait. These regulations were intended to reduce direct fishing mortality associated with harvest and improve numbers of quality-sized trout. These lakes are hereafter referred to as 'trophy lakes.'

In 2020, we sought to evaluate the size structure and relative abundance of fishes in all 7 trophy lakes and 13 HMLs managed with general regulations.

OBJECTIVES

1. Assess fish presence, species composition, relative abundance, and size structure information from HMLs to guide management actions for these fisheries.

2. Evaluate performance of special harvest regulations in trophy lakes by assessing size structure, fish condition, and relative abundance.

STUDY AREAS

Big Hazard Lake

Big Hazard Lake (45.214302°N, -116.138233°W) is a 57.9-ha lake located at an elevation of 2,125 m in the Salmon River drainage 34 km north of McCall. The lake is accessed by a well-used 500-m trail directly off Hazard Lake Road 2.4 km north of the turnoff for Hazard Lake Campground. Although there are no campsites or trails around its perimeter, Big Hazard Lake appears to receive a fair amount of use based on its close proximity to the road and developed campsite areas.

IDFG began stocking Big Hazard Lake with RBT in 1938 and continued on an irregular basis until 1977. In 2013, the lake was stocked with 2,500 GRA and in 2018, the lake was stocked with 1,500 GNT. Currently, the lake supports an established BKT population although the date and method of their introduction is unknown. We surveyed Big Hazard Lake on July 21 and 22, 2020. Due to its large size, Big Hazard Lake was sampled with three pairs of Swedish backpacking-style gill nets instead of a single net. CPUE was expressed as an average across all three pairs of gill nets.

Blue Lake

Blue Lake (44.408654°N, -116.134723°W) is a 5.7-ha lake located at an elevation of 2,232 m in the North Fork of the Payette River drainage 56 km south of McCall. The lake is accessed by a heavily used 2.1-km trail starting at Blue Lake Trailhead off of Snowbank Mountain Road. The lake appears to receive high-use with 14 campsites and a well-worn user trail around the entire perimeter.

Blue Lake was initially stocked in 1914 with BKT and RBT; however, IDFG has only stocked RBT since 1991. Since 2010, 1,000 RBT fingerlings are stocked on a triennial rotation. Blue Lake was last surveyed in 2004 before our survey on July 15 and 16, 2020.

Brush Lake – Trophy Lake

Brush Lake (45.051021°N, -115.988101°W) is a 7.5-ha lake located at an elevation of 2,165 m in the North Fork of the Payette River drainage 18 km northeast of McCall. It is accessed by hiking 5 km along the Crestline Trail #109 (northern trailhead) and taking a faint user trail (with heavy deadfall) to the east over a small hill. The lake appears to receive little use with one small campsite and fire ring on the northeast side of the lake and no trail around the perimeter.

IDFG first stocked Brush Lake in 1939 with RBT and WCT. Between 1990 and 2002, WCT X RBT, GRA, and GNT were stocked on an irregular basis. However, since 2012 it has been stocked triennially with 500 RBT and 500 WCT fingerlings (< 150 mm). Brush Lake was last surveyed in 2015 before our survey on July 29 and 30, 2020.

Crystal Lake – Trophy Lake

Crystal Lake (44.952668°N, -115.964193°W) is a 2.5-ha lake located at an elevation of 2,165 m in the North Fork of the Payette River drainage 12 km northeast of McCall. The trailhead is located on Lick Creek Road 8 km south of Lick Creek Summit. Follow the trail approximately 2.6 km to an unmarked junction, take a left, and then continue another 1.2 km to the lake. The lake appears to receive very little use, having two campsites with fire rings and a user trail around 50% of the perimeter.

IDFG first stocked Crystal Lake with RBT in 1926. Since 2012, it has been stocked triennially with 500 WCT fingerlings. This lake was last surveyed in 2005 before our survey on August 3 and 4, 2020.

Cutthroat Lake

Cutthroat Lake (45.375708°N, -115.335784°W) is a 5.0-ha lake located at an elevation of 2,254 m in the Salmon River drainage 79 km northeast of McCall. The easiest access is by flying into Chamberlain Air Strip and traveling on approximately 15.3 km of well-maintained trails to Sheepeater Lake, then hiking south 0.9 km off trail through heavy deadfall. This lake resides within the boundaries of the Frank Church River of No Return Wilderness. Angler-use is low due to the remoteness of this lake - there were no observed campsites or trails around the perimeter.

IDFG has stocked Cutthroat Lake with WCT since 1949 on an irregular basis. In 1980, it was stocked with WCT X RBT. However, since 2010 it has been stocked with 1,000 WCT fingerlings triennially. Cutthroat Lake was last stocked on August 21, 2019. The lake was last surveyed in 2006 before our survey on August 26 and 27, 2020.

Fish Lake

Fish lake (45.387290°N, -115.320445°W) is a 12.7-ha lake located at an elevation of 2,174 m in the Salmon River drainage 81 km northeast of McCall. The easiest access is by flying into Chamberlain Air Strip and traveling on approximately 13.9 km of well-maintained trails up Chamberlain Creek and then Fish Creek. This lake resides within the boundaries of the Frank Church River of No Return Wilderness. The U.S. Forest Service prohibits camping within 200 m of the perimeter of Fish Lake. Angler-use is low due to the remoteness of this lake. There is one campsite with a fire ring in a designated camping area and there is no trail around the perimeter.

There are no recorded historic stocking events for Fish Lake. Although the stocking history of this lake is unknown, surveys since 1998 indicate an established population of RBT in the lake. The lake was last surveyed in 2006 before our survey on August 27 and 28, 2020.

Flossie Lake

Flossie lake (45.394191°N, -115.276972°W) is a 8.1-ha lake located at an elevation of 2,142 m in the Salmon River drainage 84 km northeast of McCall. The easiest access is by flying into Chamberlain Air Strip and traveling 10.6 km on the well-used Flossie Lake Trail #24. This lake resides within the boundaries of the Frank Church River of No Return Wilderness. Angler-use is low - there are no campsites and there is no trail around the perimeter. The lake is currently surrounded by heavy deadfall.

IDFG first stocked Flossie Lake with RBT in 1949. Since 1981 it has been stocked triennially with 1,000 RBT fingerlings - last stocked on September 4, 2019. The lake was last surveyed in 2006 before our survey on August 27 and 28, 2020.

Grassy Mountain Lake #1

Grassy Mountain Lake #1 (45.166813°N, -116.193566°W) is a 5.1-ha lake located at an elevation of 2,238 m in the Salmon River drainage 29 km north of McCall. The lake is accessed by following the well-used Grassy Mountain Trail #161 3.2 km starting at the Coffee Cup Lake

Trailhead off Hazard Lake Road. Angler-use appears high - there are five campsites with fire rings and a trail around the entire perimeter.

IDFG first stocked Grassy Mountain Lake #1 with WCT in 1931. Although the date and method of introduction is unknown, BKT have been established in the lake since our earliest survey in 1985. In 1986, IDFG stocked 126 fall Chinook Salmon *Oncorhynchus tshawytscha* to reduce BKT abundance - this was unsuccessful. In a similar effort in 2007, 206 tiger muskellunge *Esox Lucius X E. masquinongy* were stocked in an effort to eradicate BKT (Koenig et al. 2015). Although complete eradication did not occur, relative abundance decreased substantially (89%), and in 2010 IDFG began stocking WCT fingerlings (2010) and RBT fingerlings (2011-present) in Grassy Mountain Lake #1. The most recent survey conducted in 2014 suggested that RBT were the most abundant fish species present in Grassy Mountain Lake #1. Currently, the lake is stocked on even years with up to 1,250 RBT. The lake was surveyed on July 28 and 29, 2020.

Grassy Mountain Lake #2

Grassy Mountain Lake #2 (45.166454°N, -116.199437°W) is a 5.1-ha lake located at an elevation of 2,263 m in the Salmon River drainage 29 km north of McCall. The lake is accessed by following the well-used Grassy Mountain Trail #163 3.2 km starting at the Coffee Cup Lake Trailhead off of Hazard Lake Road. Angler-use appears moderate - there are two campsites with fire rings and a trail around 70% of the perimeter.

The history of Grassy Mountain Lake #2 is similar to Grassy Mountain Lake #1. After the chinook plant in 1986, the lake was not stocked until 2007 when it was planted with 225 tiger muskellunge as part of the Koenig et al. study (2015). This effort nearly eradicated all BKT from Grassy Mountain Lake #2 (97%), and IDFG began stocking WCT fingerlings (2010) and RBT fingerlings (2011-present). The most recent survey in 2014 suggested that BKT had reestablished in Grassy Mountain Lake #2. We surveyed the lake on July 28 and 29, 2020.

Hidden Lake

Hidden Lake (44.443711°N, -116.113447°W) is a 4.0-ha lake located at an elevation of 2,149 m in the North Fork of the Payette River drainage 52 km south of McCall. The trailhead is located 0.6 km past the weather station on Snowbank Mountain Road and is unmarked. To get to the lake, proceed 1.0 km on the trail and then turn right at an unmarked junction. Hike 1.6 km on this trail, around Lost Lake, and down a gully to Hidden Lake. Angler-use appears moderate -- there are four campsites with fire rings and a trail around 40% of the perimeter.

IDFG stocked primarily RBT into Hidden Lake between 1926 and 1986, but since then 500 WCT have been stocked triennially. Hidden Lake was last stocked on August 29, 2019. This lake was last surveyed in 2005 before our survey on July 14 and 15, 2020.

Lake Rock Lake – Trophy Lake

Lake Rock Lake (45.208161°N, -115.918659°W) is a 3.0-ha lake located at an elevation of 2,226 m in the Secesh River drainage 36 km northeast of McCall. The trailhead is a small pullout off Warren Wagon Road approximately 16 km north of the entrance to Upper Payette

Lake. The hike is approximately 2.4 km to the lake along a well-worn and very steep trail. Angler use appears moderate -- there are four campsites, five fire rings, and a user trail around the entire perimeter.

Records indicate that IDFG first stocked Lake Rock Lake with WCT in 1968. Since 1975, the lake has been stocked triennially with up to 1,500 WCT. Lake Rock Lake was last surveyed in 2015 before our survey on July 29 and 30, 2020.

Long Lake – Trophy Lake

Long Lake (44.497915°N, -115.654689°W) is a 3.8-ha lake located at an elevation of 2,327 m in the South Fork of the Salmon River drainage 58 km southeast of McCall. The lake is accessed off of NFS Road 474 by following motorized trail #112 for 8.9 km then trail #84 for 2.3 km. Angler use appears low at Long Lake. There are two campsites with fire rings and a user trail around the entire perimeter.

Since 1932, IDFG has stocked RBT, GRA, and WCT in Long Lake. Since 1982, the lake has received primarily triennial plants of 500 RBT fingerlings. Long Lake was last stocked on September 4, 2019. The lake was last surveyed in 2015 before our survey on August 12 and 13, 2020.

Lost Lake

Lost Lake (44.446399°N, -116.119535°W) is a 1.9-ha lake located at an elevation of 2226 m in the North Fork of the Payette River drainage 53 km south of McCall. The trailhead is located 0.6 km past the weather station on Snowbank Mountain Road and is unmarked. From the trailhead, proceed 1.0 km on the trail and then turn right at an unmarked junction. Follow this trail for 1.0 km to the lake. Angler use appears moderate at Lost Lake. There are three campsites with fire rings and a trail around 60% of the perimeter.

IDFG first stocked Lost Lake with WCT in 1928. Since 1980, it has been stocked with up to 1,000 RBT fingerlings on a mostly triennial basis. Lost Lake was last stocked on August 29, 2019. The lake was last surveyed in 2005 until our survey on July 14 and 15, 2020.

Louie Lake – Trophy Lake

Louie Lake (44.851166°N, -115.964946°W) is a 10.0-ha lake located at an elevation of 2,136 m in the North Fork of the Payette River drainage 12.3 km southeast of McCall. There is a small dam and head gate on the outlet that is used to store and release irrigation water. Access to the lake is via a well-used 4.1 km trail that starts at Louie Lake Trailhead off of Boulder Lake Road. Angler-use is relatively high - there are four campsites with seven fire rings and a user trail around 60% of the perimeter.

IDFG first stocked Louie Lake in 1926 with RBT and WCT. Since 1997 it has been stocked triennially with 1,000 WCT and irregularly with up to 3,000 GNT. In 1999, the lake was stocked with 500 GRA. Louie Lake was last stocked on September 26, 2019. The lake was last surveyed in 2015 before our survey on August 3 and 4, 2020.

Raft Lake

Raft Lake (44.480815°N, -116.117729°W) is a 2.8-ha lake located at an elevation of 2,138 m in the North Fork of the Payette River drainage 48 km south of McCall. The lake is accessed by a 2.3-km hike on a well-used trail starting at Skein Lake Trailhead located approximately 5.6 km up Willow Creek Road. The lake appears to receive a moderate amount of use. There are four campsites with fire rings and a user trail around 30% of the perimeter.

IDFG first stocked Raft Lake in 1926 with WCT. Since 1992, the lake has been stocked with 500 RBT fingerlings, primarily on a triennial basis. Raft Lake was last stocked on September 4, 2019. The lake was last surveyed in 2005 before 0our survey on July 13 and 14, 2020.

Serene Lake - Trophy Lake

Serene Lake (45.193404°N, -116.193691°W) is 3.8-ha lake located at an elevation of 2,165 m in the Salmon River Drainage 32 km north of McCall. The lake is accessed by a well-used 3.2-km trail starting at the Coffee Cup Lake Trailhead off Hazard Lake Road. The lake appears to receive a fair amount of use. There are two campsites with fire rings and a user trail around 10% of the perimeter.

IDFG first stocked Serene Lake with RBT in 1942, but has stocked the lake with WCT since 1946. Despite no record of introduction, BKT have been observed in Serene Lake since some of the earliest records in 1989. Serene Lake has been stocked on even years since 1992 and was last stocked on August 7, 2018 with 500 WCT fingerlings. This lake was last surveyed in 2015 before our survey on July 28 and 29, 2020.

Sheepeater Lake

Sheepeater Lake (45.383901°N, -115.338165°W) is a 12.4-ha lake located at an elevation of 2,341 m in the Salmon River drainage 79 km northeast of McCall. The easiest access is by flying into Chamberlain Air Strip and traveling on approximately 15.3 km of well-maintained trails to the lake. This lake resides within the boundaries of the Frank Church River of No Return Wilderness. The lake appears to receive very little use. There is one campsite with a fire ring and a user trail around 20% of the perimeter.

Records indicate that IDFG began stocking Sheepeater Lake as early as 1955 with GNT and WCT. Since 2011, the lake has been stocked with GNT, primarily on a triennial basis. Sheepeater Lake was last stocked with up to 1,500 GNT fingerlings on September 4, 2020. The lake was last surveyed in 2006 before our survey on August 26 and 27, 2020.

Shirts Lake

Shirts Lake (44.458187°N, -116.122903°W) is a 3.5-ha lake located at an elevation of 2,249 m in the North Fork of the Payette River drainage 50 km south of McCall. The lake is accessed by going 2.0 km on a well-used trail starting at an unmarked trailhead located 0.6 km past the weather station on Snowbank Mountain Road. The lake appears to receive a high amount of use. There are four campsites with fire rings and a user trail around the entire perimeter.

IDFG first stocked Shirts Lake with RBT in 1923. From 1949 until 1998, BKT, RBT, and WCT were stocked – of which, BKT became well established. To reduce abundance of BKT, 140 tiger muskellunge were stocked in 2007 and an evaluation was conducted as part of a statewide research project (Koenig et al. 2015). Four years after the introduction of tiger muskellunge, BKT abundance dropped significantly (86%). Since 2012, up to 1,000 RBT have been stocked on an annual or biennial basis. The lake was last surveyed in 2016 before our survey on July 15 and 16, 2020.

Skein Lake

Skein Lake (44.477202°N, -116.112558°W) is a 3.2-ha dam controlled lake located at an elevation of 2,103 m in the North Fork of the Payette River drainage 48 km south of McCall. The lake is accessed by a 1.8-km hike on a well-used trail starting at Skein Lake Trailhead located approximately 5.6 km up Willow Creek Road. The lake appears to receive a fair amount of use. There are three campsites with fire rings and a user trail around 30% of the perimeter.

IDFG first stocked Skein Lake with WCT in 1928 and RBT in 1932. In 1988 this was discontinued and 2,000 Brown Trout *Salmo trutta* (BRT) fingerlings were experimentally stocked in Skein Lake and several others to provide new HML fishing opportunities in the McCall subregion. Unfortunately, growth and survival of BRT was poor and this effort was discontinued in the early 1990s. Since that time, up to 1,000 WCT have been stocked triennially. Skein Lake was last stocked with 1,000 WCT fingerlings on August 24, 2019. This lake was last surveyed in 2005 before our survey on July 13 and 14, 2020.

Tule Lake – Trophy Lake

Tule Lake (44.629344°N, -115.684082°W) is a 3.5-ha lake located at an elevation of 1,633 m in the South Fork of the Salmon River drainage 45 km southeast of McCall. The lake is accessed by a well-used 0.3-km trail located on NFS road 427 - 4.8 km after it branches off of Warm Lake Highway. Due to its close proximity to NFS road 427, Tule Lake appears to receive a fair amount of use by anglers. We did not observe any campsites, and there is a user trail around 50% of the perimeter.

IDFG first stocked Tule Lake with WCT in 1930, but subsequent stockings also included RBT and RBT X WCT. Since 2010, up to 500 WCT have been stocked on an annual or biennial basis. Tule Lake was last stocked on August 24, 2019 with 500 WCT fingerlings. This lake was last surveyed in 2014 before our survey on August 13 and 14, 2020.

METHODS

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-, and 38.0-mm bar measure). Catch-per-unit-effort (CPUE) was calculated as the average number of fish caught in a paired gill net set per net night. In addition to the netting effort, HMLs were angled by shore or inflatable raft for at least 0.5 h to estimate catch rates when time permitted.

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:

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

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:

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

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). A modified timed visual encounter survey (VES; Crump and Scott 1994) was used to determine the presence of amphibians (i.e., Columbia Spotted Frog *Rana luteiventris*, Western Toad *Anaxyrus boreas*, and Long-Toed Salamander *Ambystoma macrodactylum)* at each lake.

RESULTS AND DISCUSSION

Big Hazard Lake

We caught a total of 136 fish of two species (98% BKT and 2% RBT) in three paired gill net sets in Big Hazard Lake in 2020 (mean CPUE = 23; sinking = 43; floating = 2; Table 1). We caught 134 BKT ranging in length from 96 to 331 mm (mean = 234 mm), and mean relative weight was 85 (range = 62-118; Table 1; Figure 1). We caught two RBT that were 87 and 234 mm, respectively (Figure 1). One angler fished with artificial flies for 1.5 h and caught 3 fish (CPUE = 2 fish/h). We did not conduct a VES survey or evaluate the amount of suitable spawning substrate at Big Hazard Lake. However, the presence of RBT (not stocked since 1977) and high relative abundance of BKT in our survey (Table 1), suggest that natural reproduction is occurring. Big Hazard Lake is also unlikely to winterkill (max depth = 23.2 m; secchi = 8.3 m).

Based on these results, we do not recommend stocking this fishery unless a decision is made beforehand to eradicate or reduce abundance of BKT. Big Hazard Lake provides anglers a unique and highly accessible opportunity to catch large numbers of quality-sized BKT (Table 1; Figure 1) and should continue to be managed as a BKT fishery.

Blue Lake

We caught 24 RBT in a single sinking gill net set in Blue Lake in 2020 (CPUE = 24; Table 1). Lengths ranged from 89 to 368 mm TL (mean = 205 mm), and mean relative weight was 80 (range = 67-97; Table 1; Figure 2). The lake is relatively deep (max depth = 18.2 m; secchi = 5.7 m) with very little spawning substrate available to support natural reproduction (<10 m^2; Table 2). We did not observe any juvenile trout or fry. Columbia Spotted frogs were present (Table 2).

Blue Lake appears to receive a lot of use; with 14 campsites, 15 fire pits, and a busy parking lot area. Although popular, angling is somewhat difficult at Blue Lake due to lake morphometry (e.g., deep) and thick shoreline vegetation. Two anglers fished with artificial flies for a combined effort of two hours and did not catch any fish. The current stocking density for RBT at Blue Lake is 175 fish/ha, once every three years (Table 2). Since natural reproduction is likely not occurring, increased stocking density or frequency may help improve angling catch rates and increase the overall quality of fishing opportunities at Blue Lake. We recommend increasing stocking density to 250 fish/ha to determine whether catch rates can be improved without negatively influencing fish body condition in Blue Lake.

Brush Lake – Trophy Lake

We caught a total of 53 fish of three species (43% WCT, 30% RBT, and 26% WCT X RBT) in a paired gill net set in Brush Lake in 2020 (CPUE = 26.5; sinking = 43; floating = 10; Table 1). We collected 23 WCT that ranged in lengths from 93 to 300 mm TL (mean = 167 mm) with a mean relative weight of 112 (range = 88-137; Table 1; Figure 2), 16 RBT that ranged in lengths from 121 to 322 mm TL (mean = 206 mm) with a mean relative weight of 92 (range = 77-107; Table 1; Figure 2), and 14 WCT X RBT that ranged in lengths from 181 to 434 mm TL (mean = 315 mm; Table 1; Figure 2). We did not record a maximum depth at Brush Lake, but recorded a secchi depth of 6.2 m. We observed one inlet and outlet with ~ 25 m^2 of suitable spawning substrate, indicating that natural reproduction is possible. Columbia Spotted frogs were present (Table 2).

Two anglers fished with artificial flies for a combined effort of five hours and caught 14 fish (2.8 fish/h). Although Brush Lake provides high quality fishing opportunity as evidenced by high catch rates and high fish body condition, overall use appears to be very low (Table 2). The presence of WCT X RBT indicate that some levels of natural reproduction are occurring to maintain this fishery in addition to stocking, and survey data suggests WCT X RBT are outperforming stocked WCT and RBT in Brush Lake, as they represented the majority of the larger fish captured.

Although survey data showed excellent fish size and body condition in Brush Lake, we did not collect any fish greater than 434 mm (Table 1; Figure 2). In effect, the special 'trophy' regulations for Brush Lake are functionally serving as a de facto catch-and-release regulation. Therefore, managers should consider removing the special harvest regulations to allow these fish to be harvested by the occasional angler who would choose to do so. Current stocking densities and rotations appear to produce good catch rates of quality-sized fish and do not warrant further adjustments at this time. If special regulations are removed and Brush Lake is managed under general bag limits, the lake should be surveyed again within five years to evaluate the effects of any potential increase in harvest.

Crystal Lake – Trophy Lake

We caught a total of 15 WCT in a paired gill net set in Crystal Lake in 2020 (CPUE = 7.5; sinking = 15; floating = 0; Table 1). Lengths ranged from 281 to 415 mm TL (mean = 365 mm) and mean relative weight was 77 (61-114; Table 1; Figure 3). We recorded a maximum depth of 11.1 m (secchi = 9.7 m) and observed a single outlet with no suitable spawning substrate, indicating that natural reproduction is unlikely. Overall use appears to be low at Crystal Lake (Table 2). We did not observe any amphibians at Crystal Lake (Table 2).

Two anglers fished with artificial flies for a combined 1.75 h and caught 1 fish (0.9 fish/h). While body condition was fairly poor (Figure 3), Crystal Lake appears to produce quality-sized fish in terms of length. We observed many WCT ~ 250 mm swimming along the shoreline during our survey. However, despite special 'trophy' regulations, we did not collect any fish greater than 415 mm (Table 1; Figure 3). Therefore, removing the special regulations should be considered, as they essentially result in this lake being managed as "catch-and-release." Due to lack of natural reproduction and presence of quality-sized fish, Crystal Lake should continue to be stocked at the current density (200 fish/ha) every three years (Table 2). If special regulations are removed, this lake should be surveyed again within five years to evaluate the effects of a potential increase in harvest.

Cutthroat Lake

We collected 30 WCT in a paired gill net set in Cutthroat Lake in 2020 (CPUE = 15; sinking = 20; floating = 10; Table 1). Lengths ranged from 146 to 357 mm TL (mean = 259 mm), and mean relative weight was 95 (range = 64-130; Table 1; Figure 3). We recorded a max depth of 7.0 m (secchi = 5.9 m) with a single outlet and no suitable spawning substrate to support natural reproduction. We did not observe any amphibians at Cutthroat Lake (Table 2).

Cutthroat Lake is very remote, difficult to access, and appears to receive little to no use (Table 2). We observed many WCT fingerlings swimming along the shoreline, indicating high overwinter survival of stocked fish in 2019. Since natural reproduction is likely not occurring and the lake receives very little angling effort, managers should consider reducing the current stocking density from 200 fish/ha to 150 or 100 fish/ha to improve overall fish body condition and size structure.

Fish Lake

We captured 147 fish of three species (7% WCT, 85% RBT, and 7% WCT X RBT) in a paired gill net set at Fish Lake in 2020 (CPUE = 78.5; sinking = 106; floating = 41; Table 1). We caught 11 WCT that ranged in length from 98 to 276 mm TL (mean = 165 mm) with a mean relative weight of 81 (range = 50-107; Table 1; Figure 4), 125 RBT that ranged in length from 92 to 270 mm TL (mean = 165 mm) with a mean relative weight of 72 (range = 34-109;Table 1; Figure 4), and 11 WCT X RBT that ranged in length from 120 to 270 mm TL (mean = 203 mm; Table 1; Figure 4). Fish Lake is relatively deep (max depth = 14.3 m; secchi = 5.1 m) with three inlets and a single outlet. We observed a large amount of suitable spawning substrate in Fish Lake (Table 2), and an abundance of trout fingerlings and fry indicate high rates of natural reproduction at Fish Lake. Columbia Spotted frogs were also observed (Table 2). The current strategy of not stocking Fish Lake appears to be appropriate.

Flossie Lake

We collected 94 RBT in a paired gill net set in Flossie Lake in 2020 (CPUE = 47; sinking = 69; floating = 25; Table 1). Lengths ranged from 105 to 275 mm TL (mean = 205 mm), and mean relative weight was 72 (range = 38-109; Table 1; Figure 4). We did not record a maximum depth at Flossie Lake (secchi = 6.1 m). We observed a single inlet and outlet with high quality spawning substrate. Columbia Spotted frogs were present at Flossie Lake (Table 2).

Flossie Lake is very remote and difficult to access, and appears to receive very little angling effort as a result. Natural reproduction is likely occurring at a relatively high rate, as evidenced by high fish abundance, and low size structure and body condition. Therefore, stocking should be discontinued at Flossie Lake, as it does not seem necessary for maintaining this fishery.

Grassy Mountain Lake #1

We collected 23 BKT in a paired gill net set at Grassy Mountain Lake #1 in 2020 (CPUE = 11.5; sinking = 23; floating = 0; Table 1). Lengths ranged from 110 to 263 mm (mean = 202 mm) and mean relative weight was 94 (range = 81-110; Table 1; Figure 5). Grassy Mountain Lake #1 is relatively shallow, with a maximum depth of 4.0 m (secchi = 4.0 m). We observed a single inlet and outlet with high quality spawning substrate along the shoreline. Columbia Spotted frogs were present (Table 2).

We did not conduct an angling survey at Grassy Mountain Lake #1. The lake is relatively accessible and appears to receive a high amount of use (e.g., 4 campsites, 5 fire pits; Table 2). It appears that natural reproduction is occurring at a relatively high rate at Grassy Mountain Lake #1. Although we have been stocking high densities of RBT (245 fish/ha; Table 2) since 2011, we did not catch any RBT in our survey. Managers should consider discontinuing stocking of RBT since they are not contributing to the fishery. In order to establish a WCT or RBT fishery in this lake, BKT suppression may be warranted. Previously, tiger muskellunge were stocked in Grassy Mountain Lake #1 resulting in substantial reductions in CPUE (89%) for a period of up to five years (Koenig et al. 2015). However, this did not result in complete eradication, and refugia in inlets and outlets of both Grassy Mountain Lakes resulted in recolonization of BKT. Managers should consider electrofishing removal efforts in inlets and outlets in combination with other removal techniques (e.g., tiger muskellunge) to completely remove BKT from the system in order to establish a WCT or RBT fishery in Grassy Mountain Lake #1.

Grassy Mountain Lake #2

We collected a total of 71 fish of two species (96% BKT and 4% RBT) in a paired gill net set (CPUE = 35.5; sinking = 54; floating = 17; Table 1). We caught 68 BKT ranging in length from 90 to 270 mm (mean = 191 mm), and mean relative weight was 80 (range = 62-99; Table 1; Figure 5). We also caught three RBT ranging in length from 178 to 284 mm (mean = 220) with a mean relative weight of 87 (68-98; Table 1). We did not record a maximum depth (secchi = 4.0 m). We observed four inlets and a single outlet with high quality spawning substrate. Western Toads were present (Table 2).

Two anglers fished for a combined effort of 1 hour and caught 13 fish (CPUE = 13 fish/h). Grassy Mountain Lake #2 is relatively accessible and appears to receive a moderate amount of use (e.g., 2 campsites, 4 fire pits; Table 2). It appears that natural reproduction is occurring at a relatively high rate at Grassy Mountain Lake #2. Although we have been stocking RBT since 2011 (245 fish/ha; Table 2), we caught very few RBT (*n* = 3) in our survey. Similar to Grassy Mountain Lake #1, managers should consider discontinuing stocking, as natural reproducing BKT are primarily supporting this fishery. Conducting BKT suppression may be necessary in order to establish RBT or WCT in this lake. Similar to Grassy Mountain Lake #1, tiger muskellunge were previously stocked to reduce abundance of BKT in Grassy Mountain Lake #2, but this effort was ultimately unsuccessful. If BKT suppression efforts are attempted at these lakes again, managers should consider electrofishing or piscicide removal efforts in inlets and outlets of both lakes to decrease the likelihood of successful recolonization in the lakes.

Hidden Lake

We set one sinking net in Hidden Lake in 2020 and caught WCT (CPUE = 29; Table 1). Lengths ranged from 82 to 344 mm TL (mean = 221 mm) with a mean relative weight of 96 (52-154; Table 1; Figure 6). We recorded a maximum depth of 6.1 m (secchi = 6.1 m) and observed three inlets and a single outlet with very little suitable spawning substrate to support natural reproduction. We did not observe any trout fry or amphibians at Hidden Lake (Table 2).

Two anglers fished with artificial flies for a combined four hours and caught 11 fish (CPUE = 2.7 fish/h). Hidden Lake is relatively accessible and appears to receive a moderate amount of use (Table 2). As such, it should be managed for high catch rates, rather than improved fish growth and size structure. Catch rates are relatively high for quality-sized WCT (mean = 221 mm) and overall condition is good (W_r = 96) with the current stocking regime (Table 2). Therefore, no changes to stocking requests are recommended at this time.

Lake Rock Lake – Trophy Lake

We caught 35 WCT with a pair of gill nets in Lake Rock Lake in 2020 (CPUE = 17.5; sinking = 28; floating = 7; Table 1). Lengths ranged from 250 to 377 mm TL (mean = 292 mm) with a mean relative weight of 90 (range = 52-106; Table 1; Figure 6). We did not record a maximum depth, but observed three inlets and a single outlet with high quality spawning subset in one of the inlets. Columbia Spotted frogs were observed at Lake Rock Lake (Table 2).

Two anglers fished with artificial flies for a combined 1.75 hours and caught 15 fish (CPUE = 8.6 fish/h). Although relatively difficult to access (very steep trail), Lake Rock Lake appears to receive a moderate amount of use (Table 2) and provides high quality fishing opportunity as evidenced by high catch rates and high fish body condition. Although spawning substrate is present in one of the inlets, natural reproduction appears to be limited as we did not catch or visually observe any WCT less than 250 mm. Despite special ‘trophy’ regulations, we did not observe any WCT larger than 377 mm. Therefore, managers should consider removing the special harvest regulations, as they do not appear to be accomplishing target objectives for producing trophy-sized trout. The current stocking density and rotation (500 fish/ha; Table 2) appears adequate for producing good catch rates of quality-sized fish at this time. If special regulations are removed, this lake should be surveyed again within five years to evaluate the effects of any potential increase in harvest and to determine if stocking adjustments are needed.

Long Lake – Trophy Lake

We collected a total of 11 RBT in a paired gill net set (CPUE = 5.5; sinking = 11; floating = 0; Table 1). Lengths ranged from 158 to 585 mm (mean = 248 mm) and mean relative weight was 89 (range = 60-103; Table 1; Figure 7). We recorded a maximum depth of 12.4 m (secchi = 7.0 m) and observed two inlets and a single outlet with very little to no suitable spawning substrate to support natural reproduction. We did not observe any amphibians or trout fry (Table 2).

We did not conduct an angling survey at Long Lake. Although it is relatively easy to access, Long Lake does not appear to receive a high amount of use (Table 2). While CPUE was relatively low (Table 1), we collected two fish over 500 mm in length. Long Lake appears to support a low density of fish that are able to achieve quality-sizes. However, the majority (82%) of fish collected were less than 250 mm in length. The special "trophy" regulation does not appear to be effective in producing numbers of fish greater than 508 mm and managers should consider removing the regulation as it is essentially producing a "catch-and-release" fishery. If the current regulation is removed, Long Lake should be sampled again within five years to determine any effects of a potential increase in harvest.

Lost Lake

We caught a total of 26 fish (96% WCT and 4% WCT X RBT) in a paired gill net set (CPUE = 13; sinking = 26; floating = 0; Table 1). We caught 25 WCT ranging in length from 87 to 332 mm (mean = 217 mm), and mean relative weight was 95 (range = 63-152; Table 1; Figure 7). We also caught one WCT X RBT that was 300 mm TL. Lost Lake is relatively shallow, with a maximum depth of 5.0 m. We observed a single inlet and outlet with very little spawning substrate to support natural reproduction. Columbia Spotted frogs were observed (Table 2).

One angler fished with artificial flies for 0.25 hours and did not catch a fish. Lost Lake is relatively easy to access but fairly difficult to fish due to an expanse of lily pads along the majority of the shoreline. Although there is very little spawning substrate, the presence of WCT X RBT indicates some level of natural reproduction is occurring. Body condition of fish is very good (W_r = 95) considering Lost Lake has the highest stocking density of any lake sampled in 2020 (526 fish/ha; Table 2). High body condition indicates good forage quality in the lake, likely due to the expanse of vegetation along the shoreline. Since Lost Lake is fairly accessible, appears to receive a moderate amount of use (i.e., 3 campsites and fire pits; Table 2), and fishing is challenging due to shoreline vegetation, the current high stocking density and rotation should be maintained.

Louie Lake – Trophy Lake

We collected a total of 31 fish (58% WCT, 10% GDT, 32% unknown) in a paired gill net set at Louie Lake in 2020 (CPUE = 15; sinking = 28; floating = 2; Table 1). No angling surveys were conducted. We caught 18 WCT in gill nets that ranged in length from 121 to 381 mm (mean = 300 mm), and mean relative weight was 95 (range = 81-113; Table 1; Figure 8). We also caught three GDT that ranged in length from 97 to 187 mm (mean = 132 mm). Relative weight of the 187 mm GDT was 113. Unfortunately, ~10 m of sinking net was pulled onto shore over night at Louie Lake, making some fish unidentifiable by the time we arrived to pull the nets. This could have been expected at Louie Lake, which receives a very high amount of day-use.

The lake is relatively deep, with a maximum depth of 18.6 m (secchi = 6.2 m). We observed three inlets and one outlet with high amounts of spawning substrate, however we did not observe any trout fry or fingerlings along the shoreline. Columbia Spotted frogs were present (Table 2).

Louie Lake produces good numbers of quality-sized WCT (mean length = 300 mm). However, special harvest restrictions are not translating to fish achieving lengths larger than 508 mm. This lake functionally serves as a catch-and-release fishery under current regulations. If special regulations were removed it is very likely that harvest rates would increase substantially and catch rates would decline under the current stocking regime, as effort is relatively high at Louie Lake. Therefore, we recommend keeping the special harvest regulations at Louie Lake in place for the time-being, and re-evaluate alternative strategies in the future (such as increased stocking rates).

Raft Lake

We caught a total of eight RBT in a sinking gill net in Raft Lake in 2020 (CPUE = 8; Table 1; Figure 8). Lengths ranged from 110 to 484 mm (mean = 190 mm) and relative weight was 88 (range = 67-95; Table 1; Figure 8). We recorded a maximum depth of 9.1 m (secchi = 4.1 m) and observed one inlet and outlet with very little spawning substrate (Table 2). We did not observe any trout fry but did observe fingerlings in the outlet - likely holdovers from the 2019 plantings. Both Columbia Spotted frogs and Western toads were present at Raft Lake (Table 2).

Two anglers fished with artificial flies for a combined effort of two hours and caught three fish (0.7 fish/h), the largest of which was 457 mm. Due to expanses of lily pads along the majority of the shoreline, Raft Lake is fairly difficult to fish. Raft Lake is very accessible and appears to receive a moderate amount of use. The presence of fish greater than 450 mm, and relatively high body condition (mean W_r = 88) indicate that the current stocking density (179 fish/ha) and rotation is appropriate (Table 2).

Serene Lake – Trophy Lake

We caught a total of 32 fish of two species (91% BKT and 9% WCT) in a paired gill net set (CPUE = 16; sinking = 29; floating = 3; Table 1; Figure 9). We caught three WCT that ranged in length from 105 to 385 mm (mean = 289 mm), and mean relative weight was 75 (range = 69-82; Table 1; Figure 9). We caught 29 BKT that ranged in length from 191 to 335 (mean = 261 mm) and mean relative weight was 84 (range = 65-106; Table 1; Figure 9). We recorded a maximum depth of 15.2 m (secchi = 6.2 m) and observed three inlets and a single outlet, neither of which contained any spawning substrate. However, we did observe a small amount (< 5 m^2) of spawning substrate along the shoreline. We did not observe any trout fingerlings or fry. Western toads were present at Serene Lake (Table 2).

Two anglers fished with artificial flies for a combined effort of two hours and caught two fish (1 fish/h). Serene Lake appears to receive a moderate amount of use. Although some quality-sized WCT are present in the lake (mean length = 289 mm), it is dominated by BKT. The presence of BKT indicate natural reproduction is occurring in Serene Lake. The lack of fish greater than 385 mm in our survey indicate that special “trophy” regulations are not resulting in fish reaching lengths greater than 508 mm. Rather, this regulation is in effect protecting small BKT from being susceptible to harvest, which is likely counterproductive for improving WCT growth rates (e.g., mean W_r = 75). Therefore, removing special "trophy" regulations should be considered. Current stocking densities of WCT (132 fish/ha; Table 2) should be continued and if special regulations are removed, this lake should be surveyed again within five years to evaluate the effects of any potential increase in harvest. Brook Trout removal efforts may be warranted in the future if this population continues to persist.

Sheepeater Lake

We caught a total of 12 WCT in a paired gill net set at Sheepeater Lake in 2020 (CPUE = 6; sinking = 11; floating = 1; Table 1; Figure 9). Lengths ranged from 116 to 468 mm (mean = 243 mm) and mean relative weight was 116 (range = 95-133; Table 1; Figure 9). We recorded a maximum depth of 16.2 m (secchi = 8.0 m). We observed three inlets with no suitable spawning substrate to support natural reproduction. We did not observe any trout fingerlings or fry. Columbia Spotted frogs were present at Sheepeater Lake (Table 2).

We did not conduct an angling survey. Sheepeater Lake appears to receive very little angling use. As such, this lake should be primarily managed for maximum fish size rather than abundance. WCT in Sheepeater Lake are in excellent condition, as evidence by the highest relative weights observed in 2020. The lack of spawning substrate and observed fish size structure indicate no natural reproduction is occurring, and this fishery is solely supported by stocking. Fish size structure and body condition indicate that the current stocking density (121 fish/ha) and rotation is working (Table 2), therefore no changes are recommended at this time.

Shirts Lake

We set one sinking gill net at Shirts Lake in 2020 and did not catch any fish. We did not observe any amphibians, trout fingerlings, or fry. We recorded four inlets and one outlet with high quality spawning substrate along the shoreline (Table 2). We recorded a maximum depth of 5.0 m. We did not observe any signs of fish activity in the lake and did not conduct an angling survey.

Shirts Lake appears to receive a relatively high amount of use and we spoke with several anglers at the lake who mentioned that fishing had been good a few years ago. However, it appears as though a winter-kill has occurred in the lake. Since the lake is so shallow (max depth = 5 m), it is very likely that this lake can experience anoxia during the winter season. Shirts Lake was last stocked on September 22, 2018 and prior surveys indicated an overabundance of BKT prior to stocking tiger muskellunge in 2007. This lake should continue to be stocked with sterile fish to re-establish fishing opportunity. Shirts Lake should be surveyed again within five years to determine whether this strategy is appropriate.

Skein Lake

We caught a total of 34 WCT in a sinking gill net set at Skein Lake in 2020 (CPUE = 34; Table 1). Lengths ranged from 94 to 345 mm (mean = 182 mm), and mean relative weight was 91 (range = 62-114; Table 1; Figure 10). We recorded a maximum depth of 12.2 m (secchi = 5.4 m) and observed one inlet and outlet with very little spawning substrate. Columbia Spotted frogs were present at Skein Lake (Table 2).

One angler fished with artificial flies for 0.75 h and did not catch any fish. Skein Lake appears to receive a moderate amount of angling use (Table 2). Although no fish were caught by angling, overall body condition of fish collected was high (W_r = 91) and Skein Lake produced some quality-sized fish (> 250 mm). Therefore, we recommend no change to the current stocking density in this lake (Table 2).

Tule Lake – Trophy Lake

We caught a total of 9 fish of two species (89% WCT and 11% RBT) in a paired gill net set at Tule Lake in 2020 (CPUE = 4.5; sinking = 7; floating 2; Table 1). We caught eight WCT that ranged in length from 396 to 462 mm (mean = 424 mm), and mean relative weight was 92 (range = 85-113; Table 1; Figure 10), and we caught a single RBT that measured 600 mm and had a relative weight of 62. We recorded a maximum depth of 4.6 m and did not observe any inlets or outlets to the lake. We also did not observe any suitable spawning substrate, trout fingerlings, or fry. Both Columbia Spotted frogs and Western Toads were present at Tule Lake (Table 2).

We did not conduct an angling survey at Tule Lake. The lake appears to receive a relatively high amount of day-use due to its close proximity to NFS road 427. Although Tule Lake produced the largest RBT (600 mm) across all HMLs surveys in 2020, this fish was likely a holdover from the last stocking of RBT in 2008. Tule Lake appears to support a low density of fish that are able to achieve quality-sizes, however, the majority of fish collected were less than 462 mm (Figure 10). The special “trophy” regulation does not appear to be effective in producing numbers of fish greater than 508 mm and managers should consider removing the regulation as it is essentially producing a “catch-and-release” fishery. If the current regulation is removed, Tule Lake should be sampled again within five years to determine any effects of a potential increase in harvest.

MANAGEMENT RECOMMENDATIONS

1. Continue to assess fish presence, species composition, relative abundance, and size structure in McCall sub-region HMLs.

2. Establish a systematic HMLs survey design based on stocking rotation so that adequate time is permitted to request changes to stocking densities.

3. Consider removing special harvest regulations all HMLs except for Louie Lake. If removed, evaluate effect after five years.

4. Discontinue stocking at Big Hazard Lake, Flossie Lake, and Grassy Mountain Lake #1 and #2.

5. Consider reducing stocking densities at Cutthroat Lake.

6. Consider increasing stocking density at Blue Lake.

7. Consider BKT removal strategies for HMLs with overabundance of BKT

Table 1. Species observed, number of fish caught, summary statistics (total length [TL], relative weight [W_r] and ranges) and catch-per-unit-effort (CPUE, fish/net night) during gill netting surveys of high mountain lakes in the McCall Sub-Region, Idaho in 2020.

Lake	Species	N	Mean TL (range)	Mean Wr (range)	CPUE
Big Hazard	Brook	134	234 (96-331)	85 (62-118)	231
	Rainbow	2	161(87-234)	92 (92)	
Blue	Rainbow	24	205 (89-368)	80 (67-97)	242
Brush	Cutthroat	23	167 (93-300)	112 (88-137)	27
	Rainbow	16	206 (121-322)	92 (77-107)	
	Hybrid	14	315 (181-434)	-	
Crystal	Cutthroat	15	365 (281-415)	77 (61-114)	8
Cutthroat	Cutthroat	30	259 (146-357)	95 (64-130)	15
Fish	Cutthroat	11	146 (98-276)	81 (50-107)	79
	Rainbow	125	165 (92-270)	72 (34-109)	
	Hybrid	11	203 (120-270)	-	
Flossie	Rainbow	94	205 (105-275)	72 (38-109)	47
Grassy Mountain #1	Brook	23	202 (110-263)	94 (81-110)	11
Grassy Mountain #2	Brook	68	191 (90-270)	80 (62-99)	36
	Rainbow	3	220 (178-284)	87 (68-98)	
Hidden	Cutthroat	29	221 (82-344)	96 (52-154)	292
Lake Rock	Cutthroat	35	292 (250-377)	90 (52-106)	18
Long	Rainbow	11	248 (158-585)	89 (60-103)	6
Lost	Cutthroat	25	217 (87-332)	95 (63-152)	132
	Hybrid	1	300 (1 fish)	-	
Louie3	Cutthroat	18	300 (121-381)	95 (81-113)	15
	Golden	3	132 (97-187)	-	
Raft	Rainbow	8	190 (110-484)	88 (67-95)	82
Serene	Cutthroat	3	289 (105-385)	75 (69-82)	16
	Brook	29	261 (191-335)	84 (65-106)	
Sheepeater	Cutthroat	12	243 (116-468)	116 (95-133)	6
Shirts					
Skein	Cutthroat	34	182 (94-345)	91 (62-114)	342
Tule	Cutthroat	8	424 (396-462)	92 (85-113)	5
	Rainbow	1	600 (1 fish)	62 (1 fish)	

1 average of three paired gill net sets

2 sinking gill net only

3 excludes 9 fish (unidentifiable)

Table 2. Species observed, current stocking density (fish/ha), stocking rotation, spawning suitability, relative human-use, and amphibians observed at high mountain lakes sampled in the McCall Sub-Region, Idaho in 2020.

Lake	Last Stocked	Stocking Density	Rotation[1,2,3,4]	Spawning Suitability	Human-Use	Amphibians Obs. [8,9]
Big Hazard	2018	25.9[6]	--	--	--	--
Blue	2019	175.4	A[1]	Low	High	CSF[8]
Brush	2018	133.3	B[2]	High	Low	CSF[8]
Crystal	2018	200.0	B[2]	Low	Low	None
Cutthroat	2019	200.0	C[3]	None	Low	None
Fish	Unknown	--	--		Low	CSF[8]
Flossie	2019	123.5	C[3]	High	Low	CSF[8]
GML #1[7]	2020	245.1	EV[4]	High	High	CSF[8]
GML #2[7]	2020	245.1	EV[4]	High	Moderate	WT[9]
Hidden	2019	125.0	C[3]	Low	Moderate	None
Lake Rock	2018	500.0	A[1]	High	Moderate	CSF[8]
Long	2019	131.6	C[3]	Low	Low	None
Lost	2019	526.3	C[3]	Low	Moderate	CSF[8]
Louie	2019	150.0	B[2]	High	High	CSF[8]
Raft	2019	178.6	C[3]	Low	Moderate	CSF[8] & WT[9]
Serene	2018	131.6	EV[4]	Low	Moderate	WT[9]
Sheepeater	2020	121.0	C[3]	None	Low	CSF[8]
Shirts	2018	285.7	EV[4]	High	High	None
Skein	2019	312.5	C[3]	Low	High	CSF[8]
Tule	2019	142.9	ODD[5]	None	Moderate	CSF[8] & WT[9]

[1] A = 2017, 2020, 2023, etc.
[2] B = 2018, 2021, 2024, etc.
[3] C = 2019, 2022, 2025, etc.
[4] EV = even years
[5] ODD = odd years

[6] Last stocked with GNT in 2018
[7] Grassy Mountain Lake
[8] Columbia Spotted Frog Rana luteiventris
[9] Western Toad Anaxyrus boreas

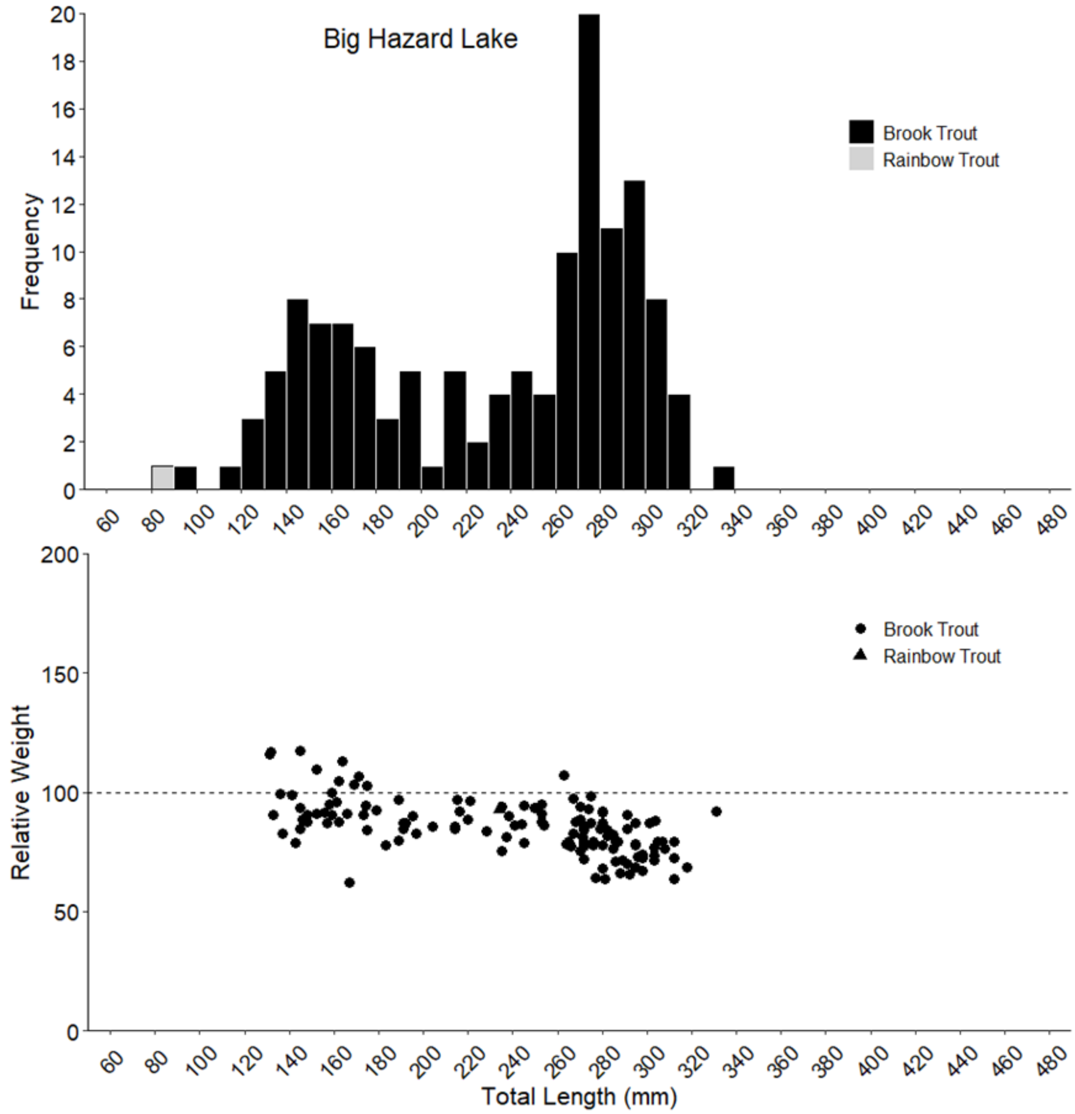

Figure 1. Length-frequency histogram and relative weights of Brook Trout (n = 134) and Rainbow Trout (n = 2) captured during gill netting surveys at Big Hazard Lake, Idaho on July 22, 2020. Horizontal dashed line represents a relative weight of 100, for reference.

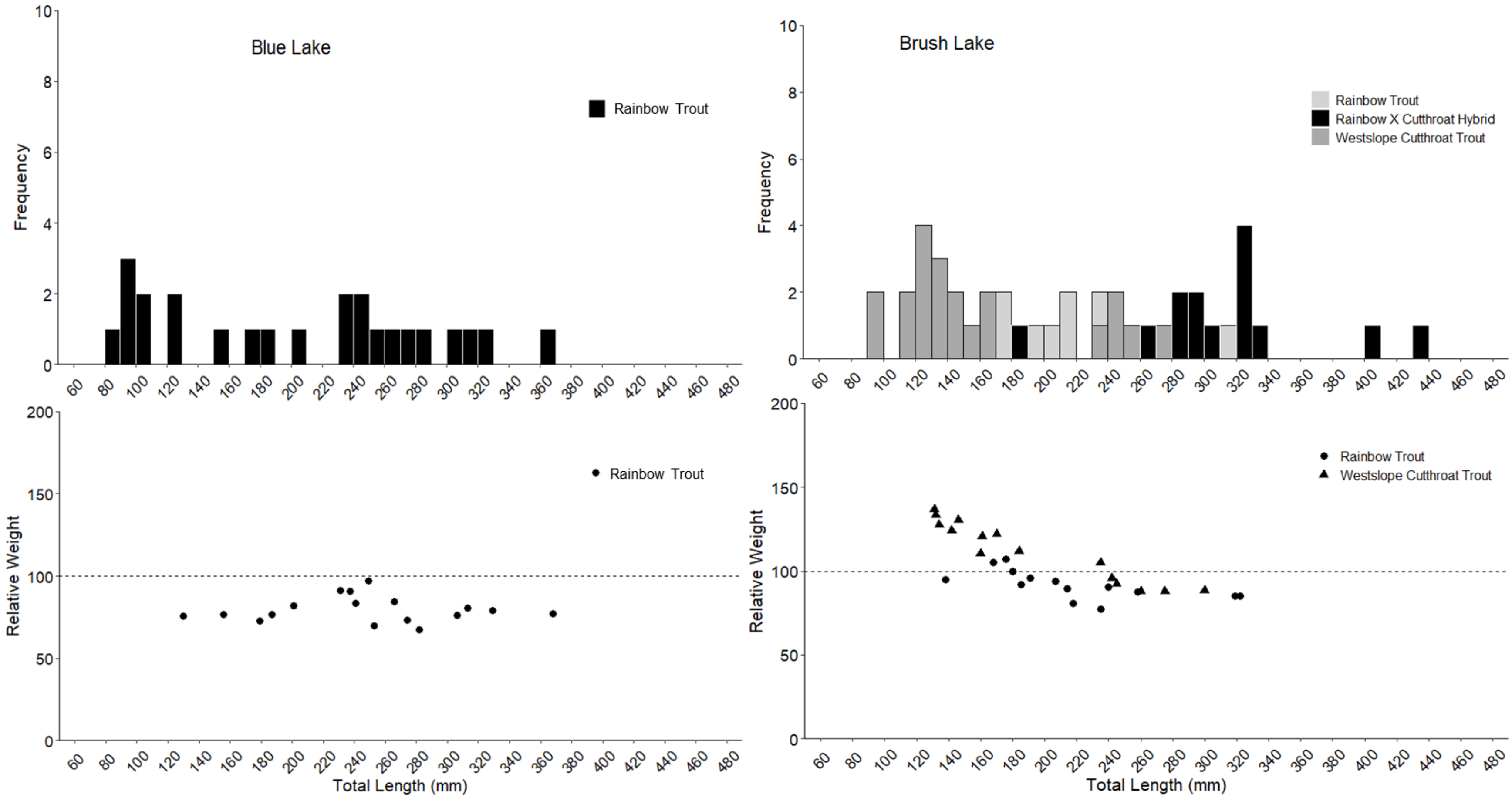

Figure 2. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Blue Lake, Idaho on July 16, 2020 (*n* = 24) and Brush Lake, Idaho on July 30, 2020 (*n* = 53). Horizontal dashed line represents a relative weight of 100, for reference.

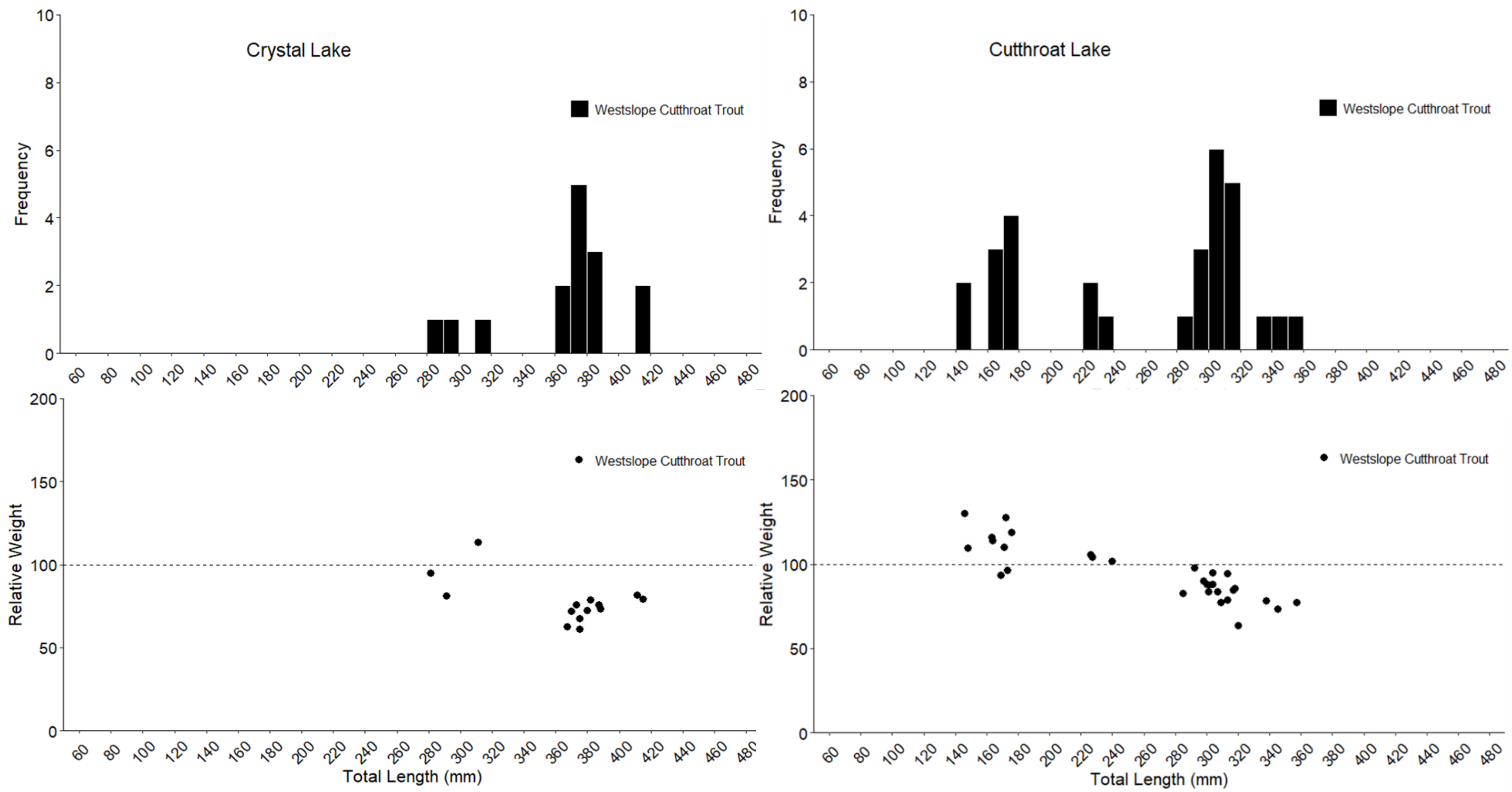

Figure 3. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Crystal Lake, Idaho on August 4, 2020 (n = 15) and Cutthroat Lake, Idaho on August 27, 2020 (n = 30). Horizontal dashed line represents a relative weight of 100, for reference.

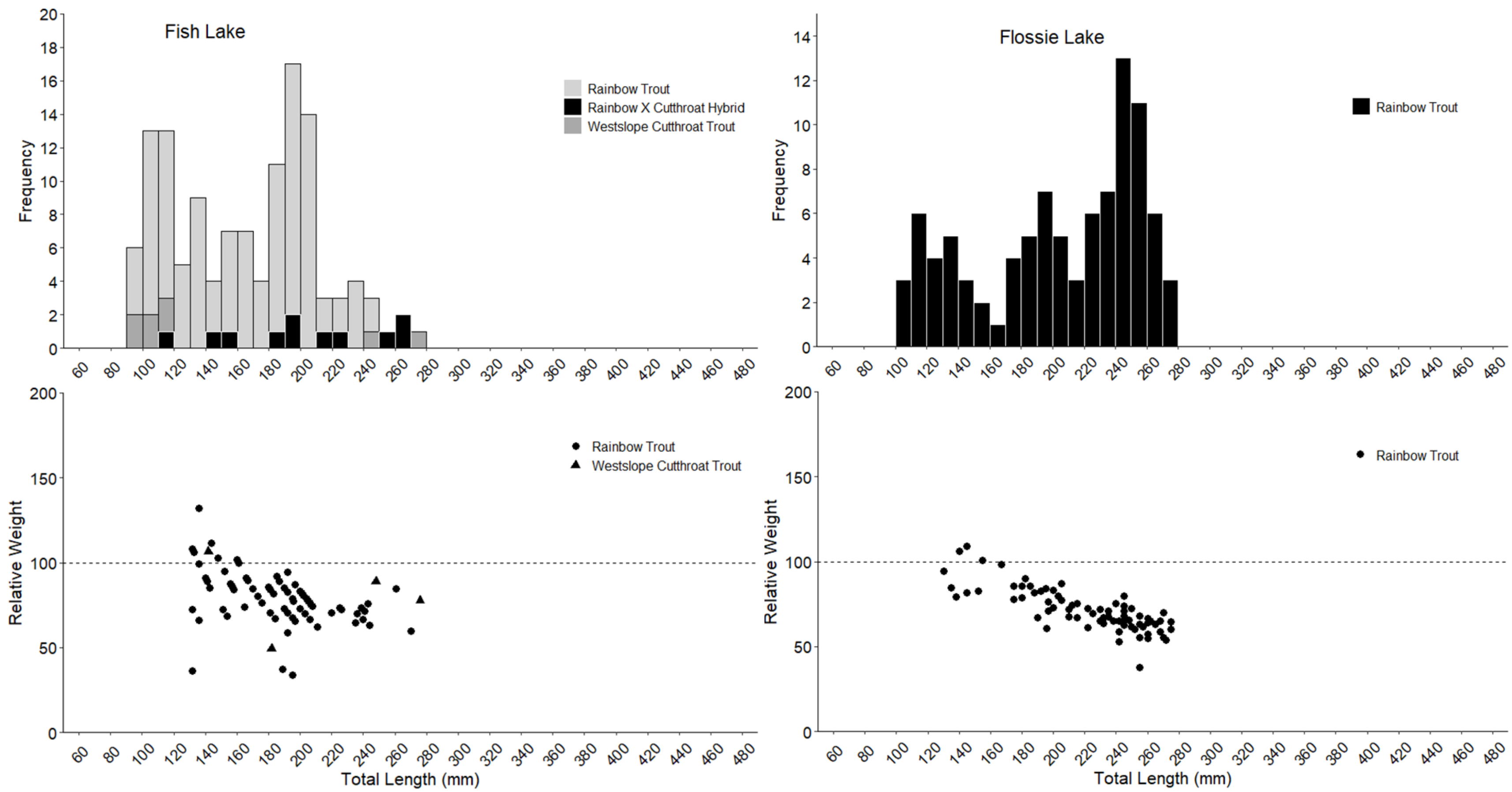

Figure 4. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Fish Lake, Idaho on August 28, 2020 (*n* = 147) and Flossie Lake, Idaho on August 28, 2020 (*n* = 94). Horizontal dashed line represents a relative weight of 100, for reference.

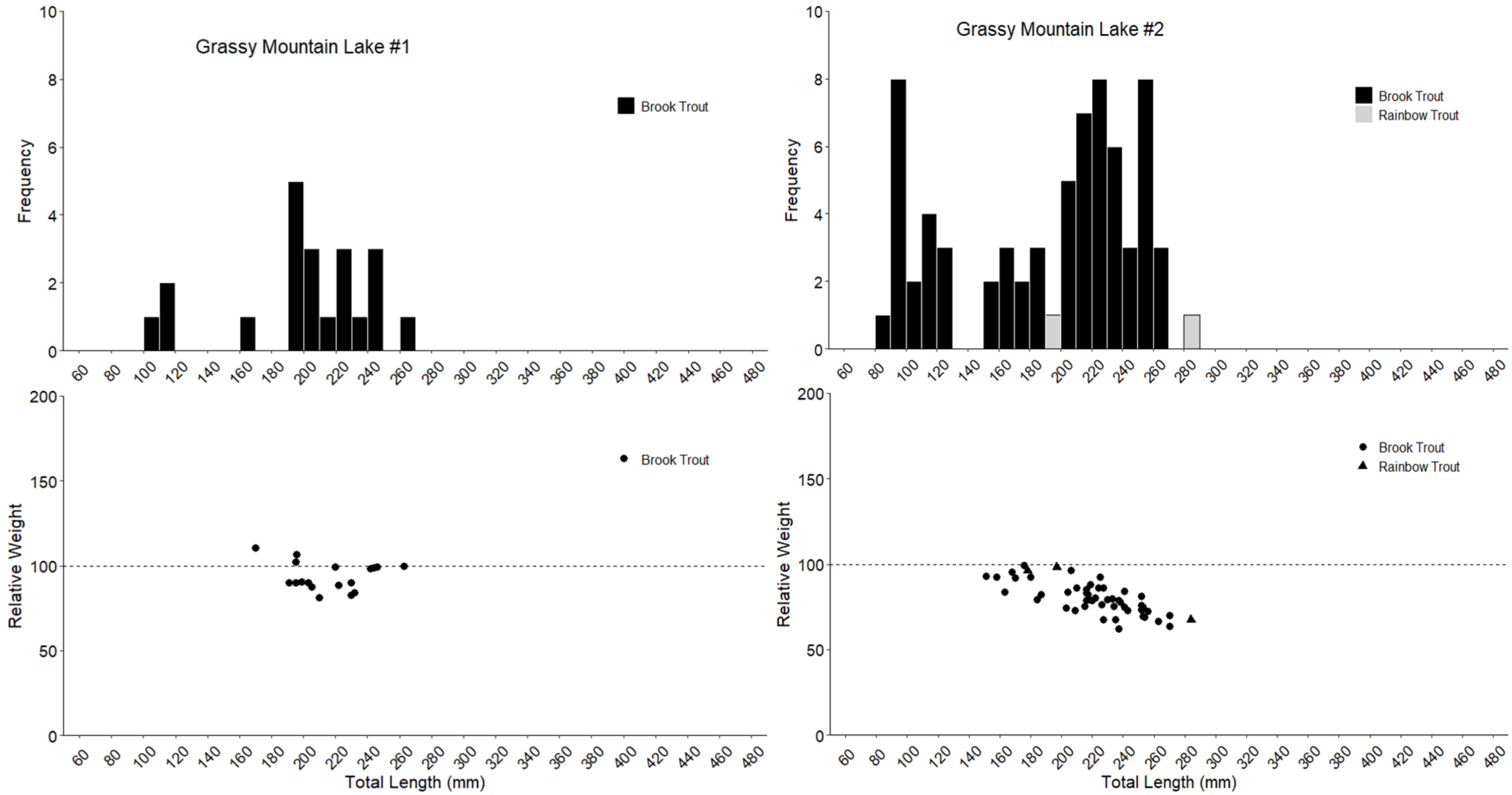

Figure 5. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Grassy Mountain Lake #1 (n = 23) and Grassy Mountain Lake #2 (n = 71), Idaho on July 29, 2020. Horizontal dashed line represents a relative weight of 100, for reference.

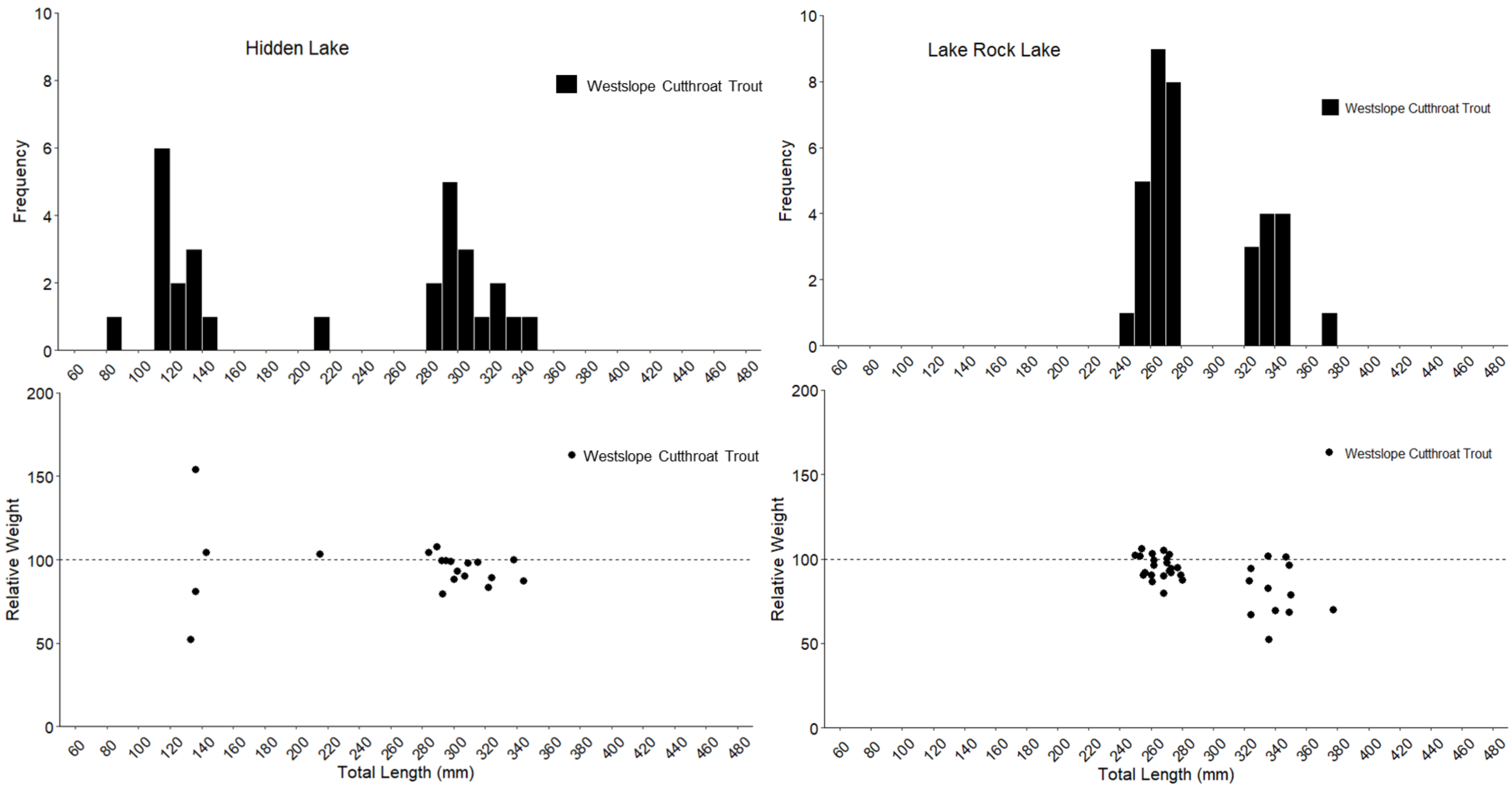

Figure 6. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Hidden Lake, Idaho on July 15, 2020 (*n* = 29) and Lake Rock Lake, Idaho on July 30, 2020 (*n* = 35). Horizontal dashed line represents a relative weight of 100, for reference.

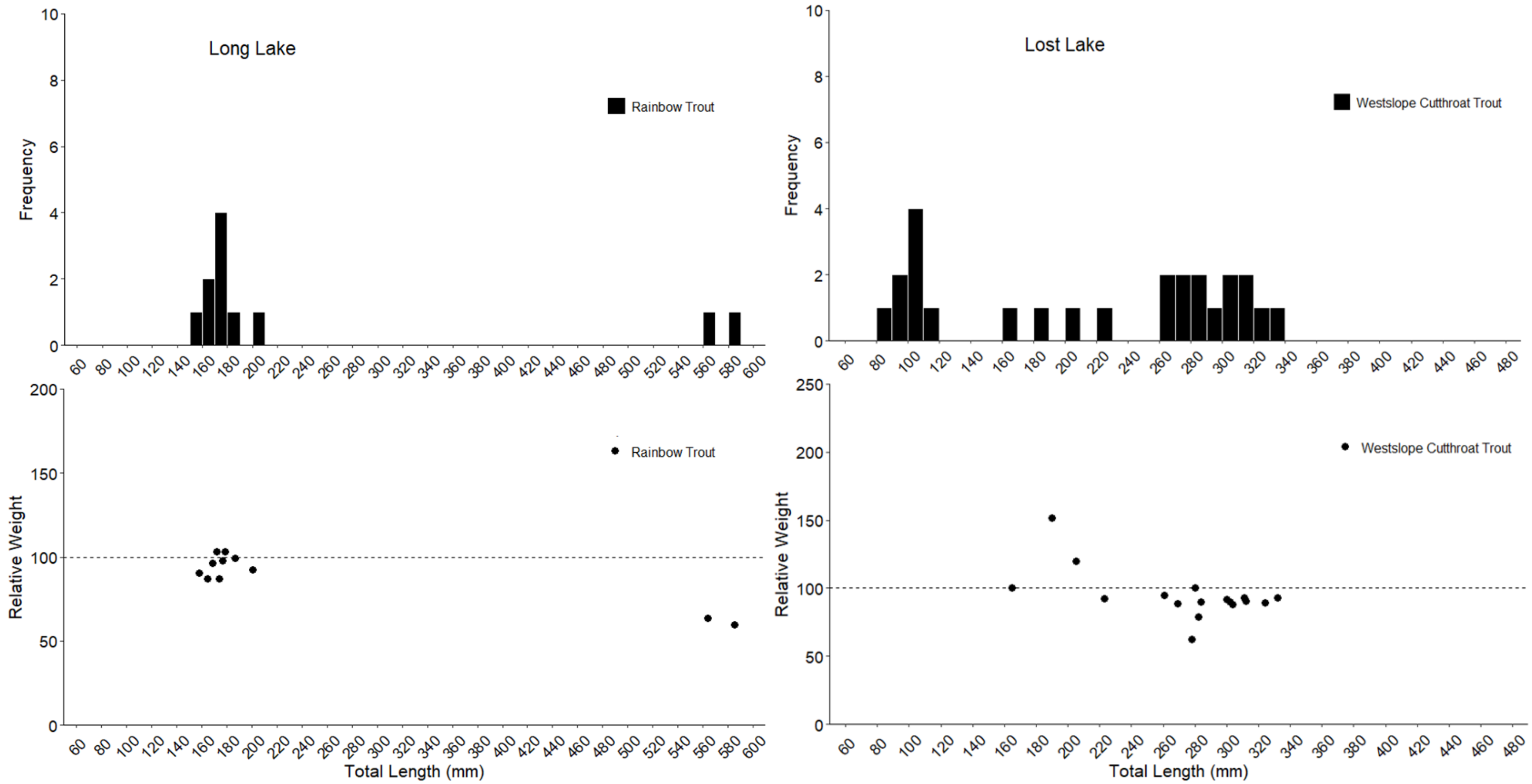

Figure 7. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Long Lake, Idaho on August 13, 2020 (*n* = 11) and Lost Lake, Idaho on July 15, 2020 (*n* = 26). Horizontal dashed line represents a relative weight of 100, for reference.

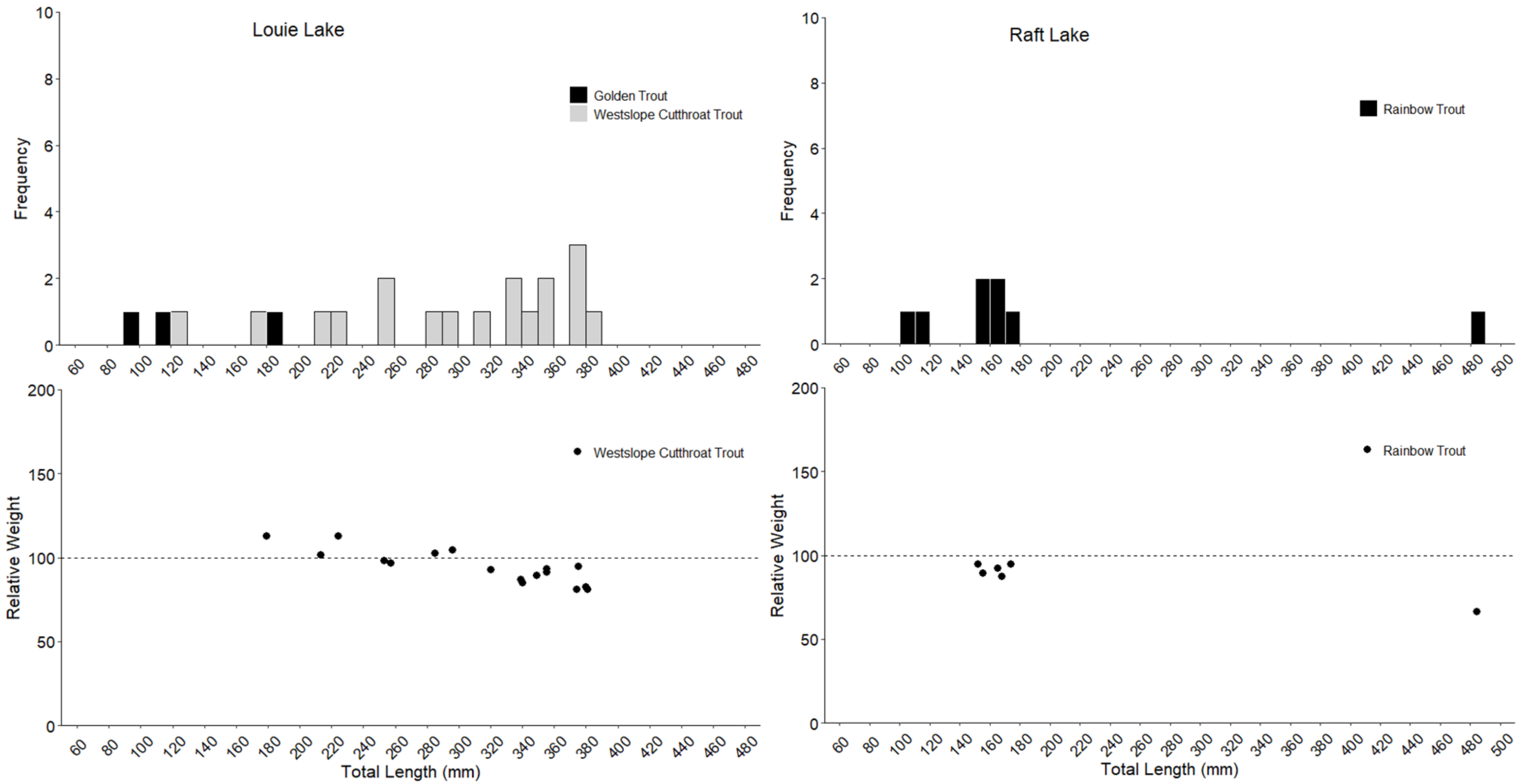

Figure 8. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Louie Lake, Idaho on August 4, 2020 (*n* = 21) and Raft Lake, Idaho on July 14, 2020 (*n* = 8). Horizontal dashed line represents a relative weight of 100, for reference.

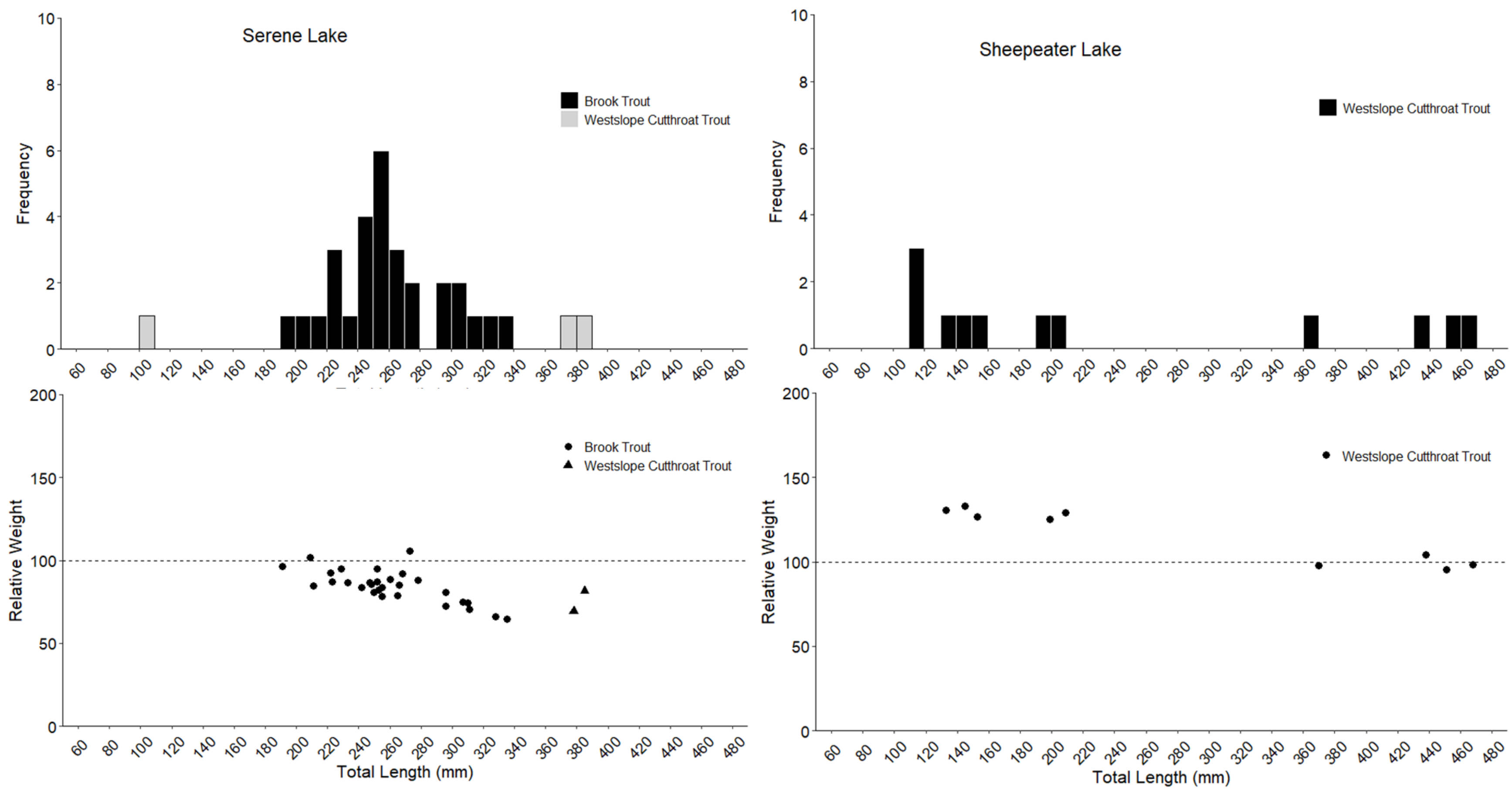

Figure 9. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Serene Lake, Idaho on July 29, 2020 (*n* = 32) and Sheepeater Lake, Idaho on August 27, 2020 (*n* = 12). Horizontal dashed line represents a relative weight of 100, for reference.

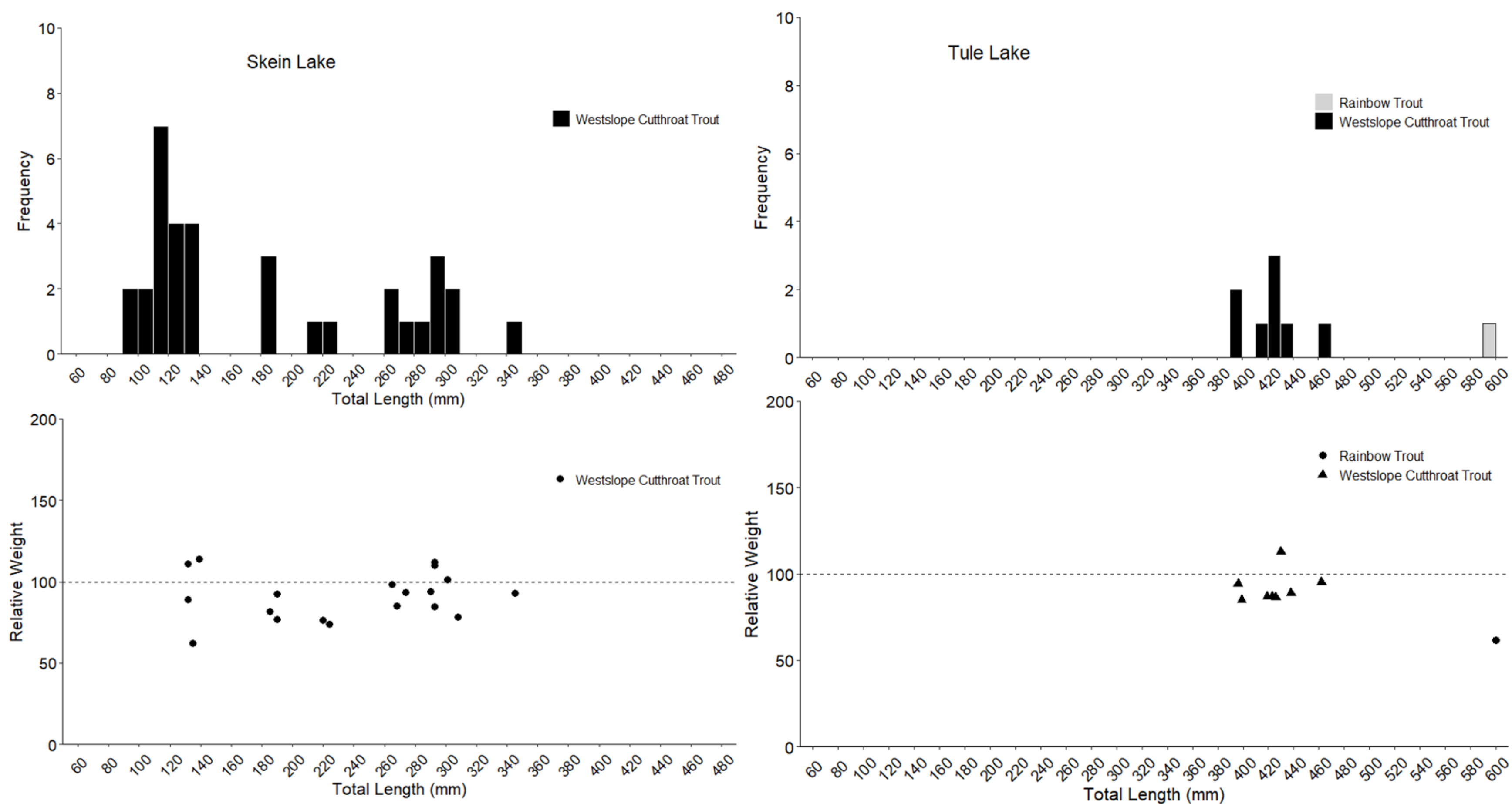

Figure 10. Length-frequency histogram and relative weights of fish captured during gill netting surveys at Skein Lake, Idaho on July 14, 2020 (*n* = 34) and Tule Lake, Idaho on August 14, 2020 (*n* = 9). Horizontal dashed line represents a relative weight of 100, for reference.

BRUNDAGE RESERVOIR TROUT INVESTIGATIONS

ABSTRACT

Brundage Reservoir was surveyed on July 22, 2020 to determine species composition, relative abundance, and size structure of the fishery. The survey consisted of two paired gill net sets, which captured a total of 50 fish (54% Rainbow Trout [RBT] *Oncorhynchus mykiss*, 4% Westslope Cutthroat Trout [WCT] *Oncorhynchus clarkii lewisi*, and 42% RBT x WCT; CPUE = 25). Our results suggest that naturally reproducing RBT have outcompeted or hybridized with the majority of remaining WCT, shifting the fish community structure compared to previous surveys. The current harvest regulations (daily bag limit of two fish < 355 mm TL, no bait allowed) appears to be working; 36% of trout collected were greater than 355 mm in length (i.e., protected harvest length). However, overall body condition of fish in our survey was low (mean RBT W_r = 77; mean WCT W_r = 72) indicating poor growth conditions in Brundage Reservoir. The results of our survey suggest that managers should investigate ways to reduce abundance of small fish (e.g., limit spawning, increase allowable harvest) to improve growth rates. We recommend that an exploitation study to evaluate current angler-use be conducted before the next routine survey in 2023.

Authors:

Mike Thomas
Regional Fisheries Biologist

Jordan Messner
Regional Fishery Manager

INTRODUCTION

Brundage Reservoir (45.050609 °N, -116.123095 °W) is a 87.5-ha waterbody located at an elevation of 1,914 m approximately 16 km northwest of McCall, ID. The reservoir was formed by the construction of an earthen dam in 1954, which was expanded in 1988 by the Brundage Water Users Association (BWUA). The expansion agreement between the BWUA and Payette National Forest resulted in a 46.5 ac/ft minimum conservation pool that greatly enhanced the potential of the fishery (Grunden and Anderson 1991). Prior to the expansion, the reservoir was drawn down annually to the creek channel, and the Idaho Department of Fish and Game (IDFG) managed a harvest-oriented put-and-take Rainbow Trout *Oncorhynchus mykiss* (RBT) fishery. The minimum conservation pool allowed RBT to overwinter and grow and obtain quality-sizes, prompting new management strategies to increase the diversity (i.e. species composition and size structure) of the fishery (IDFG 1995; IDFG 1999). In 1992 fishing regulations were changed from 'general regulations' to 'two fish, none between 305 and 508 mm, open Memorial Day Weekend to November 30', in an attempt to limit harvest and increase diversity in trout size structure.

Between 1989 and 1997, fishery managers stocked various strains and sizes of RBT in Brundage Reservoir in an attempt to maximize growth rates and return-to-creel, and increase the diversity in size structure of the fishery. Eagle Lake-strain, Kamloops-strain, Troutlodge-strain, and Hayspur-strain RBT were all stocked at various sizes (catchables > 150 mm and fingerlings < 150 mm; (Grunden and Anderson 1991). A 1993 tagging study determined that catchable-size RBT were not providing much of a resource to anglers (i.e., < 10% return-to-creel; Janssen et al. 1993), so catchable stocking was discontinued. By 1997 the majority (62%) of RBT collected in surveys appeared to be of natural-origin ("wild"; Janssen et al. 1997), likely as a result of successful natural spawning by one or more of the strains stocked as fingerlings a decade earlier. These findings led to the discontinuation of all RBT stocking in 1998.

Since 1998, RBT in Brundage Reservoir have been entirely self-sustaining. To increase species diversity in the reservoir, IDFG began stocking Westslope Cutthroat Trout (WCT) *Oncorhynchus lewisi clarki* fingerlings in 1999, and by 2001, 33% of trout collected in surveys were WCT (Janssen et al. 2001). In 2000, fishing regulations changed again to 'two fish, none under 508 mm, artificial flies and lures only, Memorial Day weekend to November 30', in an attempt to increase the size of fish in angler creels. However, managers soon realized that growth rates were slow as a result of an abundance of small fish in the reservoir competing for limited resources (Janssen et al. 2010). WCT stocking was discontinued in 2008 to allow natural-reproduction to solely sustain the fishery. WCT were last documented in Brundage Reservoir in 2013 (Janssen et al. 2014).

Natural-spawning RBT and RBTxWCT hybrids have become abundant in Brundage Reservoir. In 2010, fishing regulations were changed again to allow year-round harvest of smaller trout in the reservoir to decrease abundance and improve growth rates for the remaining fish. These current regulations (two trout < 355 mm, "no bait allowed"; IDFG 2013) still attempt to increase diversity of size structure by not allowing harvest of trout > 355 mm, and 2016 survey findings suggest growth rates have improved since regulation changes went into effect (Janssen et al. 2017).

We surveyed the fish community in Brundage Reservoir on July 22, 2020 to evaluate the current status of the fishery and determine if any further management or regulation changes are warranted.

OBJECTIVES

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

METHODS

On July 22, 2020, we set two sinking and two floating IDFG experimental gill nets (i.e., 46 m x 2 m; 6 panels 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 (45.051495°N, -116.122899°W), while the other was set offshore (44.057780°N, -116.116186°W). Gill nets were set in the afternoon, fished overnight, and pulled the next morning. 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), and weighed (g).

Condition of fish was assessed using relative weights (W_r) for RBT (Simpkins and Hubert 1996) and WCT (Kruse and Hubert 1997) larger than 130 mm. Relative weight was calculated by first using a standard weight (W_s) equation for each species:

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

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:

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

RESULTS

We collected a total of 50 fish of 3 species (54% RBT, 42% RBT x WCT, 4% WCT) in Brundage Reservoir during the 2020 survey (CPUE = 25; Table 3). We caught 27 RBT that ranged in length from 177 to 408 mm (mean = 315 mm) with a mean relative weight of 77 (range = 62 – 87; Table 3; Figure 11), two WCT that were 185 mm (W_r = 85) and 432 mm (W_r = 58; Table 3; Figure 11), and 21 RBT x WCT hybrids that ranged in length from 172 to 422 mm (mean = 346 mm). Relative weights are not available for RBT x WCT hybrids (Table 3; Figure 11).

Compared to surveys conducted prior to the harvest regulation changes implemented in 2010, size structure of RBT has improved dramatically (Figure 12). In 2007, approximately 6% of RBT were greater than 355 mm, whereas nearly 36% exceeded 355 mm in 2020 (Figure 11 and 12). While relative abundance and size structure were among the highest observed, overall body condition of RBT has remained comparatively low across survey years (i.e., W_r < 80; Table 3).

DISCUSSION

Brundage Reservoir provides anglers a unique (i.e., both scenic and accessible) opportunity for quality trout in the McCall subregion. The current harvest regulations (two trout < 355 mm, “no bait allowed”) appear to be working in terms of improving size structure; in 2020, 36% of trout collected were greater than 355 mm in length. However, overall body condition of fish in our survey was relatively low (mean RBT W_r = 77; mean WCT W_r = 72; Table 3), which may indicate poor growth conditions, though we did not specifically measure growth rates. Although body condition appeared poor in our survey, Brundage Reservoir remains a highly popular fishery that appears to provide good catch rates of quality-sized trout

The results of the 2020 survey confirm the decline of WCT first observed in 2016. It appears that wild RBT have out-competed and/or hybridized with the majority of WCT in Brundage Reservoir. This is in contrast to previous surveys (e.g., 2010 and 2013), when WCT were the most abundant species observed. Overall body condition (W_r) has declined, which may have indicated reduced growth conditions, which could be attributed to low harvest rates of small trout or increased rates of natural reproduction, resulting in increased competition for food resources. Public scoping for Brundage Reservoir should focus on determining if anglers are happy with current conditions, or if increased growth rates are desirable. To improve growth rates, if applicable, managers should consider increasing the allowable harvest of small trout (Janssen et al. 2010), or attempt to reduce success of trout spawning (Janssen et al. 2014; IDFG 2019).

Brundage Reservoir has two primary tributaries: Brundage Creek and Hartley Creek. In 1989, both tributaries were surveyed to evaluate fish passage, habitat suitability, and presence of spawning substrate (Grunden and Anderson 1991). Brundage Creek was highly embedded and did not offer any suitable spawning substrate, whereas Hartley Creek contained a limited amount of accessible substrate for natural reproduction. Anglers have provided anecdotal reports supporting the suitability of Hartley Creek for trout spawning; observing large numbers of adult trout congregating at the mouth of Hartley Creek shortly after ice-out each year.

In future assessments, a survey of angling effort, exploitation and use, preferences, and demographics should be conducted to determine if this fishery could benefit from changes to the current harvest regulations. If increased growth rates are desired, there are several options to consider. While it is possible that fishery managers could implement barriers to fish passage (e.g., picket weir) on Hartley Creek to reduce natural reproduction rates, constructing a barrier could also further congregate adult trout and increase their susceptibility to angling effort and illegal harvest. An alternative to restricting natural reproduction could be increasing the allowable harvest of small trout (e.g., < 305 mm) in Brundage Reservoir. However, the last tagging study to evaluate angler-use was conducted 28 years ago (Janssen et al. 1993). Therefore, it is unclear if angler-use has increased such that adjusting the current harvest regulation could have an appreciable affect on growth conditions. Managers should first conduct an angler-use or creel survey on Brundage Reservoir to evaluate angler behavior and preferences, before implementing any management changes. The fishery should continue to be monitored on a three-year rotation to observe trends in growth and size structure.

MANAGEMENT RECOMMENDATIONS

1. Conduct a comprehensive creel study to evaluate angler effort, demographics, and preferences and determine if increasing allowable harvest of small fish is a viable option to improve growth rates in Brundage Reservoir.

2. Pair creel survey with Tag-Your-It investigation of fish harvest and use in Brundage Reservoir.

Table 3. Total catch, proportion of total catch, mean lengths (mm TL), and relative weights (W_r) from a gill net survey at Brundage Reservoir, Idaho on July 22, 2020.

Species	**Catch**	**% of Catch**	**Mean TL (range)**	**Mean W_r (range)**
Rainbow Trout	27	54	315 (177 - 408)	77 (62 - 87)
Westslope Cutthroat Trout	2	4	308 (185 - 432)	72 (58 - 85)
RBT X WCT	21	42	346 (172 - 422)	--
Total	50	100		

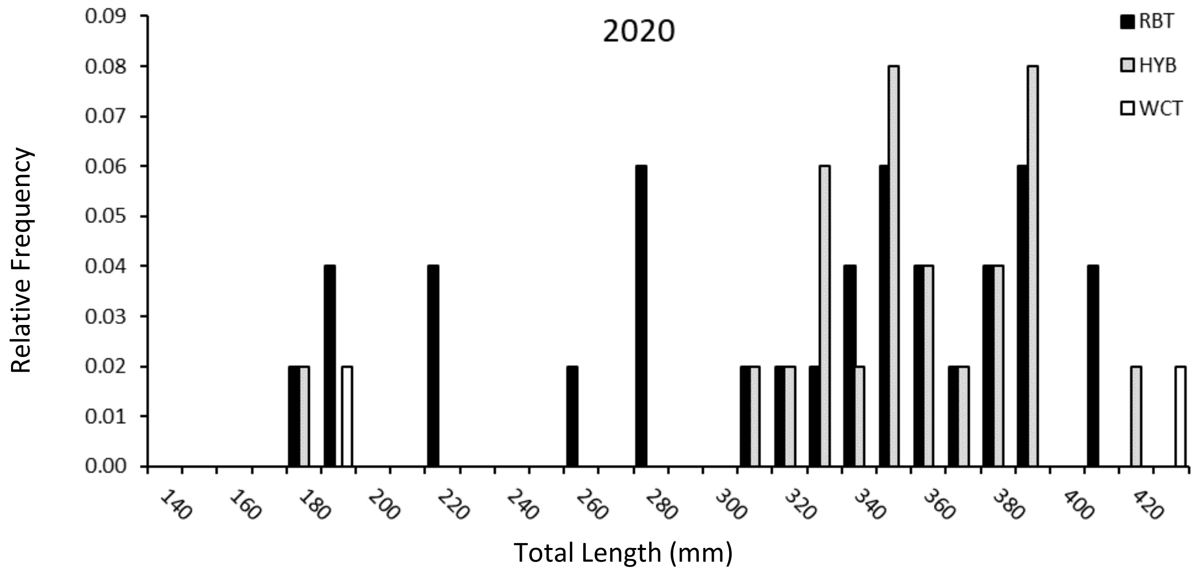

Figure 11. Relative length-frequency histogram of Rainbow Trout (RBT), Rainbow Trout X Cutthroat Trout hybrids (HYB) and Cutthroat Trout (WCT) collected during gill netting surveys in 2020.

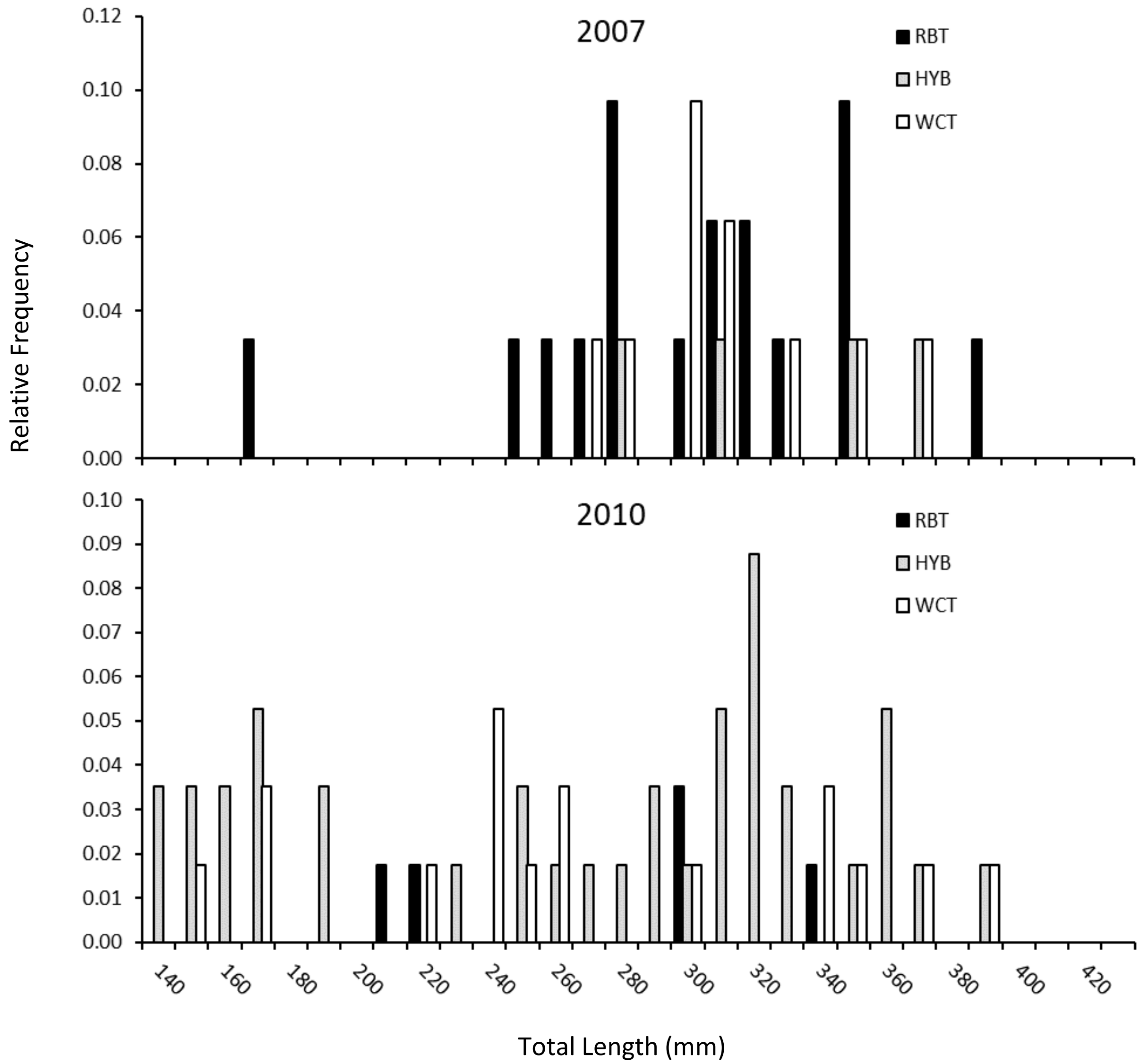

Figure 12. Relative length-frequency histogram of Rainbow Trout (RBT), Rainbow Trout X Cutthroat Trout hybrids (HYB) and Cutthroat Trout (WCT) collected during gill netting surveys in 2007 and 2010.

C. BEN ROSS RESERVOIR FISHERY MONITORING

ABSTRACT

Fish transplant efforts in C. Ben Ross Reservoir have been conducted in recent years in an attempt to boost abundance of forage fish. We surveyed the reservoir on June 3 and 4, 2020 to assess fish species composition, relative abundance, and size structure relative to surveys prior to transplant efforts. The survey included 6, 10-minute electrofishing intervals, a paired gill net night, and 2 trap net nights. We collected a total of 159 fish of 5 species. Largemouth Bass *Micropterus dolomieu* and Bluegill *Lepomis macrochirus* comprised 42% (*n* = 67) and 49% (*n* = 78) of the catch, while White Crappie *Pomoxis annularis*, Black Crappie *Pomoxis nigromaculatus*, and Rainbow Trout *Oncorhynchus mykiss* comprised 4% (*n* = 6), 3% (*n* = 5), and 2% (*n* = 3), respectively. Largemouth Bass size structure has increased since 2015, and abundance of Bluegill has nearly doubled. However, recent transplanting efforts (2015-2017) are likely not responsible for these changes. The majority (98%) of translocated fish were White Crappie and Black Crappie; and abundance did not increase for those species since the last survey. Future efforts should focus on evaluating the feasibility of using man-made habitat structures to further improve survival and recruitment of forage fish species. No changes to current harvest regulations are recommended at this time.

Authors:

Mike Thomas
Regional Fisheries Biologist

Jordan Messner
Regional Fishery Manager

INTRODUCTION

C. Ben Ross Reservoir (CBR; 44.519095 °N, -116.439026 °W) is a 144.8-ha waterbody located at an elevation of 964 m approximately 52 km southeast of McCall, ID. The reservoir was formed by the construction of an earthen dam in 1937 and receives water by gravity diversion from the Little Weiser River through a feeder canal and local drainage. The reservoir is managed by the Little Weiser Irrigation District and the surrounding property is under complete private ownership. There is a single boat ramp, dock, and parking area provided for anglers through a cooperative agreement with the Idaho Department of Fish and Game (IDFG) and the Little Weiser Irrigation District. The reservoir fills during the spring runoff period (max = 957 ha/m) and can become extremely low by late summer during dry years (min = 7 ha/m; Reid and Welsh 1978; IDFG 2019).

Historically, CBR was managed as a put and take Rainbow Trout *Oncorhynchus mykiss* (RBT) fishery that received annual 'catchable' plantings between 1968 and 1988. However, water temperature and seasonal fluctuations in water levels at CBR are more conducive to the production of warm water species, like Crappie *Pomoxis spp.* and Largemouth Bass *Micropterus salmoides* (LMB), than RBT (Reid and Anderson 1982; IDFG 2019). Therefore, in 1989 IDFG began managing CBR primarily as a warm water sport fishery. To support the warm water fishery, 300 Bluegill *Lepomis macrochirus* (BLG) were translocated from nearby waterbodies to create and supplement the forage base. Five years later, a special harvest regulation (no harvest until July 1st, two bass, none between 305 and 406 mm) was implemented to improve the size structure of LMB. Since then, the fishery has been surveyed approximately every five years to evaluate the effects of the special harvest regulation (amended in 2016 to remove the July 1st harvest restriction) and monitor the status of the fishery.

Size structure of LMB improved dramatically in years following the regulation change (Janssen et al. 2010). However, surveys in 2010 suggested forage species (i.e., Black Crappie *Pomoxis nigromaculatus* [BCR], White Crappie *Pomoxis annularis* [WCR], and BLG) were in low abundance. IDFG began transplanting crappie and BLG into the reservoir in 2011 from nearby Crane Creek Reservoir, but surveys at C Ben Ross in 2015 suggested a decline in abundance of forage species relative to 2010. Since 2015, we have translocated an additional 200 BCR, 2,250 WCR, and 50 BLG in C Ben Ross Reservoir. We surveyed the fishery on June 3 and 4, 2020 to evaluate the current status of the fishery and the effect, if any, transplanting forage species has had on the sport fishery over the past five years.

OBJECTIVES

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

METHODS

We surveyed the fish community at CBR with a combination of boat electrofishing, gill nets, and trap nets on June 3 and 4, 2020. Six electrofishing sites were chosen at random and night electrofished for a total of 10 minutes each. We set one floating and one sinking IDFG standard experimental gill net (44.51904°N, -116.44348°W) and two standard trap nets (44.51461°N, -116.44485°W; 44.52482°N, -116.43904°W; IDFG 2012). All fish were enumerated by species, measured for total length (mm “TL”), and weighed (g).

We calculated proportional stock density (PSD-Q) and incremental relative stock density (RSD) indices for LMB (stock length = 200 mm, quality length = 200 mm, protected slot length = 305 – 406 mm, greater than slot length = > 406 mm; Gabelhouse 1984; Neumann et al. 2012). Condition of fish was assessed using relative weights (W_r) for LMB larger than 150 mm TL (Wege and Anderson 1978), BLG larger than 80 mm (Hillman 1982), and Crappie larger than 100 mm (Neumann and Murphy 1991). Relative weight was calculated by first using a standard weight (W_s) equation for each species:

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

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:

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

RESULTS

We caught a total of 159 fish of 5 species in CBR during the 2020 survey (Table 4). LMB and BLG comprised 42% (n = 67) and 49% (n = 78) of the catch, while WCR, BCR, and RBT comprised 4% (n = 6), 3% (n = 5), and 2% (n = 3), respectively. Length frequencies and relative weight plots for all species caught (except RBT) are provided in Figures 13, 14, and 15.

Similar to previous surveys, LMB and BLG remained the most abundant species in the fish community. In 2020, size structure of LMB (i.e., PSD and RSD) increased nearly threefold from 2015 and was the third highest observed since 1993 (Table 5). Mean length was 233 mm (range = 64 – 430 mm), and relative weights ranged from 74 to 119 (mean W_r = 91; Table 4; Figure 13). The majority (90%) of LMB were caught with boat electrofishing (CPUE = 10 ± 2; Table 4).

Relative abundance and size structure of BLG also increased since the previous survey. In 2020, BLG comprised 49% of the catch compared to 26% in 2015, and mean length (172 mm, range = 35 – 281 mm) more than doubled (76 mm, range = 29 – 168 mm; Table 4; Figure 14). However, similar increases in abundance or size structure were not observed for BCR or WCR, even though nearly 2,500 were translocated in the last decade. All Crappie, and the majority of BLG (86%) were caught with trap nets (Table 5).

Naturally reproducing RBT have persisted in low abundance at CBR for more than 30 years after stocking was discontinued in 1988. In 2020, we captured three RBT ranging in length from 288 to 465 mm (mean = 404 mm), and relative weights ranged between 76 and 91 (mean = 83; Table 4). Although RBT have comprised a small proportion of the total catch in recent surveys, they provide an additional angling opportunity for quality-sized fish.

DISCUSSION

The fish community in CBR has shifted over time. Black Bullhead *Ameiurus melas* and Largescale Suckers *Catostomus macrocheilus* (LSS) were once common in CBR, but neither have been collected since 2004 and 2010, respectively (Janssen et al. 1997; Janssen et al. 2004). This timeline coincides with periods of reduced prey availability for LMB. However, it is unclear if predation by LMB (Janssen et al. 2010), or more broad environmental factors (e.g., drought, plankton die-off) produced these changes in the fishery.

Since 2015, we have translocated 200 BCR, 2,250 WCR, and 50 BLG in C Ben Ross Reservoir from nearby Crane Creek Reservoir to supplement the LMB forage base. Even though we saw an increase in BLG, it is unlikely that the transplant efforts are responsible for the observed increase (WCR and BCR comprised 98% of the translocations). Translocations alone do not seem to be effective at increasing forage fish abundance. Therefore, managers should consider alternative strategies to increase production of forage fish in CBR, such as deploying littoral habitat structures over-winter to provide cover and refugia for juveniles.

The special harvest regulation at CBR has been successful in providing opportunity for quality-sized LMB (PSD-Q = 68; Table 5). In fact, 33% of all LMB collected in 2020 were within the protected slot length. Previous ageing studies (Janssen et al. 2010) have shown that the majority of LMB in CBR die of natural causes before being harvested, evidenced by the presence of 13 to 17 year old fish. Due to slow growth rates, it is unlikely that more restrictive harvest regulations would improve size structure further. The current regulation seems appropriate given that opportunity is provided for both harvest- and trophy-oriented anglers. Prior to implementing the special harvest regulation in 1994, managers did not observe LMB greater than 305 mm during surveys (1993 PSD-Q = 13; Table 5). By 1996, nearly a third of all LMB collected were greater than 305 mm (Janssen et al. 1996) and size structure has continued to increase over time (e.g., PSD-Q = 89 in 2010, PSD-Q = 68 in 2020; Table 5). Therefore, we do not recommend any changes to the current harvest regulations at this time.

In future years, managers should focus on further improving the forage base for LMB in CBR. The 2019-2024 Fisheries Management Plan makes mention of ‘evaluating the feasibility of constructing habitat structures’ to improve the LMB forage base in CBR. We recommend that habitat structures be implemented in the winters of 2021-2022. The next survey should be conducted in three to five years to evaluate the effects of these habitat structures on BLG abundance and size structure. Additionally, age and growth information should be collected for these species to evaluate population characteristics and quantify changes, if any, resulting from the implementation of habitat structures in CBR.

MANAGEMENT RECOMMENDATIONS

1. Evaluate the feasibility of implementing habitat structures in CBR to improve survival and recruitment of forage fishes.

2. Survey the fishery again in three years to evaluate the influence of habitat structures and determine if growth and size structure of BLG and LMB has increased.

Table 4. Total catch, proportion of total catch, mean lengths (mm TL), relative weight (W_r), and catch-per-unit-effort (CPUE + 95% CI) from electrofishing, gill net, and trap net survey conducted at C. Ben Ross Reservoir, Idaho on June 3 and 4, 2020.

					CPUE		
Species	**Catch**	**% of Catch**	**Mean TL (range)**	**Mean W_r (range)**	**Electrofishing**	**Gill Net**	**Trap Net**
Largemouth Bass	67	42	233 (64-430)	91 (74-119)	10 (2.3)	3	2 (3)
Bluegill	78	49	172 (35-281)	109 (62-156)	2.8 (1.6)	0	31 (42)
Rainbow Trout	3	2	404 (288-465)	83 (76-91)	0	3	0
Black Crappie	5	3	265 (230-300)	91 (82-104)	0	2	2 (3)
White Crappie	6	4	239 (224-274)	99 (91-107)	0	2	2 (2)
Total	159	100					

Table 5. Proportional stock densities (PSD) and relative stock densities (RSD) for Largemouth Bass in the protected slot (RSD – slot) and over the slot (406 mm; RSD > slot) collected during IDFG standard lake surveys in C. Ben Ross Reservoir, Idaho from 1993 to 2020.

Year	**PSD**	**RSD - slot**	**RSD > slot**
1993	13	13	0
1994	Rule change	Protected slot (306 to 406 mm)	
1996	41	41	0
1999	30	27	0
2004	74	61	1
2010	89	71	17
2015	22	13	8
2020	68	60	3

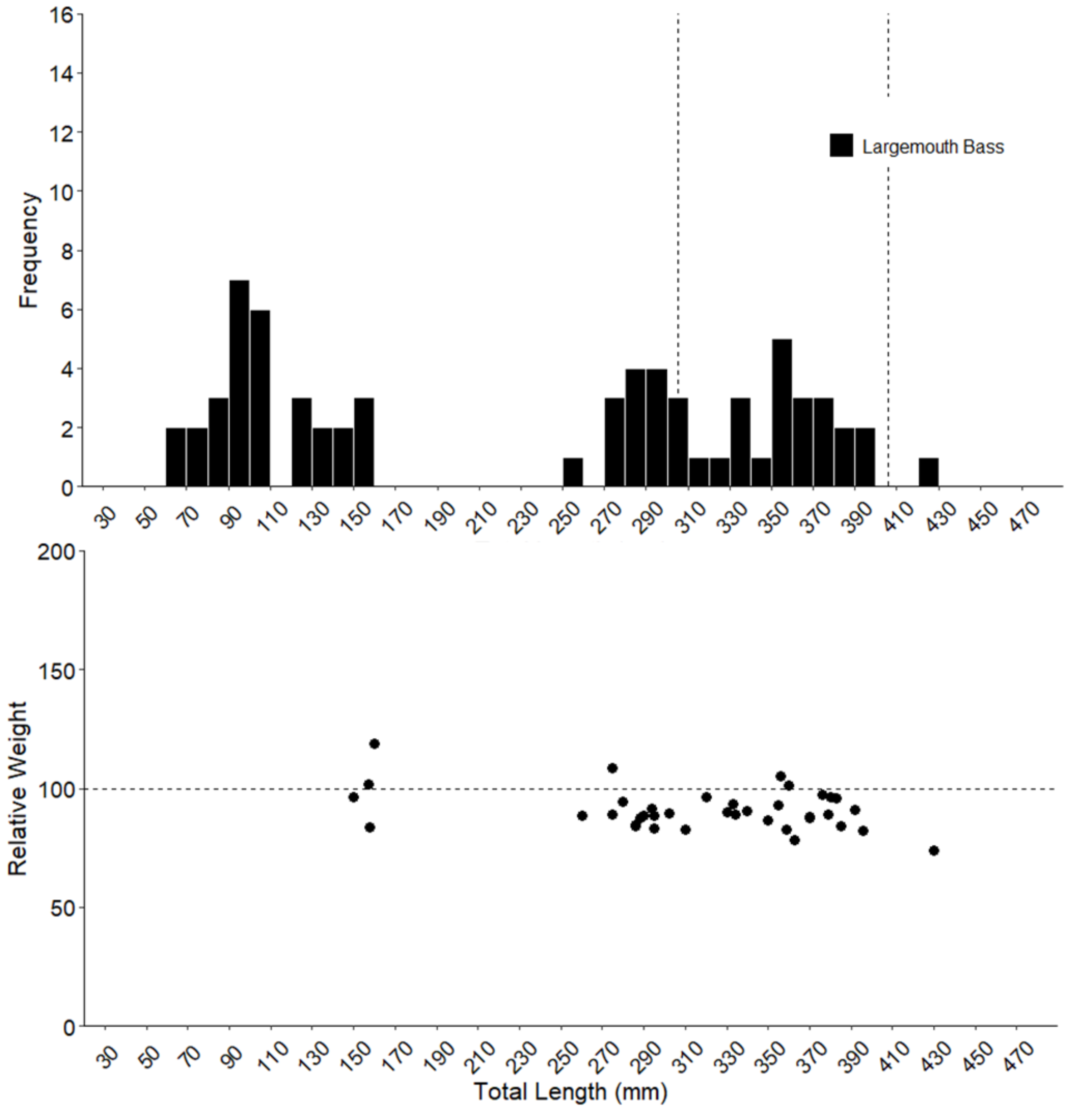

Figure 13. Length-frequency histogram and relative weights of Largemouth Bass (n = 67) captured during IDFG standard lake survey at C. Ben Ross Reservoir, Idaho on June 3 and 4, 2020. Vertical dashed lines represent upper and lower limits of protected harvest slot (305 – 406 mm).

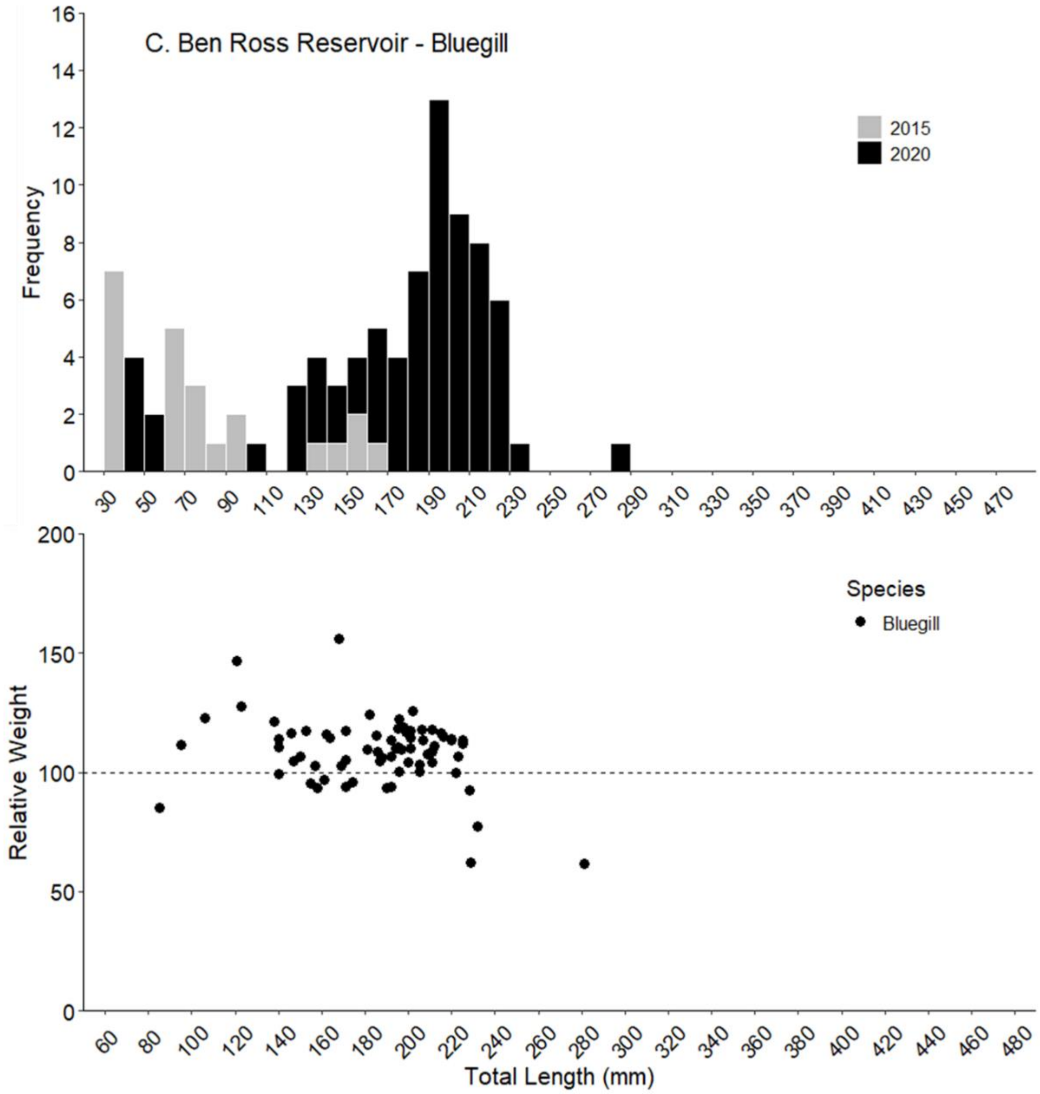

Figure 14. Length-frequency histogram of Bluegill caught in 2020 (*n* = 78) and 2015 (*n* = 42) and relative weights of Bluegill captured in 2020 during IDFG standard lake survey at C. Ben Ross Reservoir, Idaho on June 3 and 4, 2020.

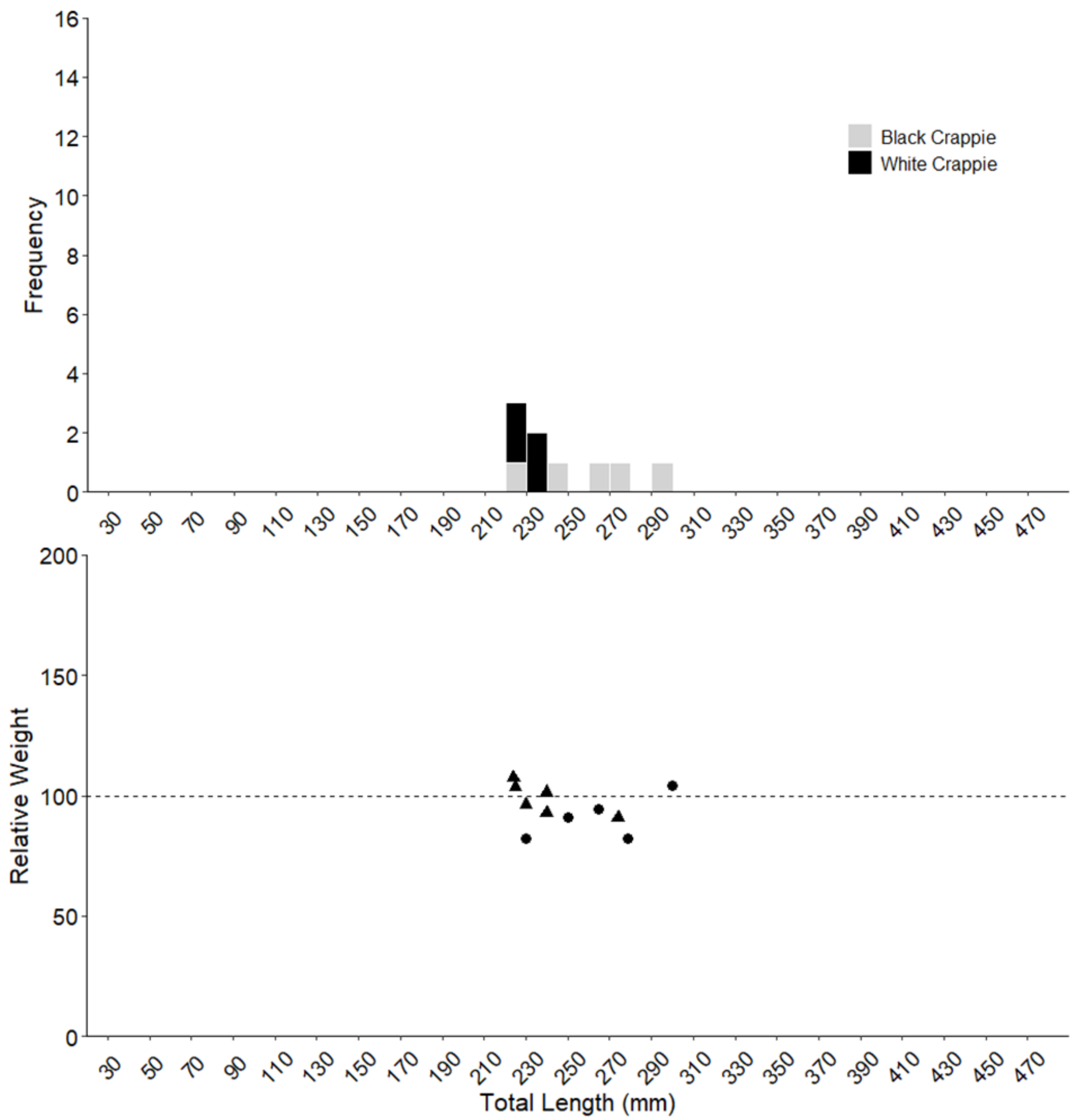

Figure 15. Length-frequency histogram and relative weights of Black Crappie (*n* = 5) and White Crappie (*n* = 6) captured during IDFG standard lake survey at C. Ben Ross Reservoir, Idaho on June 3 and 4, 2020.

UPPER PAYETTE LAKE FISHERY SURVEY

ABSTRACT

Upper Payette Lake is managed as a put-and-take Rainbow Trout *Oncorhynchus mykiss* (RBT) fishery. Previous gill netting surveys have shown that overwinter survival of stocked RBT (holdover) is low, and that the fishery is dominated by Largescale Sucker *Catostomus macrocheilus* (LSS) and other nongame species. In 2020, we surveyed Upper Payette Lake with two pairs of experimental gill nets to monitor the relative abundance and size structure of the fish community. We collected a total of 54 fish of 3 species (91% LSS, 6% hatchery RBT, 4% Brook Trout *Salvelinus fontinalis* [BKT]). We did not observe any natural-origin RBT in Upper Payette Lake. We captured three hatchery-origin RBT that ranged in length from 261 to 442 mm and were in poor body condition (mean W_r = 72), and two natural-origin BKT (285 and 290 mm) were in below average body condition (W_r = 89 and 90, respectively). LSS continue to dominate the biomass in Upper Payette Lake, and trout abundance is low. Evaluations of alternative stocking strategies or translocation or propagation of a locally adapted trout from nearby waterbodies should be considered to improve the trout fishery in Upper Payette Lake.

Authors:

Mike Thomas
Regional Fisheries Biologist

Jordan Messner
Regional Fishery Manager

INTRODUCTION

Upper Payette Lake (UPL) (45.128052 °N, -116.022083 °W) is a 122.1-ha waterbody located at an elevation of 1,695 m approximately 25 km north of McCall, ID. IDFG began stocking fish in UPL beginning with kokanee salmon (KOK) *Oncorhynchus nerka* in 1940. KOK, Rainbow Trout *Oncorhynchus mykiss* (RBT), Brook Trout *Salvelinus fontinalis* (BKT), and Cutthroat Trout *Oncorhynchus clarkii* (WCT) were stocked regularly until 1960, at which point IDFG switched to almost exclusively stocking 'catchable' RBT. Despite a long history of stocking salmonids, Largescale Sucker *Catostomus macrocheilus* (LSS), and to a lesser extent, other nongame species, have dominated the fish community in UPL for decades (Grunden and Anderson 1991; Janssen et al. 1994). The lake was chemically treated in 1970 to remove nongame fish, but the treatment was unsuccessful. In an attempt to utilize the biomass of nongame fish in UPL and provide additional angling opportunities, fishery managers introduced over 18,000 catchable splake (Lake Trout *Salvelinus namaycush* X BKT) in 1992 and 1993. Stomach contents of splake captured in 1993 and 1996 surveys confirmed that splake were utilizing a primary diet of juvenile LSS, but survival and growth rates of splake were poor and stocking was discontinued (Janssen et al. 1994). Although the current statewide Fishery Management Plan (2019-2024) directs managers to maintain UPL as a hatchery-supported system (IDFG 2018), "Tag-You're-It" evaluations from 2018 suggest that overall annual use of catchable RBT is less than 10% (IDFG, unpublished data). In addition to stocking catchable RBT, in 2019 fishery managers resumed stocking KOK fingerlings (< 150 mm) to provide additional angling opportunities in UPL.

OBJECTIVES

1. Evaluate the status of Upper Payette Lake fish composition, abundance, and size structure.

METHODS

We set two sinking and two floating IDFG experimental gill nets (i.e., 46 m x 2 m; 6 panels of 19-, 25-, 32-, 38-, 51-, and 64-mm bar mesh; IDFG 2012) in UPL on June 29 and 30, 2020. One paired set was attached to the shore and fished perpendicular to the shoreline (45.12426 °N, -116.02575°W), while the other was set offshore (45.12930°N, -116.01949°W). Gill nets were set in the afternoon, fished overnight, and pulled the next morning. 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 (W_r) for RBT (Simpkins and Hubert 1996) and Brook Trout (Hyatt and Hubert 2001) larger than 130 mm TL. Relative weight was calculated by first using a standard weight (W_s) equation for each species:

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

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:

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

RESULTS

We collected a total of 54 fish of 3 species (91% LSS, 6% RBT, 4% BKT) in UPL during the 2020 survey (CPUE = 27; Table 6). We caught 49 LSS that ranged in length from 183 to 364 mm (mean = 262 mm; Table 6; Figure 16), and 3 RBT that ranged in length from 261 to 442 mm (mean = 344 mm) with a mean relative weight of 72 (range = 68 – 75; Table 6; Figure 17). We also caught two BKT that were 285 mm (W_r = 89) and 290 mm (W_r = 100; Table 6; Figure 17).

DISCUSSION

Similar to previous surveys (Janssen et al. 2016), LSS comprised the majority of gill net catch in UPL in 2020. Hatchery-origin RBT were the second most abundant species caught (no wild origin RBT were collected), followed by natural-origin BKT. We observed low abundance and relatively poor body condition of salmonids. The most abundant salmonid observed in most years has been hatchery-stocked catchable RBT. “Tag-You’re-It” evaluations conducted in 2018 found that use and exploitation on hatchery stocked catchable RBT in UPL is very low (range 1% - 6%). Although the statewide Fisheries Management Plan (2019 – 2024) suggests ‘high catch rate and excellent return rate’ for catchable RBT in UPL, a review of previous survey data failed to produce any evidence to support that claim.

UPL is a popular destination for campers and day users during the summer months around McCall. It is a popular fishery for anglers looking to target trout, but all indications are that catchable RBT do not return-to-creel well. IDFG began stocking KOK fingerlings annually in 2019, but we have yet to determine the success of that effort. We did not collect any KOK in our 2020 survey, which was expected since they had not been stocked prior to 2019. Surveys to determine effectiveness of kokanee stocking should be conducted within the next three years to evaluate whether or not stocking of KOK fingerlings should continue in UPL.

Management goals for UPL are set at maintaining minimum trout catch rates of 0.5 fish/h, which are likely not being maintained currently with the catchable RBT stocking program. The lake is deep, cold, and water quality is excellent, thus, it appears to be a suitable lake for maintaining a healthy trout population. However, the catchable RBT stocking program that is currently employed at UPL has been in service since 1992, with little evidence to suggest it is successful. Therefore, fishery managers should consider conducting a tagging study to evaluate the current performance of stocked RBT in UPL. Depending on those findings, fishery managers should consider working with hatchery staff to evaluate the feasibility of stocking “magnum” (i.e., 305 mm) catchable RBT (Branigan et al. 2021) to improve return-to-creel of hatchery RBT in UPL, or evaluating the feasibility of propagating a self-sustaining natural population using a locally adapted brood source (e.g. Brundage Reservoir – Hartley Creek). Within three years, a gill netting survey should be conducted to evaluate the success of the KOK stocking program and monitor any changes in fish community structure.

MANAGEMENT RECOMMENDATIONS

1. Conduct a tagging study to evaluate exploitation of hatchery catchable RBT in UPL.

2. Conduct a gill netting survey within the next three years to evaluate the success of the KOK stocking program in UPL.

Table 6. Total catch, proportion of total catch, mean lengths (mm TL), and relative weights (W_r) from a gill net survey at Upper Payette Lake, Idaho on June 29 and 30, 2020.

Species	**Catch**	**% of Catch**	**Mean TL (range)**	**Mean W_r (range)**
Rainbow Trout	3	6	344 (261 - 442)	72 (68 - 75)
Brook Trout	2	4	(285, 290)	(89, 100)
Largescale Sucker	49	91	262 (183 - 364)	--
Total	54	100		

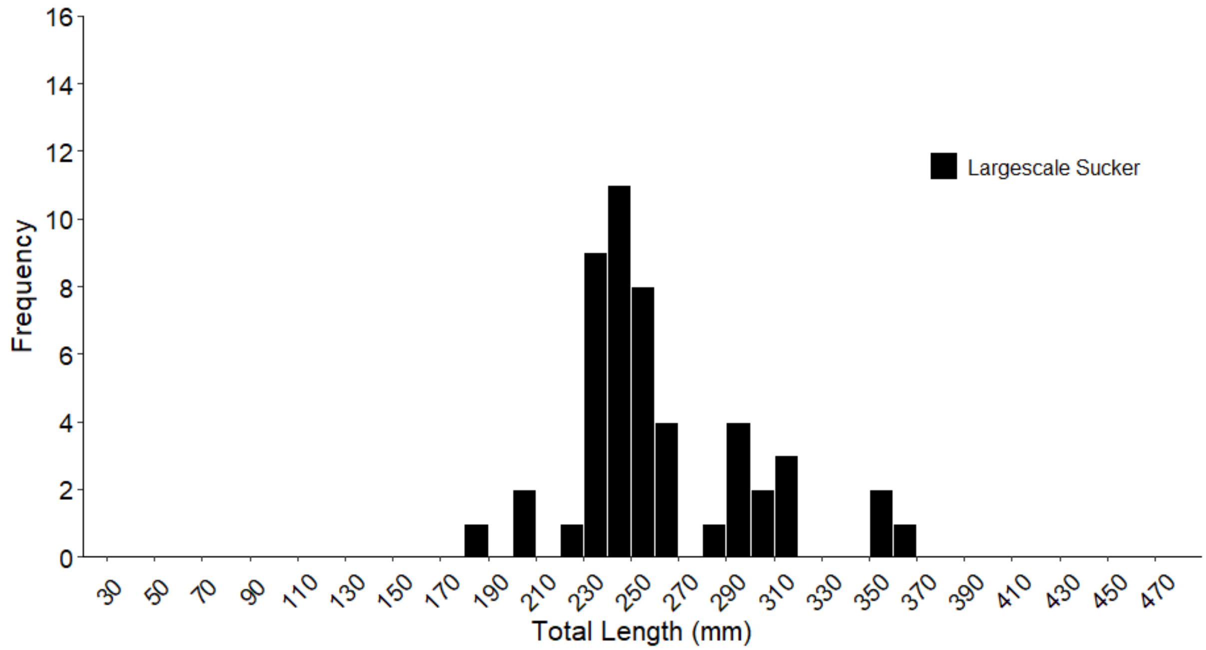

Figure 16. Length-frequency histogram of Largescale Sucker (*n* = 49) captured during a gill netting survey at Upper Payette Lake, Idaho on June 29 and 30, 2020.

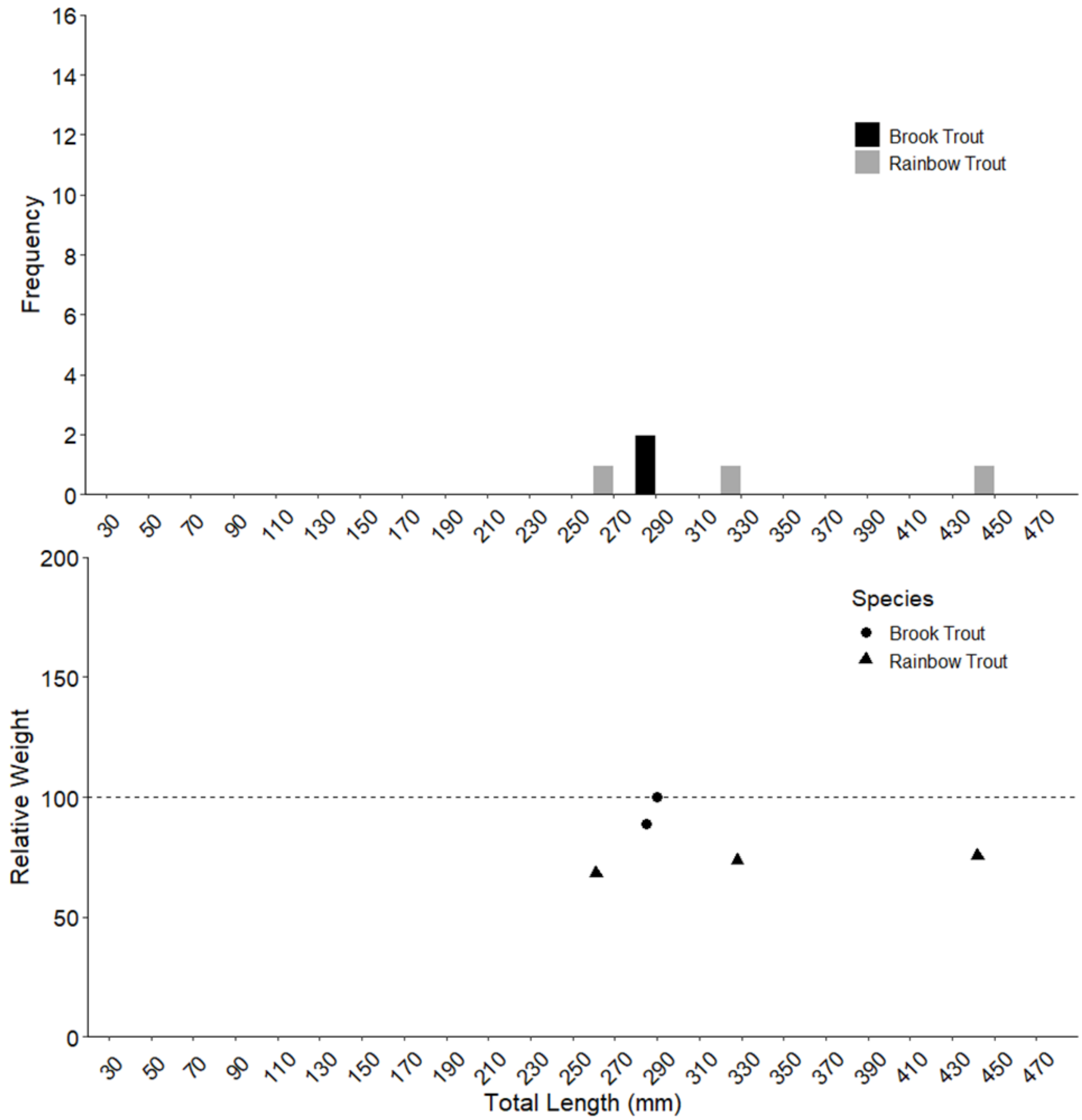

Figure 17. Length-frequency histogram and relative weights of Brook Trout (n = 2) and Rainbow Trout (n = 3) captured during a gill netting survey at Upper Payette Lake,Idaho on June 29 and 30, 2020.

LITTLE PAYETTE LAKE SMALLMOUTH BASS TRANSLOCATIONS

ABSTRACT

Smallmouth Bass *Micropterus dolomieu* (SMB) have been translocated semi-annually into Little Payette Lake (LPL) since 1988 to provide additional sport fishing opportunity for anglers. In 2020, we translocated 600 SMB (mean length = 264 mm) into LPL from Oxbow Reservoir. Angler reports suggest that these fish survive and return-to-creel . This is the first tagging conducted to confirm this. We tagged 60 SMB (10%) with t-bar anchor tags (FLOY) to evaluate angler use and determined that it was very low (expanded to 2.5%; 15 fish). Although angler use was low, it appears as though small numbers of trophy size SMB and tiger muskellunge *Esox masquinongy* x *Esox lucius* are supporting most of the angling effort on LPL. Future surveys should be conducted to evaluate angler use and preferences in LPL, and fishery managers should consider alternative stocking strategies (i.e., species, densities) to improve current sport fishing opportunity.

Authors:

Josh Poole,
Regional Fisheries Biologist

Mike Thomas,
Regional Fisheries Biologist

Jordan Messner,
Regional Fishery Manager

INTRODUCTION

Little Payette Lake (LPL) (44.917975° N, -116.035232° W) sits at 1,561-m elevation in the North Fork Payette River drainage, 2 km east of McCall. The lake has long been dominated by Northern Pikeminnow *Ptychocheilus oregonensis*, Largescale Sucker *Catostomus macrocheilus*, and Redside Shiner *Richardsonius balteatus*, which has often conflicted with fisheries management objectives. The lake was chemically treated with antimycin in 1971 and with rotenone in 1987 to remove undesirable fish species. Rainbow Trout *Oncorhynchus mykiss* fingerlings were stocked following each treatment. Smallmouth Bass *Micropterus dolomieu* were also stocked in 1988 to help slow the return of large numbers of undesirable fishes. For a short time following chemical treatments, the lake received increased angling effort, and the trout fishery was reported by anglers as being consistently excellent (Grunder and Anderson, 1991). However, undesirable fish species biomass increased in a few short years on both occasions, and again dominated gill net catches (Janssen et al. 1997). Tiger muskellunge *Esox lucius x E. masquinongy* were introduced in 1998 in another attempt to reduce undesirable fish species biomass, and have been stocked intermittently since. Rainbow Trout were stocked consistently up until 2012. Rainbow Trout survival, angling success, and effort on the fishery declined through the early 2000s, so stocking was ceased in 2012.

Today, small numbers of trophy size Smallmouth Bass and tiger muskellunge drive most of the angling effort on Little Payette. Tiger muskellunge are notoriously difficult to catch, but anecdotal evidence suggests that Smallmouth Bass catch rates can be excellent at certain times of the year. Because of poor natural recruitment due to a very short ice-free season, Smallmouth Bass have been translocated semi-annually from Hells Canyon and Oxbow Reservoirs. Both Smallmouth Bass and tiger muskellunge have performed well and grow to trophy size, but angling use and exploitation on these species is not well understood.

OBJECTIVES

1. Evaluate the status of Little Payette Lake fish composition, abundance, and size structure.

STUDY SITE AND METHODS

Little Payette Lake is a natural, alpine, oligotrophic lake (TDS = 22, Conductivity = 15-20 µs). Natural surface area of the lake is 196 hectares (ha) and natural maximum depth is 32 meters (m). There is a 5 m tall irrigation dam (built in 1926) on the outlet of the lake (Lake Fork Creek) which, when full, inundates surrounding meadow and increases surface area to 588 ha; 67% of which is less than 5 m deep. At full pool the lake contains 35,000 ac/ft of water.

Smallmouth Bass were collected from Oxbow Reservoir usinga boat-mounted Midwest Lake Electrofishing Systems “Infinity” electrofishing unit powered with a 4000-Watt Honda generator the evening of June 17, 2020. Electrofishing was conducted with one boat and two netters along shorelines, adjusting the voltage so that fish were stunned for just long enough to be netted, but showed no signs of injury, following guidelines from Bonar et al. 2009. Target power was between 3,200-3,400 W; conductivity was measured at 278 µS/cm. We fished to the south of McCormick Campground boat ramp down to the boating restriction near the Oxbow Dam. Smallmouth Bass greater than 150 mm total length (TL) were netted until approximately 50 fish were captured. Fish were then deposited in large holding pen nets that were anchored to the dock at McCormick Campground. This process was repeated until 600 fish were captured. We began at sundown (approximately 2100) and had captured our goal of 600 fish by around 0200 the following day.

Fish were held in the holding pens until approximately 0830 on June 18th when they were netted with dip nets and placed into a large truck-mounted transport tank. Oxygen levels and fish health was assessed approximately every half hour during transport to maintain 0.5 lpm. At Little Payette Lake, 10% of the translocated fish (60 fish) were measured, weighed, and t-bar tagged. Tagging data was uploaded to the "Tag-You're-It" database.

RESULTS

A total of 600 SMB were translocated to LPL with 10% (60 fish) tagged with FLOY tags. Lengths of translocated fish ranged from 167 to 289 mm with a mean length of 263.8 mm (Figure 18). Relative weights ranged from 66.6 to 108.9 with a mean of 86.6 (Figure 18).

One year after tagging, only one of the 60 marked Smallmouth Bass has been reported as caught-and-released and none were reported harvested. This represents a 1.7% use rate, or approximately 10 of 600 stocked bass caught. Meyer at al. (2012) described fairly low (54.1%) reporting rates of Smallmouth Bass in Idaho, suggesting an adjusted use rate of 2.5%, or approximately 15 bass caught.

DISCUSSION

Exploitation and use of SMB in LPL is very low compared to other Idaho fisheries. For comparison of the overall unadjusted use rate of bass is 19.3% in Brownlee Reservoir, a popular Smallmouth Bass fishery in our region where exploitation has been extensively studied. However, it is not surprising that we did not document harvest on translocated SMB in Little Payette Lake considering the minimum length limit for harvesting SMB in Little Payette Lake is 304 mm, so all translocated fish were not legally harvestable. The low observed use rate in Little Payette may also be a result of the limited use the fishery receives in general. Exploitation studies on bass should continue and be expanded to include other species in Little Payette Lake. This will help fishery managers understand if use is low for all species in Little Payette, or just for bass.

Translocations of Smallmouth Bass from Oxbow or Hells Canyon Reservoirs into Little Payette Lake have occurred 17 times since their first introduction in 1988 (Table 7). Initially, the intention of the program was to stock Smallmouth Bass until a self-sustaining population was established and then cease transplant efforts (Grunder and Anderson, 1991). However, Smallmouth Bass have not become well-established as of yet, likely due to very low or non-existent natural reproduction. The most recent fisheries survey in 2019 found that Smallmouth Bass make up less than 5% of the total catch of fishes (Janssen et al. 2020). As such, if a Smallmouth Bass fishery continues to be desired in Little Payette Late, translocations may need to continue in perpetuity.

Smallmouth Bass translocations in Little Payette Lake come at a great value to anglers with little cost. One biologist and two technicians spent 4.5-h on travel and transportation, 5-h on fish capture, and 1.5-h tagging, handling, and releasing fish. One biologist spent 2-h prepping the transportation tank; however, this included repairing the agitator system. In the future, tank preparation would likely take less than 1-h. We left McCall at approximately 1600 on June 17, 2020 and completed stocking Little Payette Lake at approximately 1300 on June 18, 2020. Estimated cost of labor and expendable supplies were around $700 USD.

Since Little Payette Lake sits within 2 km of the City of McCall, it has potential as a family fishery, but is currently utilized as a specialty fishery. It functioned as a high-use, put-and-take Rainbow Trout fishery in the past; however, stocking was discontinued due to low use and exploitation. Recently, the stocking of larger size Rainbow Trout (termed 'magnums') has been assessed across the State of Idaho and shows promising results (Branigan et al. 2021). Magnums showed an increase of 107% return-to-creel in comparison to their smaller-sized counterparts (Branigan et al. 2021). As such, stocking magnum trout into Little Payette Lake may provide opportunity that was not available before Rainbow Trout stocking was ceased in 2012. Further evaluation should assess whether stocking magnums into Little Payette Lake can improve fishery quality. Stocked magnums should be t-bar tagged to examine use and exploitation, and public outreach conducted to get anglers excited about this opportunity through press releases and fishing events.

MANAGEMENT RECOMMENDATIONS

1. Work closely with hatchery staff to determine feasibility of stocking 'magnum' hatchery RBT into LPL to supplement the sport fishery.

2. Work with IDL and SITPA to remove driftwood and open shoreline access to LPL in 2022.

Table 7. Smallmouth Bass stocking history in Little Payette Lake, Idaho.

Date	Number stocked	General size
6/18/2020	600	Greater than 6 inches
6/22/2017	560	Greater than 6 inches
6/25/2015	600	Greater than 6 inches
6/12/2014	782	Greater than 6 inches
9/27/2012	368	Greater than 6 inches
8/12/2011	849	Greater than 6 inches
7/9/2009	473	Greater than 6 inches
8/10/2007	210	Greater than 6 inches
7/20/2006	620	Greater than 6 inches
7/28/2004	526	Greater than 6 inches
6/1/2002	743	Greater than 6 inches
6/2/2001	517	Greater than 6 inches
6/3/2000	472	Greater than 6 inches
5/15/1999	120	Greater than 6 inches
5/16/1998	165	Greater than 6 inches
5/11/1991	461	Greater than 6 inches
10/13/1988	200	Less than 6 inches

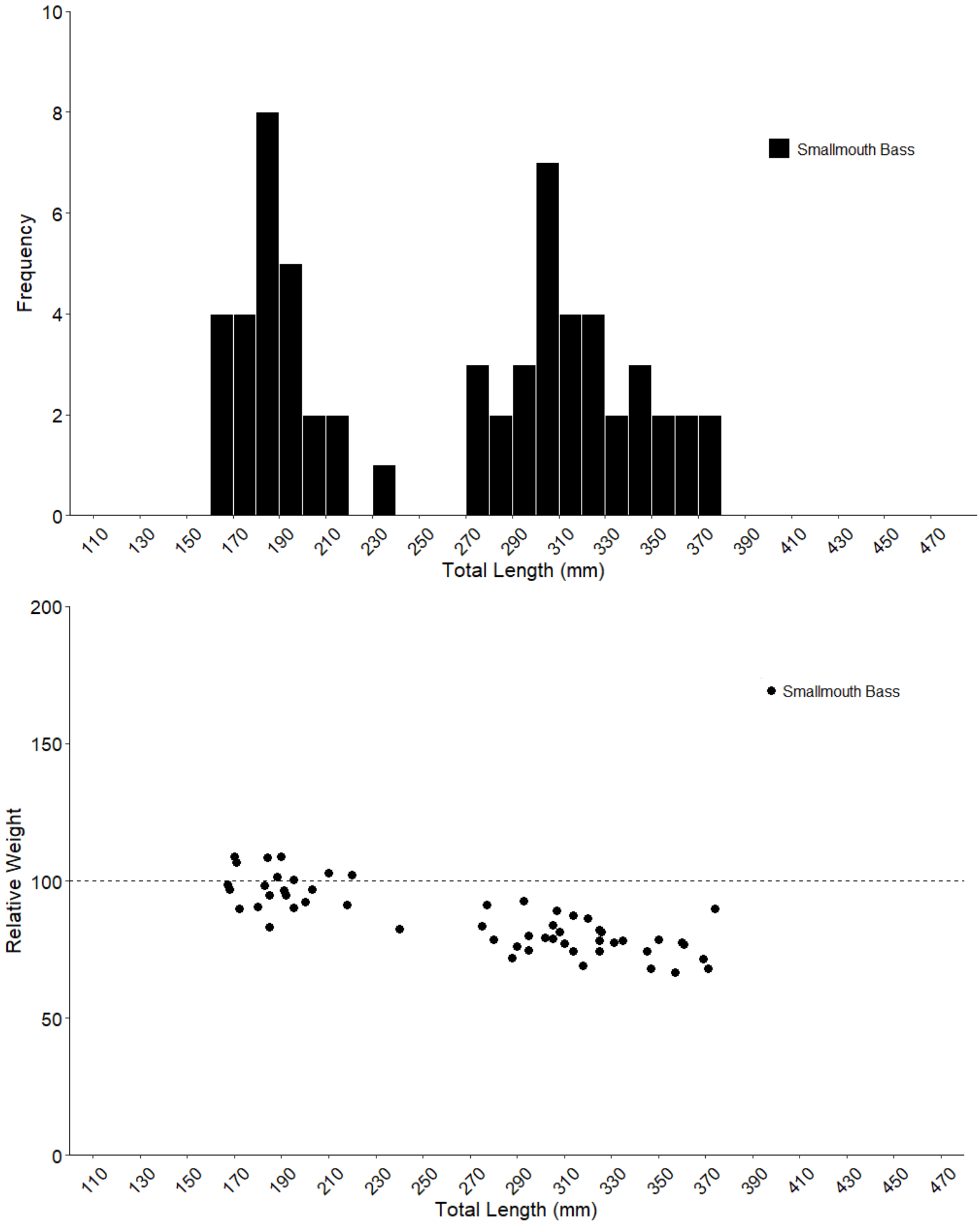

Figure 18. Length-frequency histogram and relative weights of a subset of 10% (n = 60) of Smallmouth Bass transferred into Little Payette Lake, Idaho in 2020.

LAKE CASCADE HOLIDAY ANGLER COUNT INDEX

ABSTRACT

Holiday angler counts have been conducted annually at Lake Cascade since 1996 as an index to assess trends in angler 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 2020, we counted 35 shore anglers and 65 boats on Memorial Day; 52 shore anglers and 88 boats on Independence Day; and 32 shore anglers and 17 boats on Labor Day. Mean holiday index counts in 2020 for shore anglers and number of fishing boats was 40 and 57, respectively, for a combined mean index count of 97 – the third highest counts observed since 1996. The average of combined mean index counts from 2000 to 2004 (prior to fishery restoration) was 27, whereas the average of combined mean index counts from 2006 to 2020 (post-restoration) is 67. This illustrates an increase in angler effort on Lake Cascade since the fishery restoration efforts in 2005 through 2006.

Authors:

Mike Thomas,
Regional Fisheries Biologist

Jordan Messner,
Regional Fisheries Manager

INTRODUCTION

In order to monitor long-term trends in angling effort on Lake Cascade, we have conducted annual shore angler and fishing boat counts on Memorial Day, Independence Day, and Labor Day each year since 1996. These holiday angler counts started just prior to the collapse of the Yellow Perch *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 during 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 2020 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, Independence Day, and Labor Day on Lake Cascade in 2020. A fishing boat is defined as a boat visibly containing fishing rods. 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 all three surveys to derive an index count for 2020, 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 2020, we counted 35 shore anglers and 65 fishing boats; on Independence Day, we counted 52 shore anglers and 88 fishing boats; and on Labor Day, we counted 32 shore anglers and 17 fishing boats (Table 8). Mean index counts for shore anglers and fishing boats were 40 and 57, respectively, for a combined mean index total of 97 (Table 8 and 9). The average of combined mean index counts from 2000 to 2004 (prior to fishery restoration) was 27, whereas the average of combined mean index counts from 2006 to 2020 (post-restoration) was 67 (Table 9). In general, angler counts have increased since the fishery restoration efforts in 2004 through 2006. The combined index count in 2020 was the third highest value observed since 1996 (Figure 19). Weather conditions were favorable on both Memorial Day and Independence Day (e.g., sunny with little wind), while smoke and high winds may have influenced counts on Labor Day (particularly for fishing boats; Table 8).

DISCUSSION

The combined holiday index count in 2020 was the second highest count since the Yellow Perch restoration project (2004 – 2006) and the third highest count since the first year of this survey in 1996 (Table 9). In general, angler counts have increased since the Yellow Perch restoration project (Figure 19). However, with only three days of counts for the entire year, inclement weather on any count day may have a significant reduction of some yearly means and should continue to be recorded (Janssen et al. 2020). For example, in 2020, poor weather conditions likely reduced the number of fishing boats counted on Labor Day. Additionally, the COVID-19 pandemic likely resulted in increased fishing effort on Lake Cascade in 2020. During this time, the sales of Idaho fishing licenses increased by 58,612 from 2019. It is important to record these types of information and consider how variability in trend data with so few data points can be influenced by them.

We assume the count of shore anglers and fishing boats on Lake Cascade is directly correlated to angler success. That is, when fishing is good, more anglers come to fish the lake. However, angler counts are not necessary correlated with the quality of the Yellow Perch fishery, only. The Smallmouth Bass fishery also attracts anglers from the surrounding area and bass fishing tournament effort has also increased on Lake Cascade in recent years (IDFG unpublished data). Gathering angler catch rate and target species data to supplement index count data would be valuable to better understand what species are driving fishing effort and to inform management of the fishery.

The last comprehensive creel surveys conducted at Lake Cascade were in 2016 and 2009 (Table 9). Conducting a comprehensive creel survey is important, both for collecting angler catch rate information and to ensure variability in holiday index counts are accurately representing overall variability in annual angling effort. Repeatable creel methodology should be developed for conducting comprehensive surveys once every three to five years at Lake Cascade. Creel surveys should focus on collecting angler effort, catch, and harvest data, as well as target species data and angler preferences to inform relative importance of each species' contribution to the value of the fishery, and to determine where best to focus management efforts.

MANAGEMENT RECOMMENDATIONS

1. Continue holiday index angler counts to monitor trends in angler effort.
2. Record weather conditions during angler effort and creel surveys.
3. Develop a standardized annual winter angler vehicle count to supplement holiday index count data.
4. Work with fisheries biometrician to develop repeatable methodology for comprehensive creel surveys to be conducted every three to five years.

Table 8. Weather conditions and total counts of shore anglers and fishing boats conducted on Memorial Day, Independence Day, and Labor Day on Lake Cascade, Idaho in 2020.

Holiday	Shore Anglers	Fishing Boats	Weather
Memorial	35	65	Good[1]
Independence	52	88	Good[1]
Labor	32	17	Poor[2]
Mean:	40	57	

[1]*Sunny and low winds*

[2]*Smoke and high winds*

Table 9. Mean boat and shore angler counts on Lake Cascade, Idaho on three major holidays including Memorial Day, July 4th, and Labor Day, in 1982, 1991, 1992, 1996 - 2010, and 2014 - 2020 with corresponding intensive creel survey angler hour estimates for 1982, 1991, 1992, 2009 and 2016.

	Mean Holiday Index Counts		Creel surveyed angler hours (hours * 1000)			
Year	Mean Boat Count	Mean Shore Angler Count	Boat Anglers	Shore Anglers	Ice Anglers	Total Effort
1968[1]	--	--	32.3	27.4	n/a	59.7
1969[1]	--	--	38.7	27.9	n/a	66.6
1970[1]	--	--	53.3	24.8	n/a	81.3
1982	154	85	254.6	119.9	39.8	414.2
1986	n/a	n/a	212.8	128.2	50.8	391.8
1991	41.5	32	135.2	102	13.8	237.2
1992	52.5	28	144.2	177.3	61.7	321.5
1996	35	27	--	--	--	--
1997	36.5	19	--	--	--	--
1998	58	39.5	--	--	--	--
1999	27	31	--	--	--	--
2000	15	12	--	--	--	--
2001	11	12	--	--	--	--
2002	16.5	12	--	--	--	--
2003	17	6	--	--	--	--
2004	23	8.5	--	--	--	--
2005	28	12.5	--	--	--	--
2006	25	23	_	_	--	_
2007	24	28	_	_	--	_
2008	34	37	_	_	--	--
2009[2]	29	29	29.2	23.1	17.9	70.6
2010	22.5	22	--	--	--	--
2011	--	--	--	--	--	--
2012	--	--	--	--	--	--
2013	--	--	--	--	--	--
2014	63	54	--	--	--	--
2015	44	42	--	--	--	--
2016[3]	22	16	31.8	22.1	11.1	65.0
2017	36	24	--	--	--	--
2018	52	23	--	--	--	--
2019	38	35	--	--	--	--
2020	57	40	--	--	--	--

[1] *Creel survey from mid-April thru late October 1968, 1969, 1970*
[2] *Creel survey from May 15, 2009 thru May 30, 2010*
[3] *Creel survey from May 1, 2016 thru March 31, 2017*

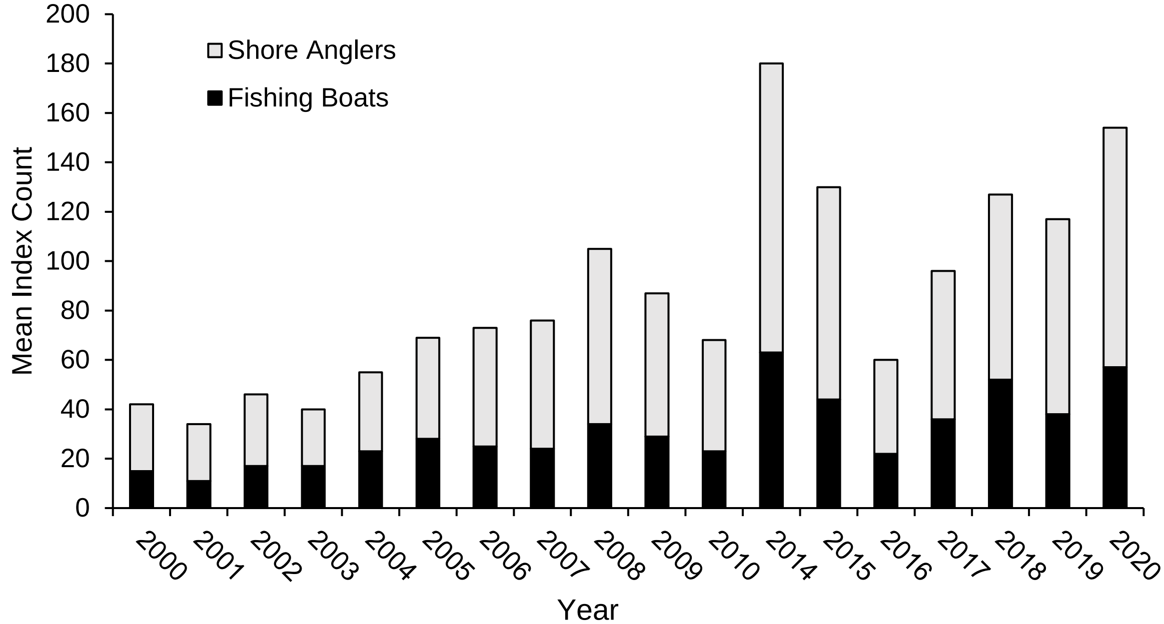

Figure 19. Mean index counts of shore anglers and number of fishing boats on Lake Cascade, Idaho on Memorial Day, Independence Day, and Labor Day, 2000 - 2020.

LAKE CASCADE JUVENILE YELLOW PERCH TRAWLING

ABSTRACT

Bottom trawl surveys have been employed at various times in Lake Cascade (1998 – 2011, 2019 – 2020) to monitor trends in abundance and sizes of juvenile Yellow Perch (YLP) *Perca flavescens*. Trawl surveys were discontinued after 2011 but re-instituted in 2019 to monitor trends in young-of-year (YOY) YLP. In 2020, we compared trawl catches across all 21 historic sites (i.e., 3 lake divisions; 7 transects each) in June, August, and October. In total, we completed 63 trawl hauls and collected 28,312 juvenile YLP (mostly YOY and age-1). The majority of YLP were caught in August (*n* = 22,627) compared to June (*n* = 4,014) and October (*n* = 1,671). Mean lengths of YOY YLP were 19 mm in June, 39 mm in August, and 54 mm in October. Low sample sizes in June and October make these sampling periods less desirable if a single annual sampling event is to be used moving forward. Our results suggest that August trawl surveys may provide the most useful information for building an annual index series. August trawl data should be combined with sampling methods used to collect predominately age-1 to -3 YLP to develop indices of juvenile perch recruitment and survival. These index data could be used to predict year class strength and forecast future fishery quality.

Authors:

Mike Thomas,
Regional Fisheries Biologist

Jordan Messner,
Regional Fisheries Biologist

INTRODUCTION

A bottom trawl was utilized from 1998 through 2011 in Lake Cascade to monitor juvenile Yellow Perch (YLP) *Perca flavescens* size and abundance. Although at that time it did not appear to be effective at predicting recruitment of juvenile age classes into harvestable-sized YLP (Janssen et al. 2012), the potential for utilization of a trawling index is worth re-visiting. Standard gillnetting surveys did not begin until 2012, so the full utilization of index trawl data combined with that gillnet data was perhaps not yet realized when trawling was previously discontinued. Although the annual gill netting survey describes trends in relative abundance and size structure of the entire fish community in Lake Cascade, YLP do not fully recruit to the gear until age-4 or -5. Previous ageing studies indicate that age-4 and older YLP experience very low mortality rates (near zero), suggesting that the majority of YLP mortality is occurring between age-0 and -4 (Janssen et al. 2020). A variety of factors could influence juvenile YLP survival in Lake Cascade and sources of variation are poorly understand. Therefore, in order to better understand sources of juvenile mortality, a method of indexing juvenile abundance, recruitment, and survival is necessary. Annual trawling was re-established in 2019 to evaluate whether trends in relative abundance and survival of YOY and age-1 YLP (Anderson et al. 2011) can be used to predict trends in gillnet catch 4 to 5 years later.

OBJECTIVES

1. Utilize a bottom trawl, in addition to other sampling gears, to develop an index to monitor recruitment and survival of juvenile YLP annually.

2. Compare monthly catch (June, August, October) to determine which month should be used for a single sampling event moving forward.

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). Unlike 2019, where only nine historic sites were sampled in October, we sampled all trawl sites (n = 21) in June, August, and October, 2020. Each lake area division contained 7 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). We measured all or a random sample (first 100 fish) of YOY YLP to the nearest mm depending on catch and all YLP that appeared to be age-1 or older. Length-frequencies were then used to estimate the minimum length of age-1 fish caught during each month and to calculate mean lengths of YOY and age-1 YLP.

To explore the relationship between trawl catch and fall gill netting catch (see Lake Cascade Annual Fall Gill Netting Chapter for more information), we subset the trawling data for all years following fishery restoration (2007 – 2011) and compared it to the total gill net catch of 200 to 250 mm YLP (roughly age-4 and -5) between 2012 and 2016. Comparisons were made using a Pearson correlation coefficient to measure the statistical relationship, if any, between the two continuous variables.

RESULTS

In total, we completed 63 trawl hauls (315 min) and collected 28,312 YLP (mean catch = 449 fish per trawl) in 2020. August produced the greatest number of YLP in 2020 (*n* = 22,627) and average catch per trawl was 1,078 fish (Table 10 and 11). Catch differed by lake division and was highest in the east section (*n* = 13,751) compared to the west (*n* = 7,717) and south (*n* = 1,159) sections (Table 10).

In June, we caught a total of 4,014 YLP and average catch per trawl was 191 fish. Catch was highest in the west section (*n* = 2,970) compared to the south (*n* = 668) and east (*n* = 376) sections (Table 10). Average length of YOY YLP in June was 19 mm. Based on the length-frequency distribution of YLP caught in June, we collected 37 age-1 YLP with a minimum length of 40 mm (Figure 20). Water temperature ranged between 18 and 21˚C (mean = 19˚C).

In August, average length of YOY YLP was 39 mm. Catch was highest in the east section (*n* = 13,751) compared to the west (*n* = 7,717) and south (*n* = 1,159) sections (Table 10). Based on the length-frequency distribution of YLP caught in August, we caught 191 age-1 YLP with a minimum length of 65 mm (Figure 21). Water temperature ranged between 21 and 24˚C (mean = 23 ˚C) during August trawling.

Total catch in 2020 was lowest in October (*n* = 1,671) with an average catch of 80 fish per haul. Catch was highest in the east section (*n* = 1,215) compared to the west (*n* = 203) and south (*n* = 253) sections (Table 10). Average length of juvenile YLP in October was 54 mm. Based on the length-frequency distribution of YLP caught in October, we collected 122 age-1 YLP with a minimum length of 80 mm (Figure 22). Water temperature ranged between 10 and 12˚C (mean = 11˚C).

Compared to historic trawl catches (1998 – 2011), we caught more YLP per trawl in 2020 than all previous years except 2007 through 2009 (immediately after fishery restoration; Table 11). Catch in 2020 was very similar to 2007, which preceded a very dominate year class that was observed entering the fishery in 2012 (Figure 23; see Lake Cascade gill netting chapter of this report). In 2019, an abbreviated survey of sites with the highest historic catch was conducted (3 sites; 3 lake divisions). Among these sites, we caught fewer YLP in 2020 (*n* = 1,447) compared to 2019 (*n* = 9,226). However, the majority (> 99%) of YLP collected in 2019 and 2020 were YOY, which suggests the 2019 cohort experienced high rates of mortality.

We also discovered a statistically significant relationship between mean August trawl catch (2007 – 2011) and total gill net catch of 200 to 250 mm YLP (roughly age-4 and -5) between 2012 and 2016 (Pearson, $r = 0.93$, $p < 0.05$, df = 3, Figure 23).

DISCUSSION

Annual gill netting surveys in Lake Cascade indicate that total annual mortality rates are very low (< 25%) for YLP greater than age-4 (see Lake Cascade Annual Gill Netting Survey Chapter for more detail). YLP in Lake Cascade are approximately 205 mm at age-4, therefore, variability in recruitment of YLP into the fishery is primarily driven by factors influencing juvenile age classes. Results of trawling surveys in 2020 suggest increased abundance of YOY YLP relative to all previous years with the exception of 2007 through 2009 (years which corresponded to relatively high abundance of age-4 YLP, 4 years later). Currently, factors contributing to variability in recruitment and survival of juvenile age classes are poorly understood. A variety of factors can influence juvenile recruitment and survival, including predation, competition, abundance of sexually-mature YLP, and various abiotic factors (Forney 1971, Sanderson et al., 1999, Dembkowski et al. 2016). Although these interactions can be complex and unique to each fishery, our historic trawl data indicate that competition among year classes and predation may be significant factors in Lake Cascade. For example, in 2008, we caught 70,674 YLP (mean = 3,032/trawl in August), the majority of which were YOY. The following year (2009), age-1 YLP dominated the trawl catch (63,580 YLP) and very few YOY were collected. In 2010, we caught very few YLP overall (total = 3,690 fish, mostly age-1) in our trawl survey. Finally, in 2011, we saw a modest increase in catch of YOY YLP. Unfortunately, trawling was discontinued later that year. These data, collected after the YLP recovery project, suggest that the production of a dominant year class (e.g., 2008 hatch) can influence proceeding year classes, which may be a significant factor causing the observed oscillations in recruitment to age-4 in Lake Cascade. In fact, mean trawl catch between 2007 and 2011 (after fishery restoration efforts) is highly correlated with total gill net catch of 200 to 250 mm YLP (roughly age-4 and age-5) in subsequent surveys 4-5 years later ($p < 0.05$; Figure 23). Therefore, trawling should continue to be conducted each August to build upon this potentially useful dataset.

There are many factors, including NPM predation, that should be evaluated to determine if, and(or) when, management intervention (e.g., rotenone, transplanting YLP, habitat improvement, regulation changes) can be used to provide a more consistent YLP fishery. While some factors may be uncontrollable, such as climate (Dembkowski et al. 2016) or intraspecific interactions (Sanderson et al. 1999), others could be controlled for (e.g., water levels, habitat, and interspecific predation) and an improved understanding of factors influencing variability in recruitment of juvenile YLP could allow fishery managers to take a proactive approach instead of a reactive approach to changes observed during annual surveys of the fish community. Further investigations on the population dynamics and food habits of YLP and NPM would greatly improve our understanding of factors regulating the YLP population. A research proposal should be developed to determine seasonal patterns in growth, condition, and food habits using bioenergetics and age-structured population models to provide a comprehensive understanding of the YLP population and interactions within the Lake Cascade fish community.

Trawling has proven to be effective at monitoring trends in YOY, and to a lesser degree, age-1 YLP abundance in Lake Cascade. However, additional sampling methodologies should be incorporated (e.g., mini trap nets, cloverleaf traps) to collect age-1 and -2 YLP to develop indices of survival post-YOY. Combined with the 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.

MANAGEMENT RECOMMENDATIONS

1. Conduct annual trawling surveys for juvenile YLP in August to index YOY abundance and assess trends over time.

2. Evaluate feasibility of utilizing miniature trap nets, cloverleaf traps, or gill nets with mesh sizes targeting age-1 to age-3 YLP (e.g., 25-38-mm bar mesh) in conjunction with annual trawling data to help index trends in abundance and survival of juvenile age classes of YLP not currently collected with other methods of sampling.

3. Develop a research proposal to assess factors influencing variability in year-class strength of juvenile YLP, in order to help guide fisheries management activities to maximize fisheries quality in Lake Cascade.

Table 10. Trawl catch (total and mean) of Yellow Perch by lake section (i.e., South, West, East) and month in Lake Cascade, Idaho in 2020.

	June			August			October		
Area	**Sites**	**Total Catch**	**Mean Catch/Haul**	**Sites**	**Total Catch**	**Mean Catch/Haul**	**Sites**	**Total Catch**	**Mean Catch/Haul**
South	7	668	95 ± 184	7	1,159	166 ± 226	7	253	36 ± 47
West	7	2,970	424 ± 678	7	7,717	1,102 ± 1,468	7	203	29 ± 33
East	7	376	54 ± 57	7	13,751	1,964 ± 1,545	7	1,215	174 ± 215
Total	21	4,014	191	21	22,677	1077	21	1,671	80

Table 11. Number of trawl hauls and mean catch per haul of Yellow Perch by month and year between 1998 – 2011 and 2019 – 2020 in Lake Cascade, Idaho.

Year	**June**	**August**	**October**	***n* Hauls**	**Mean Catch/Haul**
1998	2	2	7	141	2
1999	2	38	23	74	21
2000	3	4	24	74	10
2001	2	6	51	68	188
2002	1	2	15	68	7
2003	0	2	2	67	2
2004	207	57	11	65	93
2005	2	347	313	63	220
2006	125	720	466	62	436
2007	635	1,235	66	62	651
2008	4	3,032	329	62	1,140
2009	15	1,736	1,359	62	1,029
2010	37	111	28	63	59
2011	1	758	235	63	331
2019	--	--	1,025[1]	9	--
2020	191	1,078	80	63	449
Mean Catch/Month	82	609	201		

[1] *only nine (9) of the most historically productive sites were sampled.*

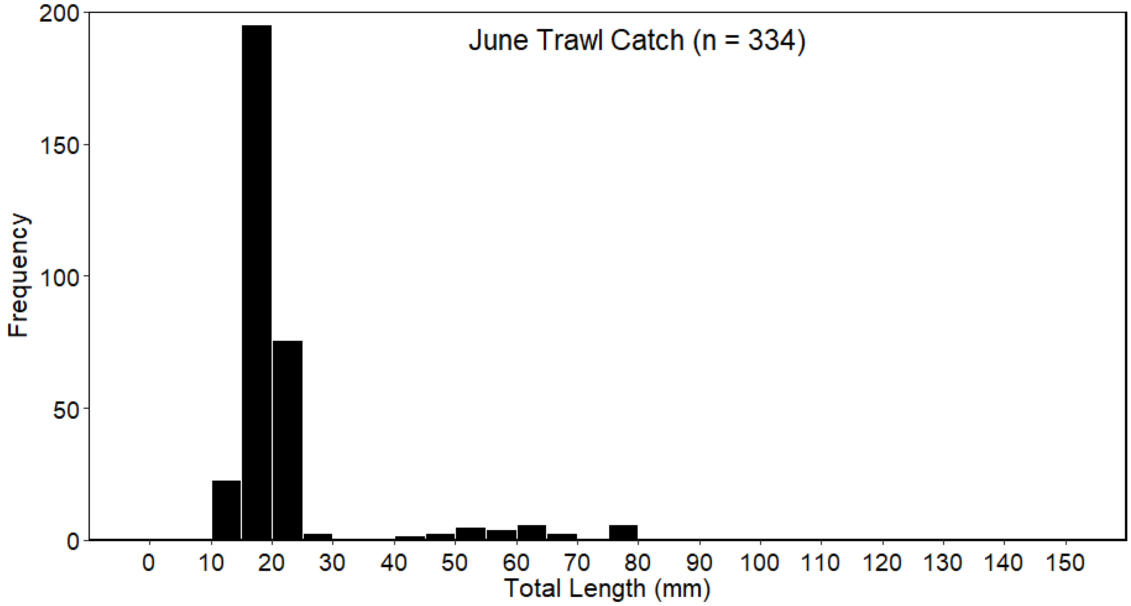

Figure 20. Length-frequency histogram of juvenile Yellow Perch collected with a bottom trawl in Lake Cascade, Idaho during June, 2020.

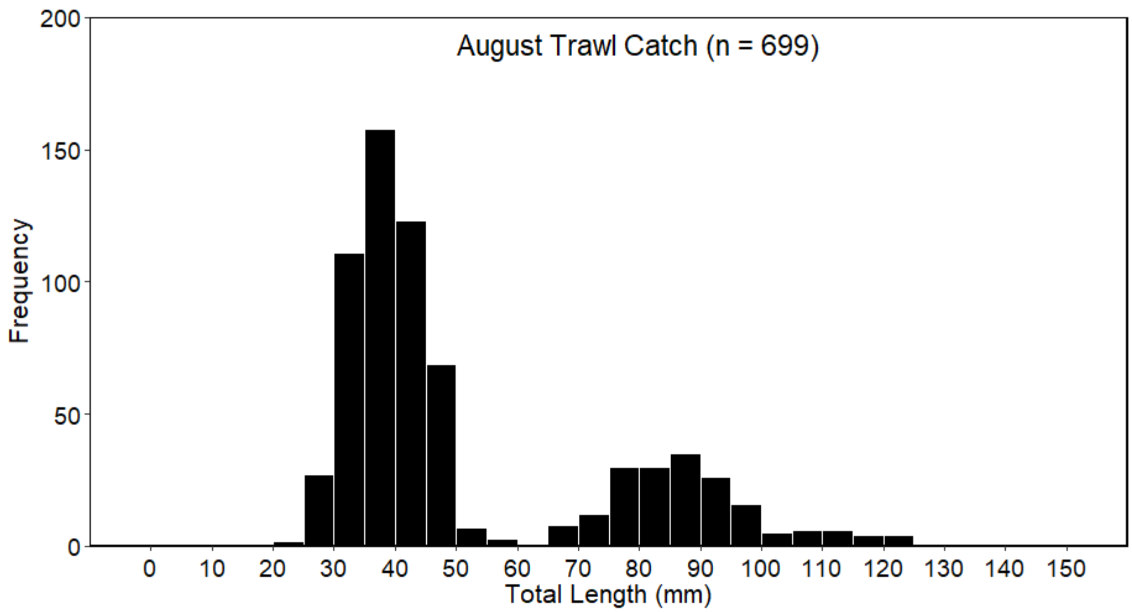

Figure 21. Length-frequency histogram of juvenile Yellow Perch collected with a bottom trawl in Lake Cascade, Idaho during August, 2020.

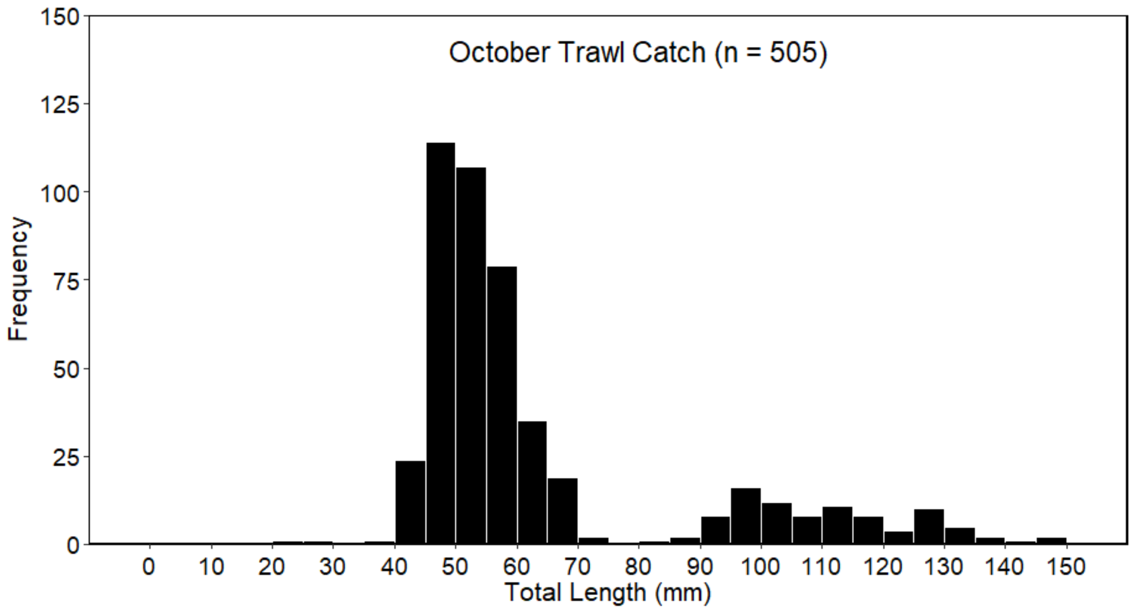

Figure 22. Length-frequency histogram of juvenile Yellow Perch collected with a bottom trawl in Lake Cascade, Idaho during October, 2020.

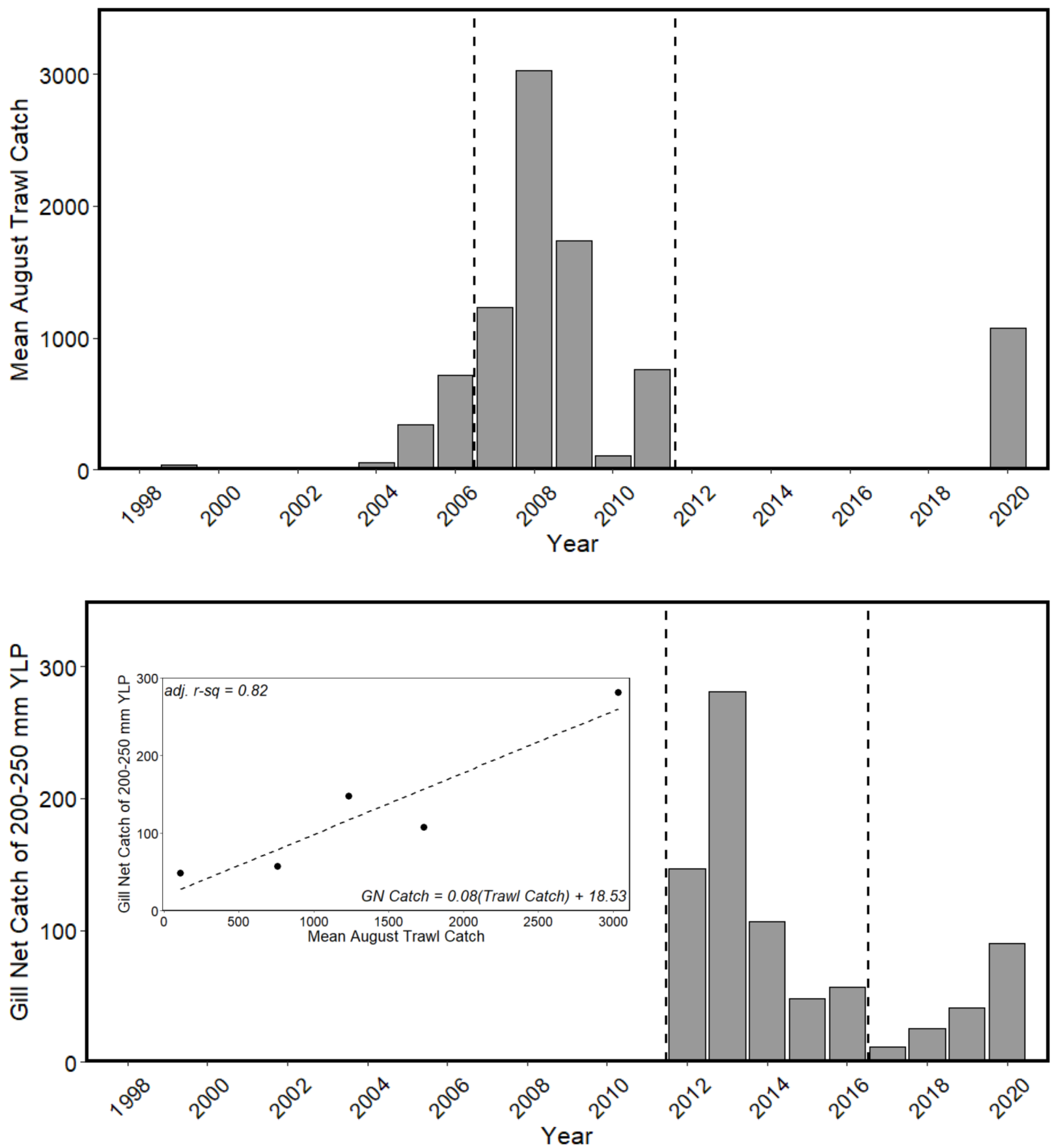

Figure 23. Top: mean catch of young-of-year Yellow Perch (YLP) using a bottom-trawl between 1998 and 2020. Vertical lines highlight 2007 through 2011 cohorts. Bottom: gill net catch of 200 and 250 mm perch (approximately age-4 and -5) collected during annual fall surveys between 2012 and 2020. Vertical lines highlight potential relationship between 2007-2011 cohorts and subsequent gill net catch. Embedded figure shows linear relationship between August trawl catch and subsequent gill net catch.

LAKE CASCADE YELLOW PERCH AND SMALLMOUTH BASS AGEING STUDY

ABSTRACT

Previous evaluations of Yellow Perch *Perca flavescens* (YLP) and Smallmouth Bass *Micropterus dolomieu* (SMB) age structure and population dynamics (i.e., growth, recruitment, mortality) in Lake Cascade were estimated using operculums (OPs) or length-frequency distributions. While OPs are easy to process and read, precision and accuracy of this structure for Lake Cascade YLP or SMB has not been tested. While sectioned sagittal otoliths (SOs) are widely accepted as a preferred lethal structure for ageing these species, both whole view sagittal otoliths (WOs) and OPs require less processing time. Therefore, we sought to evaluate between-reader precision, readability, and differences in age estimates obtained from SOs, WOs, and OPs of YLP (n = 143) and SMB (n = 74). For both species, WOs were the least precise and readable structure. For YLP, coefficient of variation (CV) was lowest for SOs (CV = 8), while percent agreement within-1 year and readability was highest for OPs (PA-1 = 90, mean confidence = 2). However, OPs ages were consistently lower than (P < 0.001) age estimates from SOs. For SMB, OPs exhibited higher precision (CV = 7), readability (mean confidence = 2), and within one year agreement (PA-1 = 90) than SOs (CV = 9, mean confidence = 1.6, PA-1 = 86), but OPs also underestimated ages compared to SOs (P < 0.001). Based on these results, we recommend that future evaluations of age structure and population dynamics use SOs for age estimation.

Authors:

Mike Thomas,
Regional Fisheries Biologist

Isaac Fournier,
Fisheries Technician

Steven Hughes,
Fisheries Technician

Jordan Messner,
Regional Fisheries Manager

INTRODUCTION

The Yellow Perch *Perca flavescens* (YLP) sport fishery in Lake Cascade is extremely popular and draws anglers from surrounding states, the Midwest, and Canada (Janssen et al. 2020). In recent years, Lake Cascade has produced multiple state- and world-record YLP – including a 1.46-kg state record caught during the 2020-2021 ice fishing season. Smallmouth Bass *Micropterus dolomieu* (SMB) also comprise a significant component of the sport fishery; drawing bass anglers from around the region. Lake Cascade hosts numerous bass tournaments each year (2020 tournaments canceled due to COVID-19).

Accurately estimating the age of fishes is essential to understanding the basic ecology of a population and for guiding the management direction of a fishery (Quist and Isermann 2017). Age data associated with individual fishes or a population can then be used to determine population dynamic rates (i.e., growth, mortality, recruitment), which fishery managers can use to monitor populations through time and develop science-based regulations (Ricker 1975; Kerns and Carlson 2017). Both accuracy and precision of age estimates can vary depending on which calcified (hard) structure is used, species, and geographic region (Quist et al. 2012). Further, accuracy is rarely known as it requires age-validation using known-age fish; therefore, precision, relative bias (i.e., differences in age estimates), and processing times are commonly used to evaluate various ageing structures (Phelps et al. 2017).

Previous evaluations of YLP and SMB age structure and population dynamic rates in Lake Cascade have relied upon age estimates obtained from operculum (OPs) and length-frequency histograms. Length-frequency histograms are much less reliable than using hard structures for ageing. OPs require much less time to remove from the fish and process in the lab compared to other structures, but the validity of using this structure for long-lived perch and centrarchids is unknown. Therefore, we sought to compare age estimates obtained from OPs to those obtained from sagittal otoliths (both whole view and sectioned; WO and SO, respectively) by evaluating between-reader precision, readability, and differences in age estimates between structures.

Currently, there are no known studies that have evaluated the accuracy of age estimates from any hard structures for YLP (Phelps et al. 2017), and this is outside the scope of our study in Lake Cascade. However, sagittal otoliths have generally displayed high levels of precision (Robilland and Marsden 1996; Niewinski and Ferreri 1999; Vandergoot et al. 2008) and operculums (OPs) have been reported to be more precise than scales (Baker and McComish 1998) while requiring far less processing time (Isermann et al. 2003). For SMB, sagittal otoliths have been validated up to age-4 (Heidinger and Clodfelter 1987) and are among the most widely-used structures for ageing centrarchids (Maceina et al. 2007). For a similar species, the Largemouth Bass *Micropterus salmoides*, sagittal otoliths have been found to be more than 90% accurate between age-0 and -16 (Buckmeier and Howells 2003; Klein et al. 2017). OPs have been recommended for ageing SMB up to age-6 (Sotola et al. 2014). Lastly, whole view sagittal otoliths (WOs) are worth considering for ageing analysis as they require very little processing time (Isermann et al. 2003; Quist and Isermann 2017) compared to sectioned otoliths.

OBJECTIVES

1. Evaluate relative precision and bias of three lethal structures (i.e., SOs, WOs, OPs) for estimating ages of YLP and SMB.

METHODS

We collected YLP and SMB sagittal otoliths and OPs from five fish of each 10-mm total length group caught during the 2020 annual fall gill netting survey. OPs were removed using procedures outlined by Le Cren (1947), making cuts above and below the opercal plate. OPs were boiled for approximately three minute before being scrubbed clean of any remaining flesh with a brush. Sagittal otoliths were extracted using the “through-the-gills” method outlined by Schneidervin and Hubert (1986). Sagittal otoliths for each fish were viewed whole and sectioned. Whole otoliths were sanded then viewed through digitalized images taken from a dissection microscope (Leica Microsystems, Buffalo Grove, Illinois, USA) with reflected light. To prepare otoliths for sectioning, whole otoliths were mounted in bullet molds (Ted Pella, Inc., Redding, California, USA) using epoxy and cross-sectioned using an Isomet low-speed saw (Buehler Inc., Lake Bluff, Illinois, USA) to approximately 0.58-mm thickness following IDFG otolith sectioning protocol (Mamer, unpublished). Resulting cross-sections were viewed using a compound microscope and image analysis system (Leica Application Suite, Leica Microsystems, Buffalo Grove, Illinois, USA).

We followed methods outlined by Yates et al. 2016 to enumerate annuli. Annuli were enumerated on all structures by two experienced readers and two inexperienced readers. Experienced readers had estimated ages of many different species using multiple structures, while inexperienced readers had no prior ageing experience. Inexperienced readers were provided training by the experienced readers prior to estimating ages. Readers assigned a confidence level to each age estimate on a 0-3 scale (Fitzgerald et al. 1997). After ageing, both reader groups convened separately to agree on a single age estimate and confidence rating for each structure. Mean confidence levels were calculated for each reader group and structure, however all structures that had an age estimate with a confidence of zero were removed from further evaluations.

Exact and within-1 year percent agreement rates between reader groups were calculated across age estimates for each structure to assess precision. Additionally, coefficient of variation (CV) was calculated to evaluate between-reader precision:

$$CV_j = 100 * \frac{\sqrt{\sum_{i=1}^{R} \frac{\left(X_{ij} - X_j\right)^2}{R-1}}}{X_j}$$

where X_{ij} is the ith age estimated for the jth fish, X_j is the mean age of the jth fish, and R is the number of times an age was estimated for each fish. A CV was calculated for every fish of each structure and then averaged across all fish for each structure. Experienced reader age estimates for SOs were plotted against those for OPs and WOs to create structure-bias plots and evaluate relative bias.

Pairwise Wilcoxon rank-sum tests were conducted to evaluate differences in estimates between structures, and lengths-at-age were back-calculated for YLP and SMB based on SOs age estimates from experienced readers. Back-calculated lengths-at-ages (BCLAA) were estimated using the Fraser-Lee method:

$$L_i = ((L_c - a)/S_c)\, S_i + a$$

where L_i is the back-calculated length of the fish when the ith increment was formed, L_c is the length of the fish at capture, S_i is the radius of the hard structure at the ith increment, and S_c is the radius of the hard structure at capture (Ricker 1975; Quist et al. 2012).

For both species, a von Bertalanffy (VB) growth function was used to estimate growth and verify back-calculated age estimates,

$$L_t = L_\infty\left[1 - e^{-K(t-t_0)}\right]$$

where L_t is the mean length at age of capture, L_∞ 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).

RESULTS

Yellow Perch

Ages were estimated for 143 YLP ranging from 144 to 396 mm (mean = 275 mm). YLP in Lake Cascade, ID are extraordinarily long-lived – reaching ages up to 16 years old. Age estimates ranged from 2 to 16 for SOs, 2 to 15 for OPs, and 2 to 14 for WOs. Highest exact between-reader agreement was tied between SOs and OPs (47%) and lowest for WOs (42%; Table 1). Percent agreement within-1 year nearly doubled for each structure and was highest for OPs (Table 12). CV was lowest for SOs and highest for WOs. Mean reader confidence was highest with OPs.

Age-bias plots showed higher agreement between readers for SOs and OPs but lower agreement for WOs (Figures 24, 25, and 26). Structure-bias plots suggested that age estimates from OPs and WOs were significantly lower than those from sectioned otoliths (P < 0.001, P < 0.001; Figures 30 and 31). Mean BCLAA of age-0 YLP was 50 mm, which aligns with mean lengths of known age-0 YLP collected during an October 2020 otter trawl survey (see Lake Cascade Juvenile Perch Trawling chapter for more detail).

Smallmouth Bass

Ages were estimated from 74 Smallmouth Bass between 268 and 490 mm (mean = 370 mm). Similar to YLP, the SMB in Lake Cascade are extremely long-lived – up to 21 years old. Age estimates ranged from 3 to 21 for SOs, 2 to 17 for OPs, and 4 to 12 for WOs. Unlike YLP, exact between-reader agreement was much lower for SOs (32%) and WOs (32%) than OPs (63%; Table 12). However, within-1 year reader agreement were similarly high for OPs (90%)

and SOs (86%), compared to WOs (57%). CV was lowest and mean confidence was highest for OPs (Table 12).

Similar to YLP, age-bias plots showed higher agreement between readers for SOs and OPs, but very low agreement for WOs (Figures 27, 28, and 29). Structure-bias plots showed that age estimates from OPs were significantly lower than SO estimates ($P < 0.001$; Figure 32). Whereas age estimates from WOs were not significantly different than SOs ($P = 0.67$), but highly variable (Figure 33). Mean BCLAA of age-0 SMB was 248 mm, which is unrealistically high, suggesting that SOs also underestimated ages of SMB in this study.

DISCUSSION

For both species, WOs were the least precise and readable structure evaluated (Table 12). Since our gill net surveys generally select for larger and older fishes of either species, the thickness of the WOs in this study likely made distinguishing annuli more difficult (Quist and Isermann 2017). In addition to thickness, the use of digitalized images may have also hindered our ability to detect annuli along the curved, outer edges of WOs. Based on these results, we do not recommend using WOs to estimate ages of YLP and SMB in Lake Cascade moving forward.

In our study, OPs displayed the highest between-reader agreement rates and readability (Table 12), indicating high precision in estimates between inexperienced and experienced reader groups. This was encouraging, since OPs require far less processing time than SOs. However, when differences in age estimates were compared to SOs, we found that they were consistently lower than SO ages by one or more years (Figures 30 and 31). To determine if ages were also underestimated by SOs, we back-calculated mean length-at-ages and our estimate of mean length for age-0 YLP aligned closely with mean lengths of age-0 YLP collected with bottom trawl surveys in October 2020 (Figure 34). This provides some evidence that ages obtained from SOs are likely the most accurate, and OPs underestimated ages of YLP compared to SOs. Therefore, we do not recommend the use of OPs in future ageing studies in Lake Cascade.

For Smallmouth Bass, OPs also appeared to underestimate ages compared to SOs. However, we found that mean BCLAA of age-0 SMB with SOs was unrealistically high, and therefore SOs also underestimated ages in our study (Figure 35). This could be attributed to our gill net survey selecting for predominately very large and old SMB, with very few SMB collected under 250 mm. Therefore, future evaluations of age structure of SMB in Lake Cascade should incorporate other sampling methodologies to collect younger, smaller fish to verify age estimates.

MANAGEMENT RECOMMENDATIONS

1. Use SOs to estimate age and growth of YLP and SMB in Lake Cascade periodically from specimens collected during annual gill netting surveys.

2. Explore different sampling methodologies (e.g., tournaments, electrofishing) for collecting smaller-bodied SMB.

Table 12. Age estimate precision and readability by species and structure from samples collected in Lake Cascade, Idaho in 2020. Precision metrics are exact (PA) and within-1 year (PA-1) percent agreement between experienced and inexperienced reader groups. Coefficient of variation (CV) is provided for experienced reader group estimates. Readability is expressed as mean experienced reader confidence.

Species	Structure	PA	PA-1	CV	Conf.
Yellow Perch	Sectioned Otolith	47	86	8	1.8
	Whole View Otolith	42	80	12	1.6
	Operculum	47	90	10	2.0
Smallmouth Bass	Sectioned Otolith	32	86	9	1.6
	Whole View Otolith	32	57	16	1.0
	Operculum	63	90	7	2.0

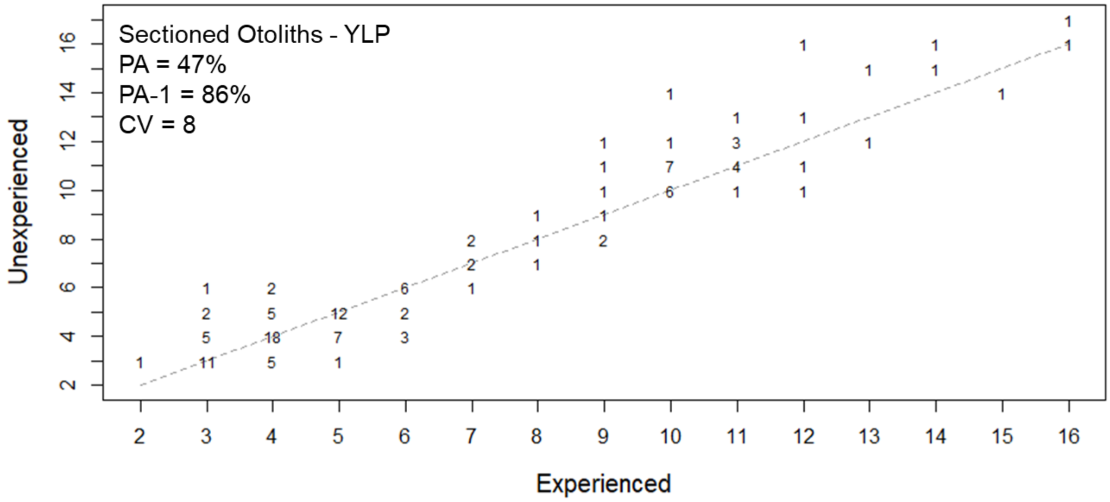

Figure 24. Age-bias plot of age estimates assigned to sectioned otoliths from Yellow Perch sampled from Lake Cascade, Idaho in 2020 (*n* = 134). Precision between experienced and inexperienced readers is expressed in exact (PA) and within-1 year (PA-1) agreement and coefficient of variation (CV). Diagonal line represents a reference 1:1 agreement between readers. Numbers represent number of observations.

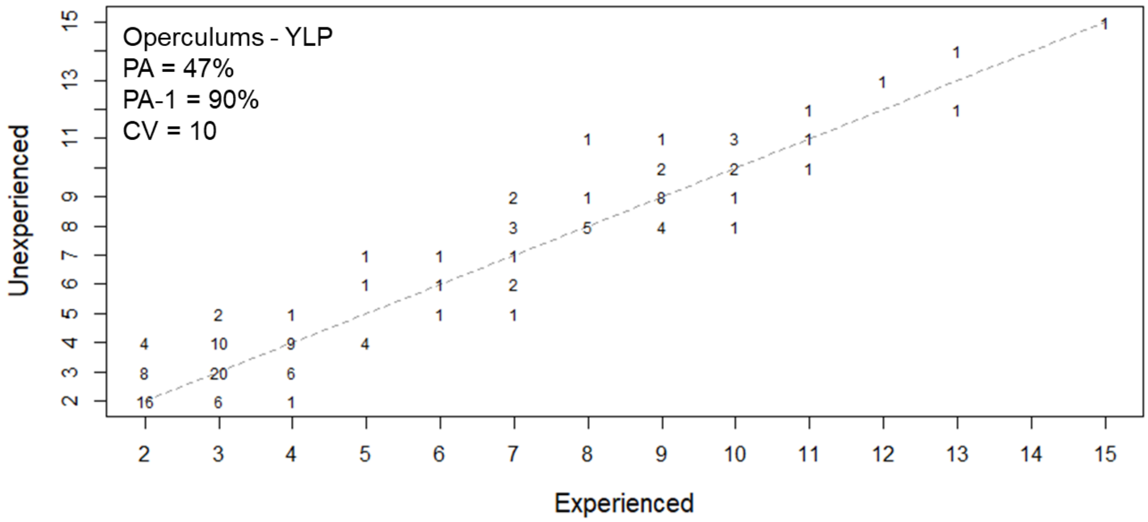

Figure 25. Age-bias plot of age estimates assigned to operculums from Yellow Perch sampled from Lake Cascade, Idaho in 2020 (n = 139). Precision between experienced and inexperienced readers is expressed in exact (PA) and within-1 year (PA-1) agreement and coefficient of variation (CV). Diagonal line represents a reference 1:1 agreement between readers. Numbers represent number of observations.

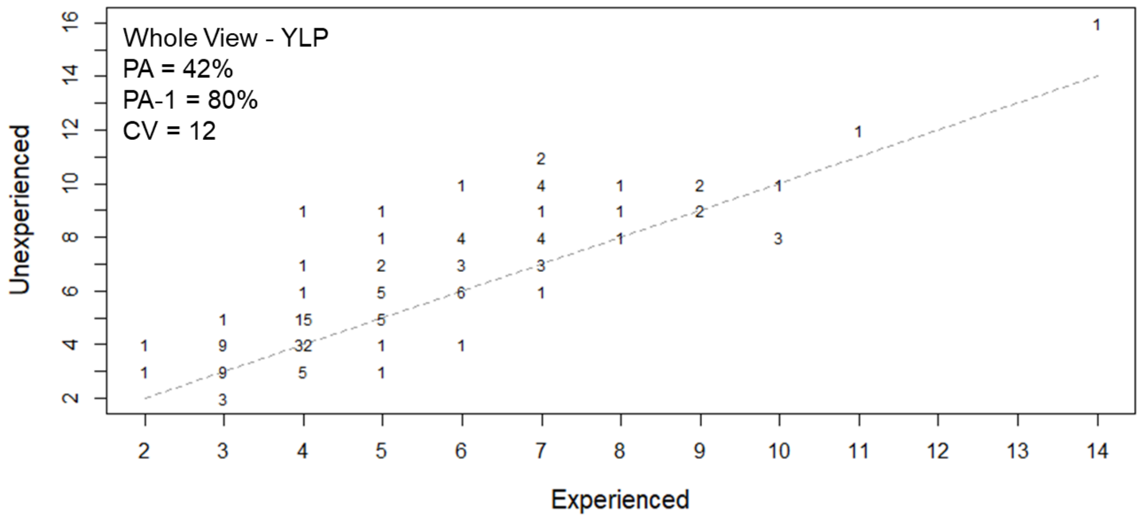

Figure 26. Age-bias plot of age estimates assigned to whole view otoliths from Yellow Perch sampled from Lake Cascade, Idaho in 2020 (*n* = 143). Precision between experienced and inexperienced readers is expressed in exact (PA) and within-1 year (PA-1) agreement and coefficient of variation (CV). Diagonal line represents a reference 1:1 agreement between readers. Numbers represent number of observations.

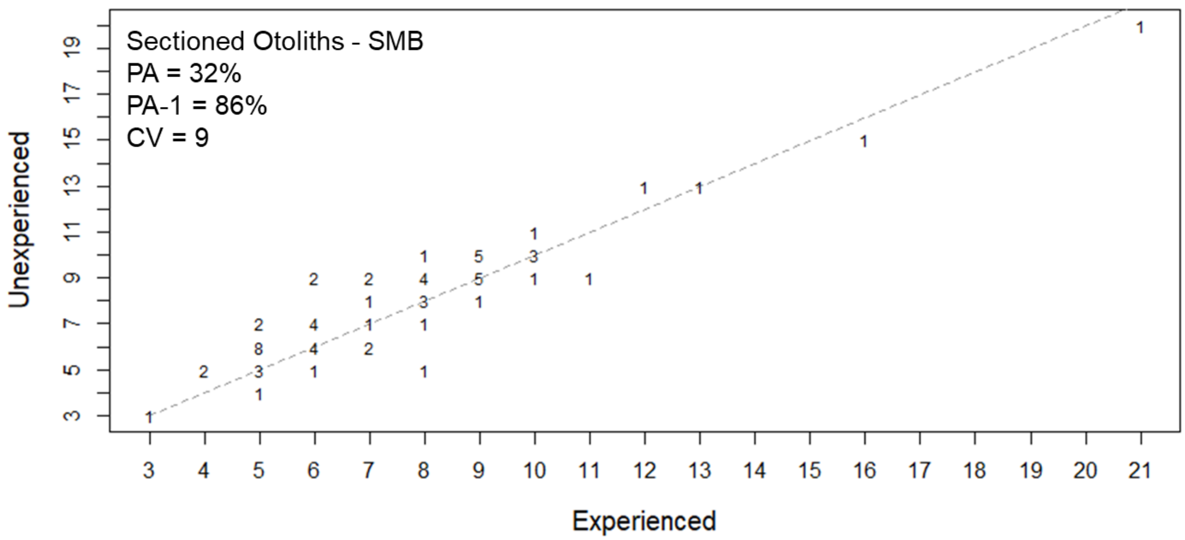

Figure 27. Age-bias plot of age estimates assigned to sectioned otoliths from Smallmouth Bass sampled from Lake Cascade, Idaho in 2020 (*n* = 69). Precision between experienced and inexperienced readers is expressed in exact (PA) and within-1 year (PA-1) agreement and coefficient of variation (CV). Diagonal line represents a reference 1:1 agreement between readers. Numbers represent number of observations.

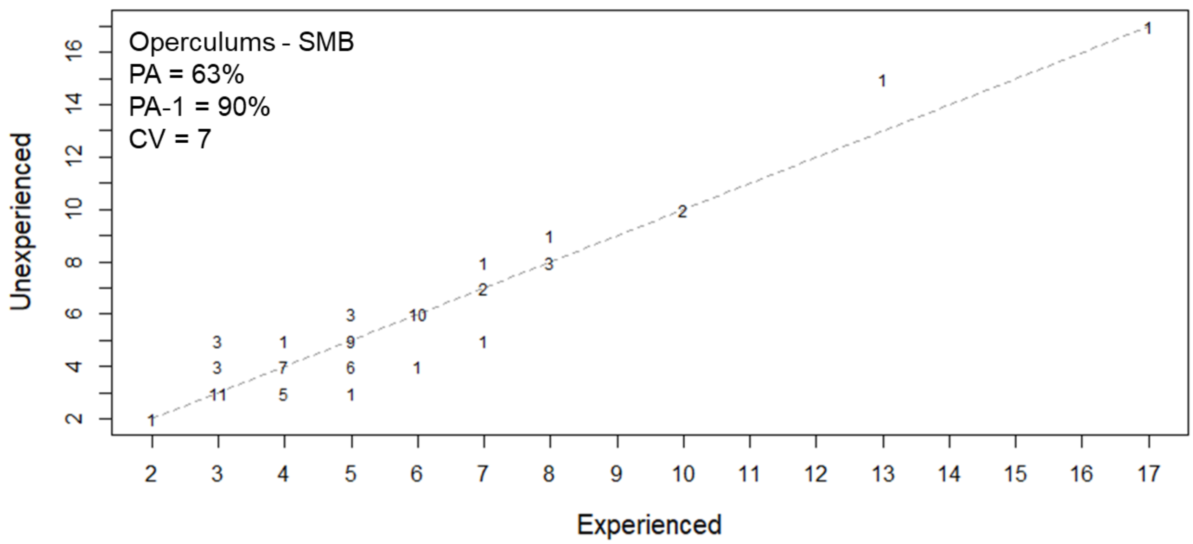

Figure 28. Age-bias plot of age estimates assigned to operculums from Smallmouth Bass sampled from Lake Cascade, Idaho in 2020 (*n* = 73). Precision between experienced and inexperienced readers is expressed in exact (PA) and within-1 year (PA-1) agreement and coefficient of variation (CV). Diagonal line represents a reference 1:1 agreement between readers. Numbers represent number of observations.

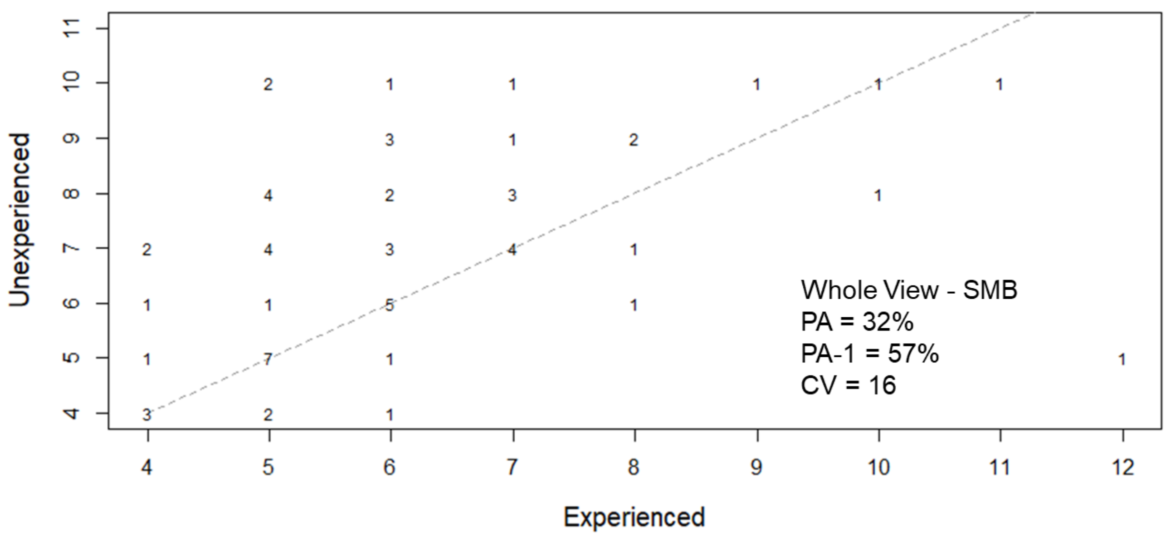

Figure 29. Age-bias plot of age estimates assigned to whole view otoliths from Smallmouth Bass sampled from Lake Cascade, Idaho in 2020 (*n* = 74). Precision between experienced and inexperienced readers is expressed in exact (PA) and within-1 year (PA-1) agreement and coefficient of variation (CV). Diagonal line represents a reference 1:1 agreement between readers. Numbers represent number of observations.

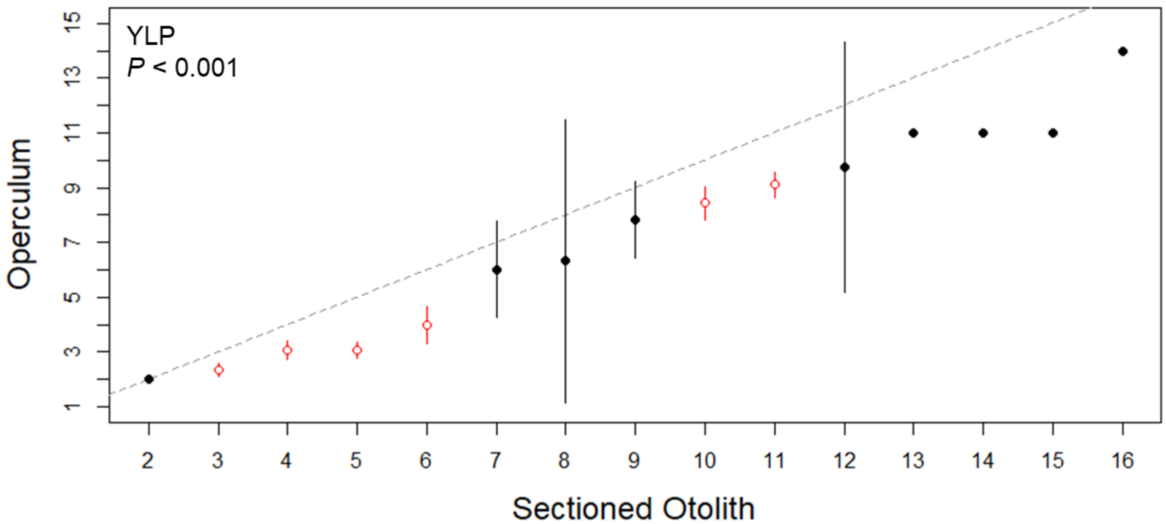

Figure 30. Structure-bias plot for ages estimated by experienced readers using operculums and sectioned otoliths from Yellow Perch (n = 128) collected in Lake Cascade in 2020. Error bars represent 95% confidence intervals and red denotes age estimates that do not overlap the 1:1 reference (agreement) line. Age estimates from operculums were significantly lower than sectioned otolith estimates (P < 0.001).

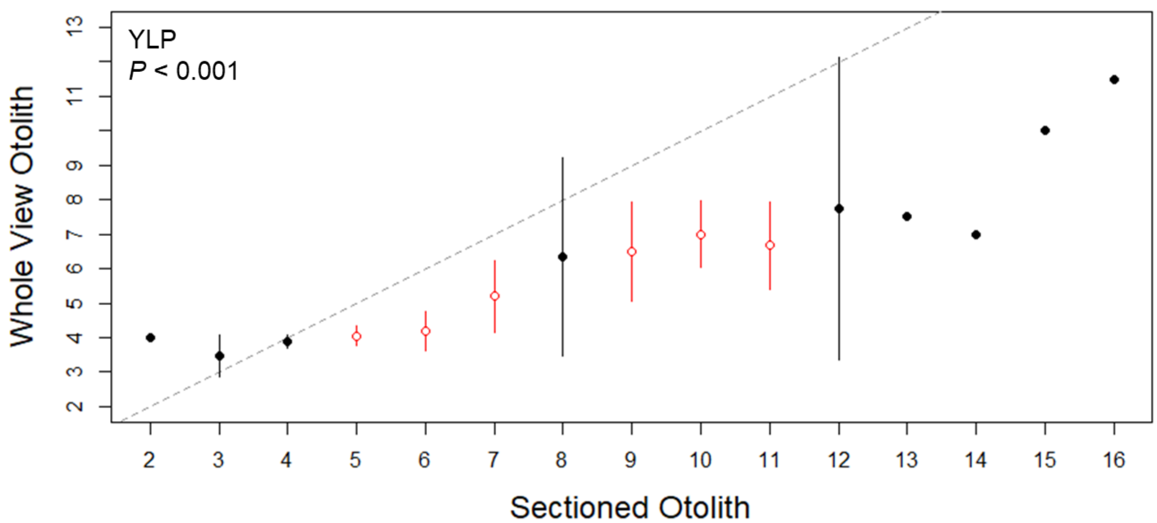

Figure 31. Structure-bias plot for ages estimated by experienced readers using whole view otoliths and sectioned otoliths from Yellow Perch (n = 124) collected in Lake Cascade, Idaho in 2020. Error bars represent 95% confidence intervals and hollow circles denote age estimates that do not overlap the 1:1 reference (agreement) line. Age estimates from operculums were significantly lower than sectioned otolith estimates (P < 0.001).

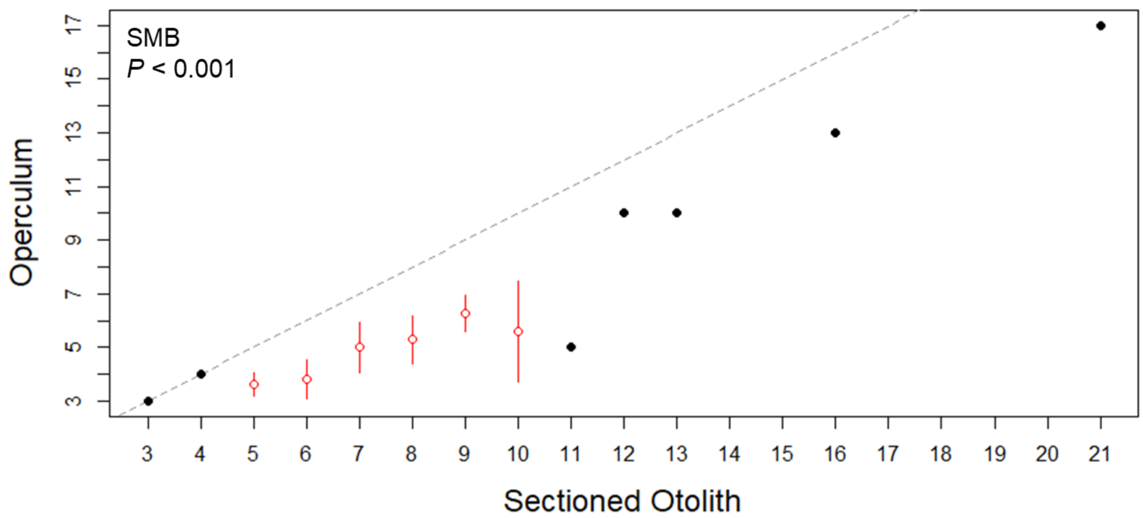

Figure 32. Structure-bias plot for ages estimated by experienced readers using operculums and sectioned otoliths from Smallmouth Bass (n = 65). Error bars represent 95% confidence intervals and hollow circles denote age estimates that do not overlap the 1:1 reference (agreement) line. Age estimates from operculums were significantly lower than sectioned otolith estimates (P < 0.001).

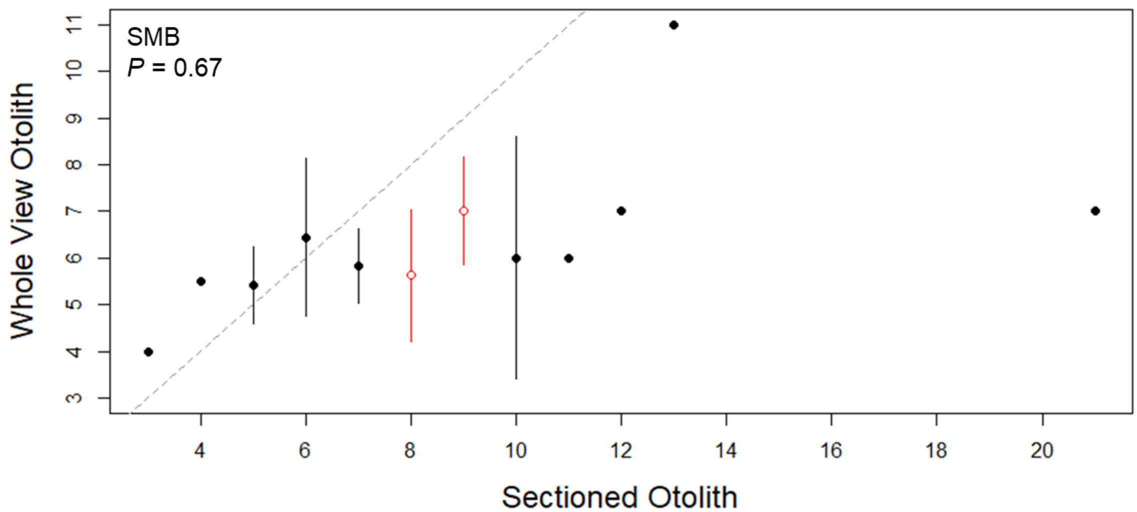

Figure 33. Structure-bias plot for ages estimated by experienced readers using whole view otoliths and sectioned otoliths from Smallmouth Bass (n = 55). Error bars represent 95% confidence intervals and hollow circles denote age estimates that do not overlap the 1:1 reference (agreement) line. Age estimates from operculums were not significantly different than sectioned otolith estimates (P = 0.67).

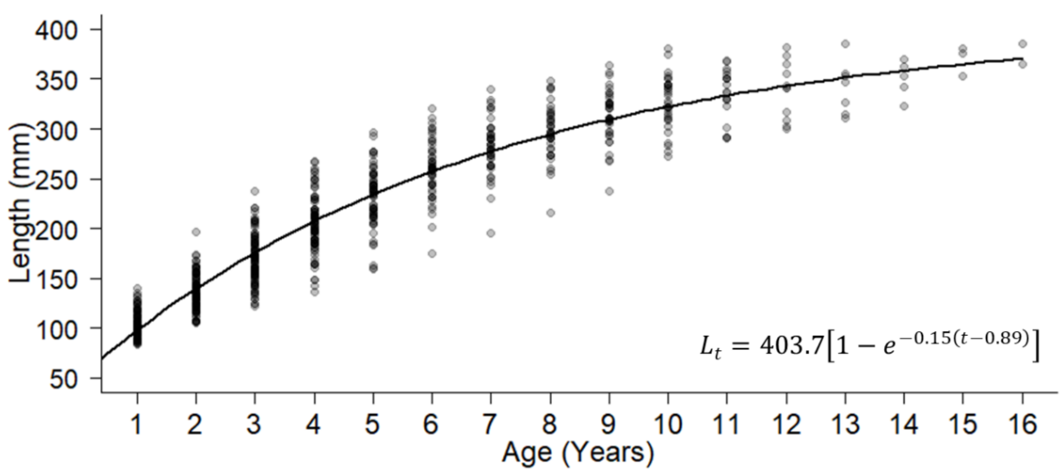

Figure 34. Von Bertalanffy growth curve for Yellow Perch (n = 134) collected in Lake Cascade, Idaho in October 2020. Curve is plotted against mean back-calculated length-at-age based on age estimates obtained from sectioned sagittal otoliths. Growth parameters shown in lower-right of plot.

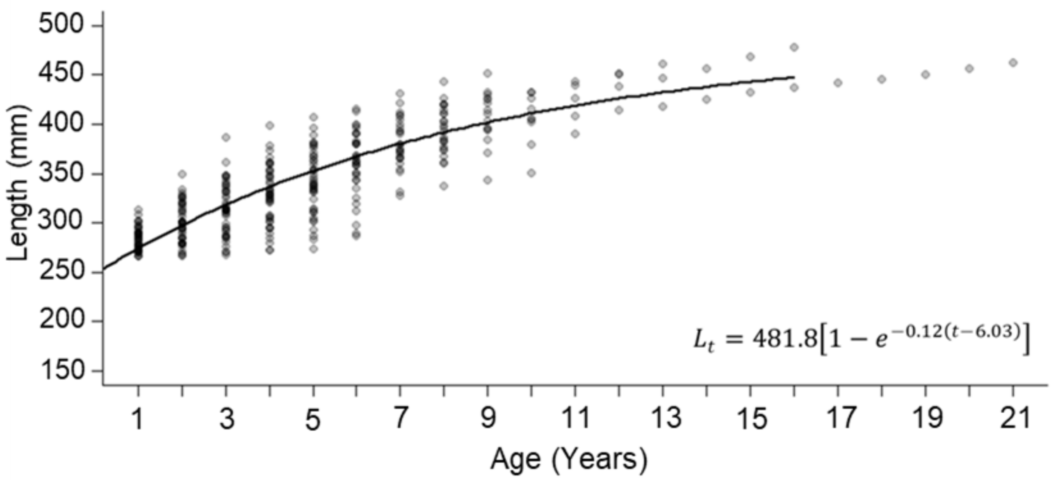

Figure 35. Von Bertalanffy growth curve for Smallmouth Bass (n = 69) collected in Lake Cascade, Idaho in October 2020. Curve is plotted against mean back-calculated length-at-age based on age estimates obtained from sectioned sagittal otoliths. Growth parameters shown in lower-right of plot.

LAKE CASCADE ANNUAL FALL GILL NETTING SURVEY

ABSTRACT

A gill netting survey is conducted annually in Lake Cascade each October to monitor changes in abundance and size structure of the fish community. In 2020, we collected 1,030 fish of 11 species. Yellow Perch (YLP) *Perca flavescens* comprised 28.5% of the catch (*n* = 294), Smallmouth Bass *Micropterus dolomeiu* comprised 9.8% of the catch (*n* = 101), and Rainbow Trout *Oncorhynchus mykiss* comprised 3.3% of the catch (*n* = 34). Northern Pikeminnow *Ptychocheilus oregonensis*, Largescale Sucker *Catostomus macrocheilus*, and Black Bullhead *Ameiurus melas* comprised 16.1% (*n* = 166), 22.4% (*n* = 231), and 15.1% (*n* = 156) of the catch, respectively. Relatively few Mountain Whitefish *Prosopium williamsoni* (*n* = 23, 2.2%), kokanee salmon *Oncorhynchus nerka* (*n* = 14, 1.2%), Pumpkinseed *Lepomis gibbosus* (*n* = 10, 1%), and Largemouth Bass *Micropterus salmoides* (*n* = 1, 0.1%) were collected. YLP catch per site in 2020 was higher than the previous three years (CPUE = 20 ± 6) with a mean = 11; SD± 5 per site greater than 250 mm TL. Mean catch per site of NPM was lower than 2018 and 2019 (CPUE = 11 ± 3) with an average of 5 ± 2 greater than 350 mm.

Authors:

Mike Thomas,
Regional Fisheries Biologist

Jordan Messner,
Regional Fisheries Manager

INTRODUCTION

Lake Cascade is a very popular and economically important recreational fishery in Idaho. Gill netting surveys are currently 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, 2020. Each site was sampled once with paired (i.e., one floating and one sinking) IDFG standard experimental gill nets (i.e., 46 m x 2 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; ± 90% confidence intervals) was calculated to compare relative abundance between years. Significant differences in CPUE between years were indicated when 90% confidence intervals did not overlap.

All fish were identified by 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 mm, quality length = 200 mm) and Smallmouth Bass (SMB) *Micropterus dolomieu* (stock length = 180 mm, quality length = 300mm) were calculated to summarize and compare size structure between years (Gabelhouse 1984; Neumann et al. 2012). Relative weight (W_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).

We collected YLP sagittal otoliths from five fish of each 10-mm length group (see Lake Cascade Ageing Study chapter in this report). Age frequencies, catch curves, and growth models were developed to evaluate population dynamics of both YLP and SMB. A von Bertalanffy growth function was used to estimate growth,

$$L_t = L_\infty\left[1 - e^{-K(t-t_0)}\right]$$

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; FSA package, Ogle et al. 2021; R Development Core Team 2020).

RESULTS

We caught a total of 1,030 fish of 11 species in Lake Cascade during the 2020 annual survey. YLP comprised 28.5% of the catch (*n* = 294), SMB comprised 9.8% of the catch (*n* = 101), and Rainbow Trout (RBT) *Oncorhynchus mykiss* comprised 3.3% of the catch (*n* = 34). Northern Pikeminnow (NPM) *Ptychocheilus oregonensis*, Largescale Sucker *Catostomus macrocheilus*, and Black Bullhead *Ameiurus melas* comprised 16.1% (*n* = 166), 22.4% (*n* = 231), and 15.1% (*n* = 156) of the catch, respectively. Relatively few Mountain Whitefish *Prosopium williamsoni* (*n* = 23, 2.2%), kokanee salmon *Oncorhynchus nerka* (*n* = 14, 1.2%), Pumpkinseed *Lepomis gibbosus* (*n* = 10, 1%), and Largemouth Bass *Micropterus salmoides* (*n* = 1, 0.1%) were sampled (Table 13). Relative length-frequencies of all fish caught (except Pumpkinseed and Largemouth Bass) in 2020, by species, are shown in Figures 36 and 37.

Compared to 2019, mean CPUE (± 90% CI) for YLP increased in 2020 from 13 ± 4 to 20 ± 6 in and from 8 ± 3 to 11 ± 5 for YLP greater than 250 mm (Table 14). Overall, total catch, CPUE, and CPUE > 250 mm were the highest observed since 2016 (Figures 38 and 39). Mean length of YLP was 270 mm (max TL = 396 mm) and mean W_r was 87 (Table 13). PSD-Q was 88 and RSD-250, -300, and -380 were 57, 33, and 3, respectively (Table 15). Estimated ages of YLP ranged between 2 and 16, with a mean age of 6 (Table 16; Figure 40). The same age-length key (Table 16) was applied to YLP catch in 2017 (when abundance dropped significantly) and the mean estimated age was 8 years old, suggesting a recent shift in age-structure towards younger YLP. Mean length-at-age-at-capture for a 4 year old YLP was 205 mm and 342 mm for a 10 year old (Figure 41).

Overall CPUE (± 90% CI) for NPM in 2020 (11 ± 3) was lower than in 2019 (15 ± 6) although CPUE > 350 mm was similar (5 ± 2 vs. 4 ± 3, respectively; Table 14). In 2020, 44% of NPM caught (*n* = 73) were over 350 mm TL, an increase from the previous two years and similar to 2017. However, overall catch of NPM in 2020 was lower than in 2018 and 2019, and was the second lowest catch since the YLP Restoration Project (2004 – 2006; Figures 42 and 43). Mean length of NPM was 344 mm in 2020 (max TL = 586 mm; min TL = 180 mm; Table 13).

We collected 34 RBT in 2020, of which 22 appeared to be of natural origin (Table 17). These natural-origin RBT ranged in length from 176 to 572 mm, with a mean relative weight of 91 (Table 13; Figure 36). Hatchery RBT ranged in length from 323 to 585 mm, with a mean relative weight of 87 (Table 13; Figure 36). Nearly 95,000 catchable-sized hatchery-origin RBT were stocked in Lake Cascade in the spring of 2020. No fall catchables (> 150 mm) were stocked in 2020.

We collected 101 SMB in 2020 ranging between 268 and 490 mm (Table 13). Mean catch per site was 6.7 (± 4) and PSD, RSD-400, and RSD-480 were 91, 28, and 1, respectively (Table 18). Total catch of SMB was highest observed since 2015 (*n* = 142).

Black Bullhead mean catch per site decreased from 24.1 (± 19) in 2019 to 10.4 (± 12.8) in 2020, although this difference is not significant due to high variability in catch per site in 2020 (Table 13). In fact, 73% (*n* = 122) of all Black Bullhead captured were collected from a single site on the northern end of Lake Cascade. Mean catch per site of Largescale Sucker was stable at 15.4 ± 4.5 which did not increase from the 2019 catch (15.1 ± 4.2; Table 13).

DISCUSSION

The increase in YLP abundance in 2020 was primarily due to an increase in age-4 and -5 YLP (mean TL = 225 and 255 mm, respectively), and suggests that juvenile YLP (i.e., age 0 – 3) survival has increased in recent years at Lake Cascade. These results are encouraging, as we have observed a prolonged period of low recruitment for age-4 YLP in Lake Cascade, which has been concerning for sustainability of the fishery.

Boom-and-bust cycles have been documented in Lake Cascade YLP previously (Griswold and Bjornn 1989) and in many YLP populations across their native range (Forney 1971; Sanderson et al. 1999; Dembkowski et al. 2015). In 2000, YLP in Lake Cascade were virtually absent. NPM suppression efforts from 2004 to 2006 resulted in excellent survival rates of approximately 860,000 YLP stocked during that period. In 2008, the stocked cohorts produced a very strong year class of YOY (see trawling section of this report), which also survived well and were observed as the dominant year class (age-4) when standard gill net monitoring began in 2012. Since that time, juvenile perch survival to age-4 has been very low, and the fishery has been comprised mainly of large, older age classes of YLP.

Historically, reduced juvenile YLP survival in Lake Cascade was attributed to high rates of predation by NPM. Previous research on Lake Cascade (Bennett 2004) indicated that NPM predation on juvenile YLP and other sport fishes is a substantial threat to the status of the sport fishery (see Janssen et al. 2020). Therefore, we continually monitor NPM abundance and size structure in Cascade to determine when reduction efforts are warranted, based on objectives set forth in the IDFG Fisheries Management Plan. The current IDFG Fisheries Management Plan (2019 – 2024) specifies that adult NPM abundance should be aggressively reduced if mean CPUE of NPM greater than 350 mm reaches or exceeds 10, or the proportion of NPM caught greater than 350 mm reaches or exceeds 75% during fall-gillnetting (IDFG 2018). In 2020, mean CPUE of NPM greater than 350 mm was relatively stable at 5 ± 2, and less than half of the catch (44%) exceeded 350 mm TL, neither of which exceed the action thresholds outlined in our current management plan. While our current findings do not trigger implementation of NPM suppression as outlined in the FMP, more information is needed to better understand how the NPM population in Lake Cascade influences the quality of the sport fishery, and if a revision of the action thresholds in the FMP are warranted.

A variety of factors including prey availability, environmental conditions (Dembkowski et al. 2015), inter- and intra-specific competition and predation (Forney 1971; Sanderson et al. 1999), and angling mortality can influence YLP survival. Over the past several years, anglers have expressed concern about a perceived decline in catch rates of large YLP in Lake Cascade, which they attributed to overharvest. However, tagging studies since 2009 suggest exploitation is very low in Lake Cascade (7%) and total annual mortality estimated from catch curves in 2020 was 24% (Figure 44), which indicates that for each fish harvested by an angler, two are dying from natural causes. These data suggest that angling mortality has little influence on the observed cycles in abundance of YLP in Lake Cascade. Rather, these cycles are likely affected by inter- and intraspecific mechanisms that are currently poorly understood.

The intraspecific boom and bust patterns observed in most YLP fisheries typically occur on a 2- to 5-year cycle; however, in Lake Cascade, YLP are extraordinarily long-lived (i.e., 16 years old; Figures 40 and 41) which could prolong or exacerbate these cycles. When a strong year class of YLP reach age-4 in Lake Cascade, survival increases significantly (Figure 44) and intraspecific mechanisms may then occur for periods of 10 years or more (i.e. competition and predation). It is currently unclear how much influence cannibalism from large YLP (Forney 1971) or intraspecific competition with other juvenile YLP (Sanderson et al. 1999) has on the observed variability in juvenile YLP survival in Lake Cascade. Again, when standardized monitoring began in 2012, we observed a strong age-4 cohort entering the fishery with very little recruitment following behind (Figure 45). Then, in 2016 and 2017, abundance of large YLP dropped significantly (potentially ageing-out), which created favorable conditions that once again resulted in a relatively-strong cohort that we now observe entering the fishery at age-4 in 2020. These results suggest a level of YLP recruitment that has not been observed in Lake Cascade for a period of seven years (Figure 45).

In addition to species interactions within Lake Cascade, a suite of environmental variables may also affect survival of juvenile YLP; including water temperature (Power 1999), reservoir hydrology (Maceina and Stimpert 1998; Dembkowski et al. 2014), water quality, and climate (Ward et al. 2004; Dembkowski et al. 2016). To better understand these cycles in the Lake Cascade YLP population, a model should be developed that includes factors that could contribute to variability in YLP recruitment/survival. We also recommend implementing a new annual survey to evaluate trends in relative abundance and survival of juvenile YLP using mini-trap nets, cloverleaf traps, or micromesh gill nets. Prior to implementing this survey, a study should be conducted to compare the efficacy of these gears for sampling juvenile YLP in Lake Cascade.

RBT are an important component of the sport fishery in Lake Cascade. Unfortunately, gill net catch for hatchery RBT varies greatly from year to year, largely due to time of stocking relative to time of gill netting. In our 2020 survey, 65% of RBT appeared to be of natural origin. Currently, very little is known about these natural-origin RBT. These adfluvial fish make up a significant portion of this fishery (see Janssen et al. 2020), and further investigations should be conducted to learn more about if and how productivity can be increased. In the North Fork Payette River, Gold Fork River, and Lake Fork Creek, seasonal reductions in flow, increased water temperatures, unscreened irrigation diversions, and angling mortality could be influencing production. In the near future, fisheries managers should begin working with other stakeholders to address limitations and discuss methods for improving productivity, as it could greatly improve the quality of seasonal stream fisheries as well as the open-water and ice fishery in Lake Cascade. Snorkeling surveys should be conducted to develop trend sites for evaluating juvenile RBT production and mobile PIT-tag arrays should be installed to evaluate the timing of the spawning migration in Lake Cascade tributaries.

While bass are another important component of the sport fishery at Lake Cascade, low water conductivity (15-20 µS) 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.

MANAGEMENT RECOMMENDATIONS

1. Continue standard annual monitoring of the Lake Cascade fishery as a status index.

2. Implement repeatable creel survey methodology for Lake Cascade to study trends in angler dynamics over time in 2021.

3. Evaluate the efficacy of gear types for indexing abundance of age-1 through age-3 YLP.

4. Develop a plan to better understand adfluvial RBT productivity and limitations in Lake Cascade tributaries. Begin working with other stakeholders to address limitations and improve productivity.

5. Conduct snorkeling surveys in Lake Cascade tributaries to develop trend sites for evaluating juvenile RBT production.

6. Use mobile PIT-tag arrays to evaluate spawning migration timing of NPM and adfluvial RBT in the NFPR.

7. Evaluate feasibility of using bass tournaments and floating net pens to estimate exploitation of SMB in Lake Cascade.

Table 13. Total numbers of fish caught, relative weights (W_r), and total length (TL) by species collected with gill nets in Lake Cascade, Idaho in October 2020.

Species	**Total Catch**	**% of Catch**	**Mean W_r**	**Mean TL**	**Min TL**	**Max TL**
Yellow Perch	294	28.5	87	269.3	144	396
Northern Pikeminnow	166	16.1		344.4	180	586
Smallmouth Bass	101	9.8	94	371.7	268	490
Rainbow Trout (Natural)	22	2.1	91	430.7	176	572
Rainbow Trout (Hatchery)	12	1.2	87	424.7	323	585
Kokanee	14	1.4	84	421.6	364	461
Largemouth Bass	1	0.1	122 (1 fish)	426 (1 fish)		
Largescale Sucker	231	22.4		525.2	228	656
Mountain Whitefish	23	2.2	101	327.7	212	440
Pumpkinseed	10	1.0		144.6	99	184
Black Bullhead	156	15.1	85	257.9	173	364
Grand Total	1030					

Table 14. 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, Idaho in 1991, 2003, 2005, 2008 and annually in October from 2012 through 2020.

	Yellow Perch				Northern Pikeminnow				
Year	**Total Catch**	**mean CPUE**	**CPUE >250 mm**	**% > 250 mm**	**Total Catch**	**mean CPUE**	**Total Catch > 350 mm**	**CPUE > 350 mm**	**% > 350 mm**
1991[1]	1,361	109	--	60	795	31	673		85
2003[2]		1	0	--			651	10 sink/3 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 ± 11	18 ± 4	45	351	23 ± 10	110	7 ± 3	31
2013	739	49 ± 28	14 ± 23	28	213	14 ± 7	70	5 ± 2	33
2014	441	29 ± 10	19 ± 32	66	335	22 ± 10	122	8 ± 4	36
2015	465	31 ± 10	15 ± 6	47	275	18 ± 6	118	8 ± 4	43
2016	400	27 ± 8	17 ± 7	63	243	16 ± 6	58	4 ± 2	24
2017	188	13 ± 4	10 ± 5	58	139	9 ± 6	65	4 ± 2	47
2018	183	12 ± 3	7 ± 3	60	239	16 ± 6	64	4 ± 2	27
2019	194	13 ± 4	8 ± 3	59	227	15 ± 6	65	4 ± 3	29
2020	294	20 ± 6	11 ± 5	59	166	11 ± 3	73	5 ± 2	44

[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 2018).

Table 15. Proportional (PSD) and incremental Relative Stock Densities (RSD) for 250 , 300 and 380 mm Yellow Perch (total length) collected annually with gill nets in Lake Cascade, Idaho in October 2012 through 2020.

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

Table 16. Age-length key developed for Yellow Perch sampled at Lake Cascade, Idaho in 2020. Age estimates obtained from Yellow Perch (*n* = 133) were used to develop key. Includes estimated age in years, number of Yellow Perch assigned to each age category (*N)*, length (mm TL), and one standard error of the mean (SE).

Age	*N*	Length	SE
2	2	147	3.0
3	32	182	5.2
4	84	240	3.5
5	58	245	4.4
6	25	256	7.2
7	10	318	8.9
8	5	345	14.3
9	13	345	4.4
10	30	345	3.9
11	17	355	3.5
12	7	361	9.1
13	4	360	20.2
14	4	348	9.2
15	1	392	-
16	2	386	9.0

Table 17. Total catch, mean catch-per-unit-effort (CPUE), mean and range of total lengths of hatchery holdover (> 399 mm) and natural origin Rainbow Trout collected from Lake Cascade, ID annually during fall fish surveys (15 sites per year) in October 2014 through 2020.

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

Table 18. 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, Idaho annually from 2012 – 2020, during October gill netting.

Year	Total Catch	Mean CPUE	PSD	RSD-400	RSD-480
2012	64	5 ± 3	69	32	2
2013	38	3 ± 5	95	53	3
2014	67	5 ± 3	72	27	0
2015	142	10 ± 5	83	22	1
2016	65	4 ± 3	93	36	0
2017	41	3 ± 2	88	46	5
2018	59	4 ± 3	75	17	0
2019	80	5 ± 3	87	37	6
2020	101	7 ± 4	91	28	1

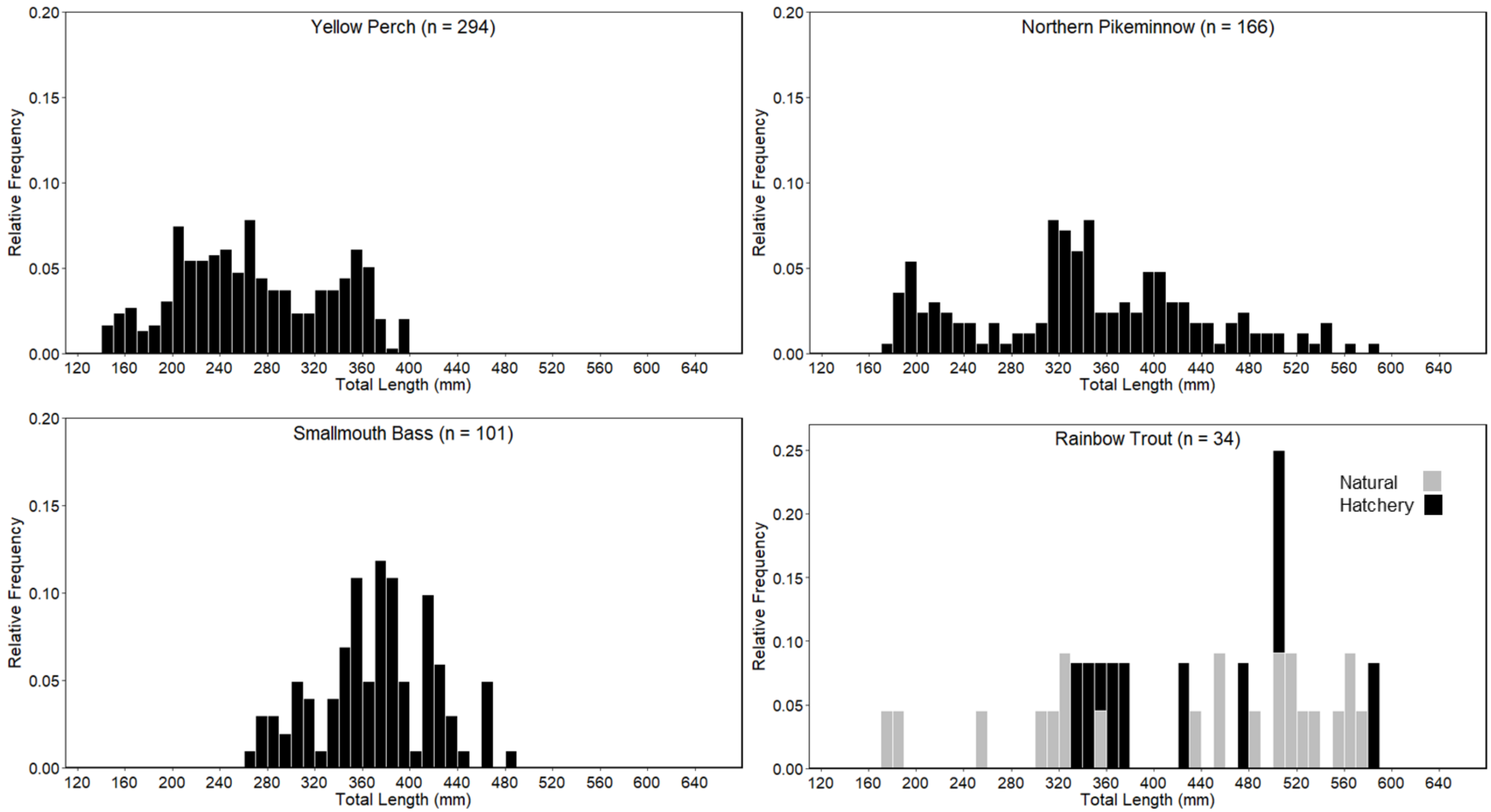

Figure 36. Relative length-frequency histograms of fish species collected during the 2020 gill net survey at Lake Cascade, Idaho.

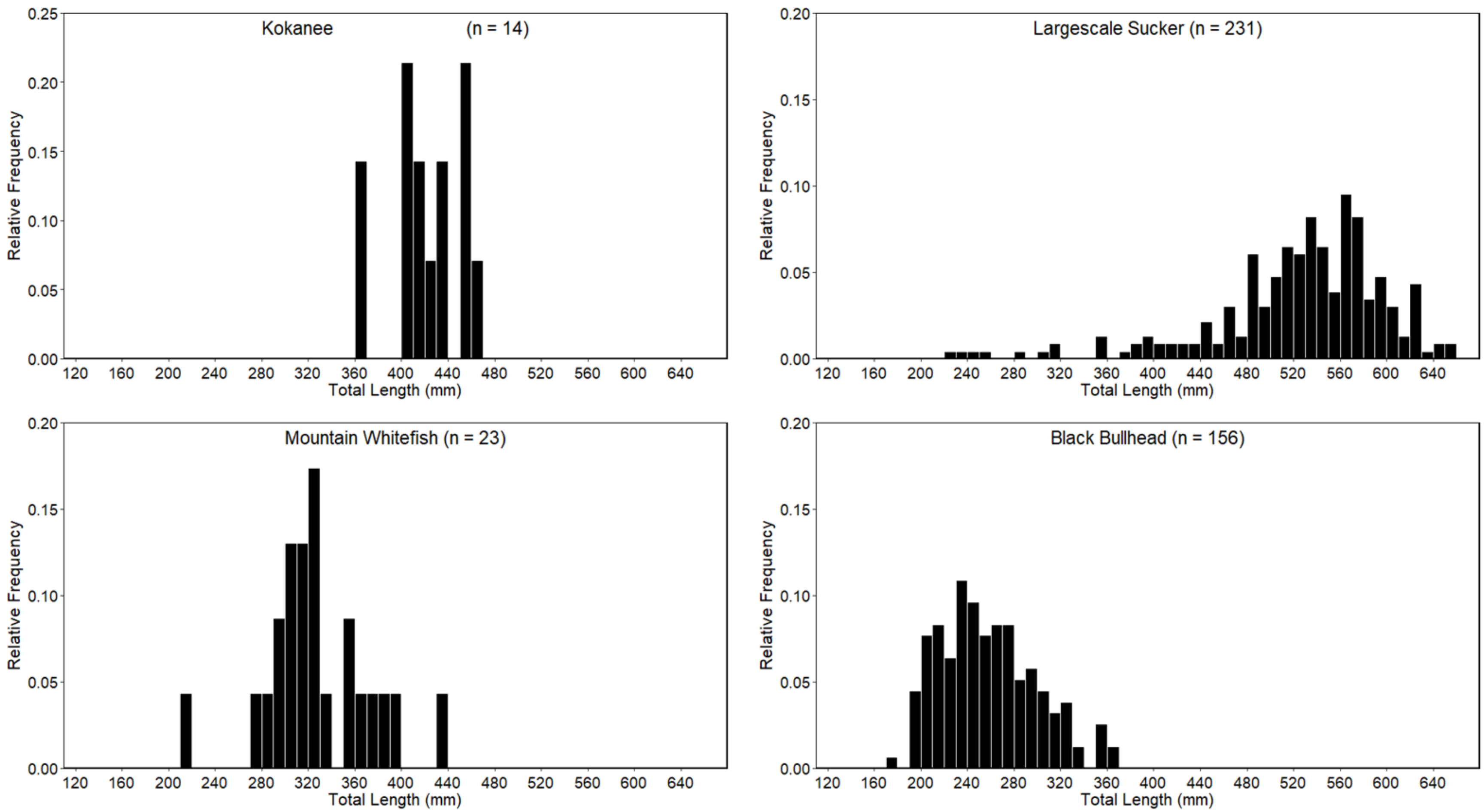

Figure 37. Cont'd. Relative length-frequency histograms of fish species collected during the 2020 gill net survey at Lake Cascade, Idaho.

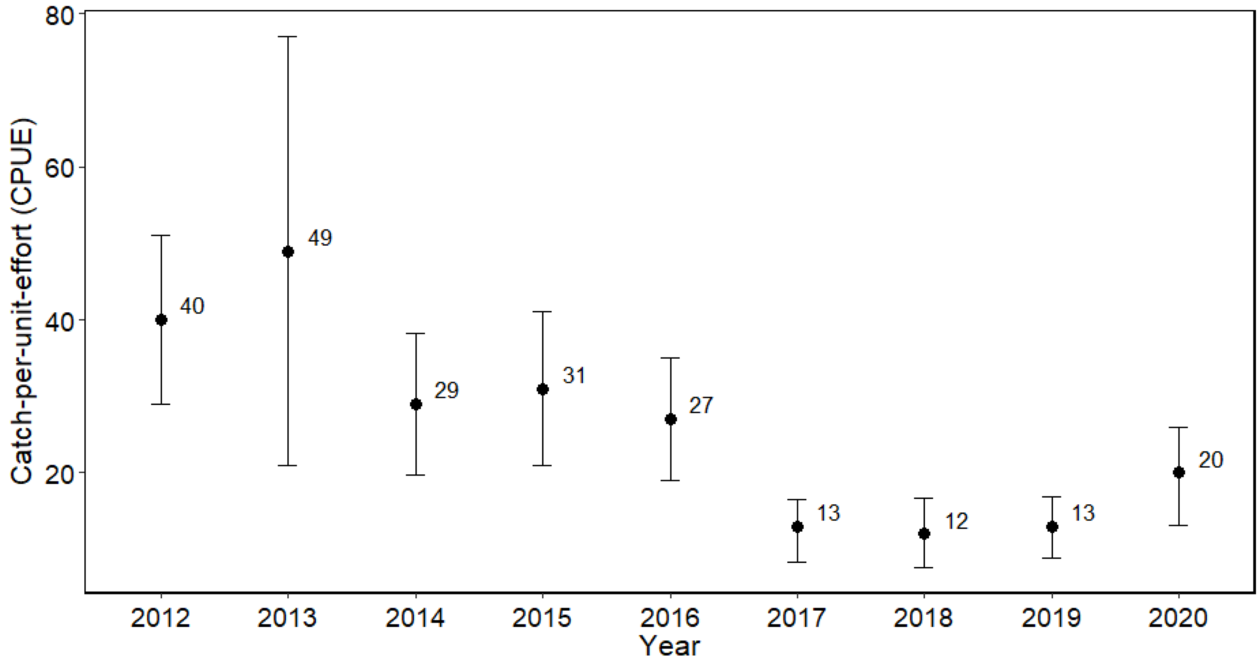

Figure 38. Mean catch-per-unit-effort (CPUE) with 90% confidence intervals for Yellow Perch collected with gill nets in Lake Cascade, Idaho annually from 2012 through 2020.

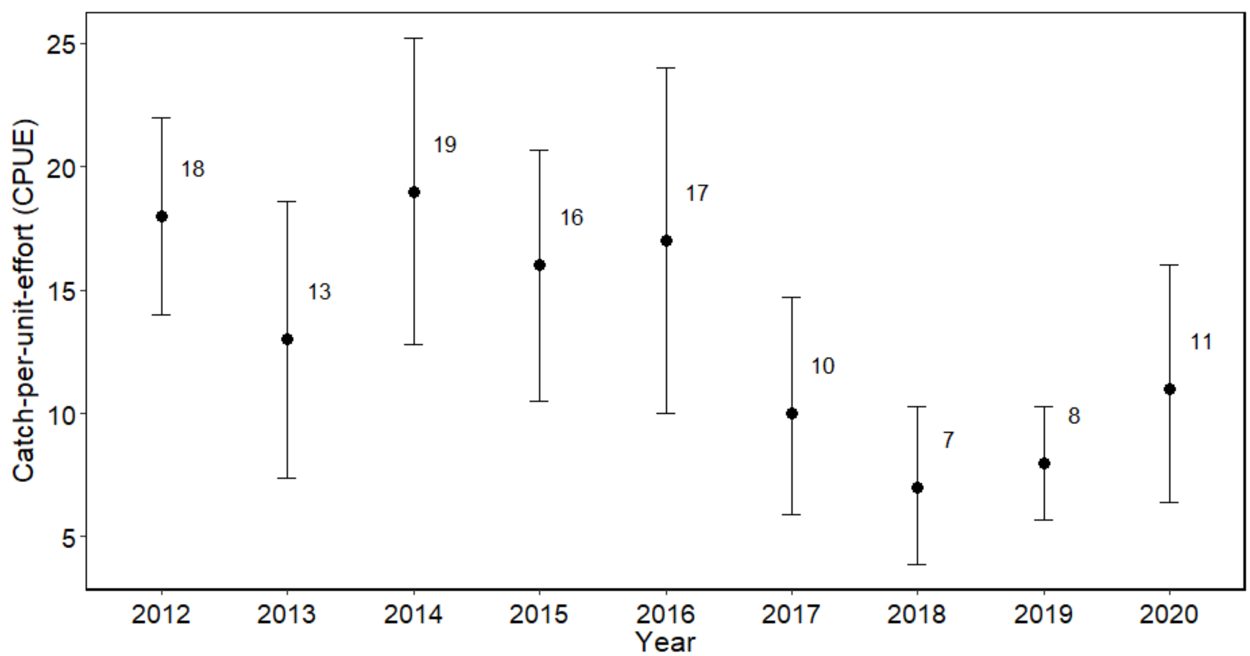

Figure 39. Mean catch-per-unit-effort (CPUE) with 90% confidence intervals for Yellow Perch greater than 250 mm total length collected with gill nets in Lake Cascade, Idaho from October 2012 through 2020.

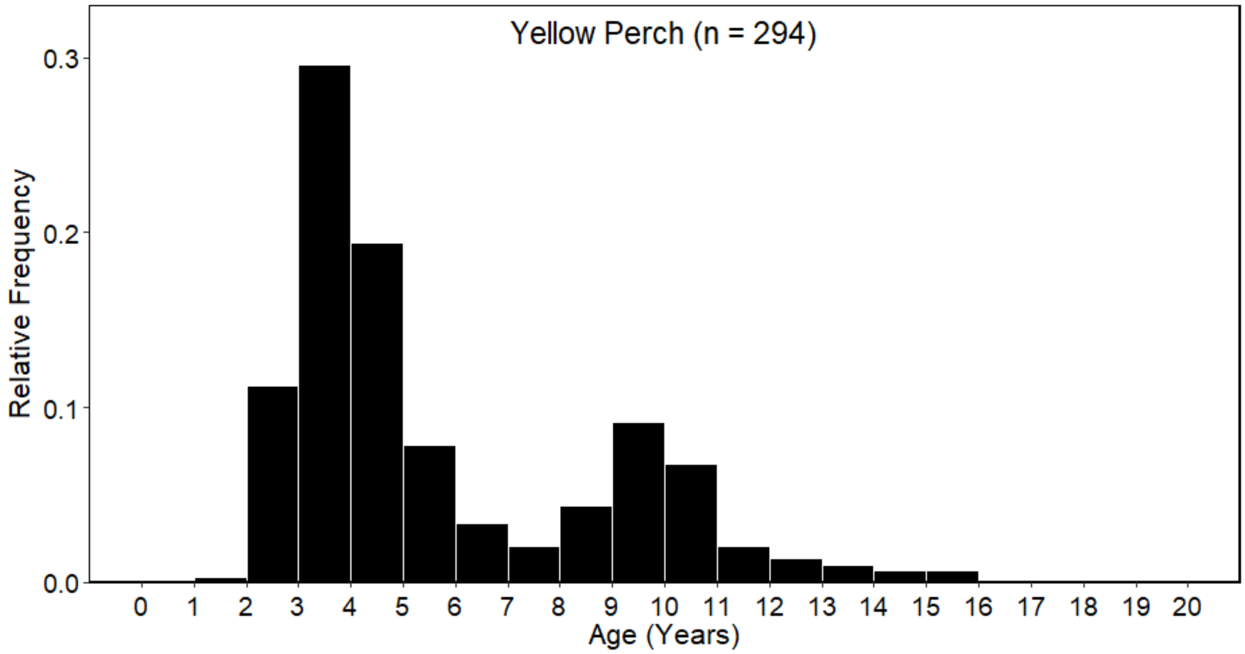

Figure 40. Estimated age-frequency histogram for Yellow Perch collected with gill nets at Lake Cascade, Idaho in 2020.

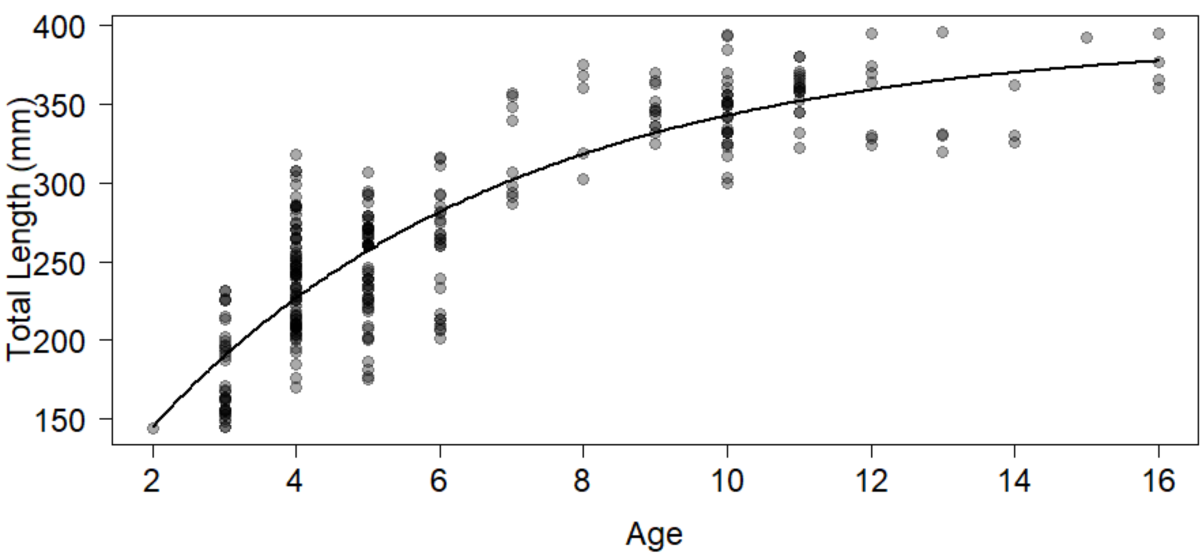

Figure 41. Von Bertalanffy growth curve for Yellow Perch in Lake Cascade, Idaho plotted against estimated length-at-age-at-capture data for all Yellow Perch collected in 2020.

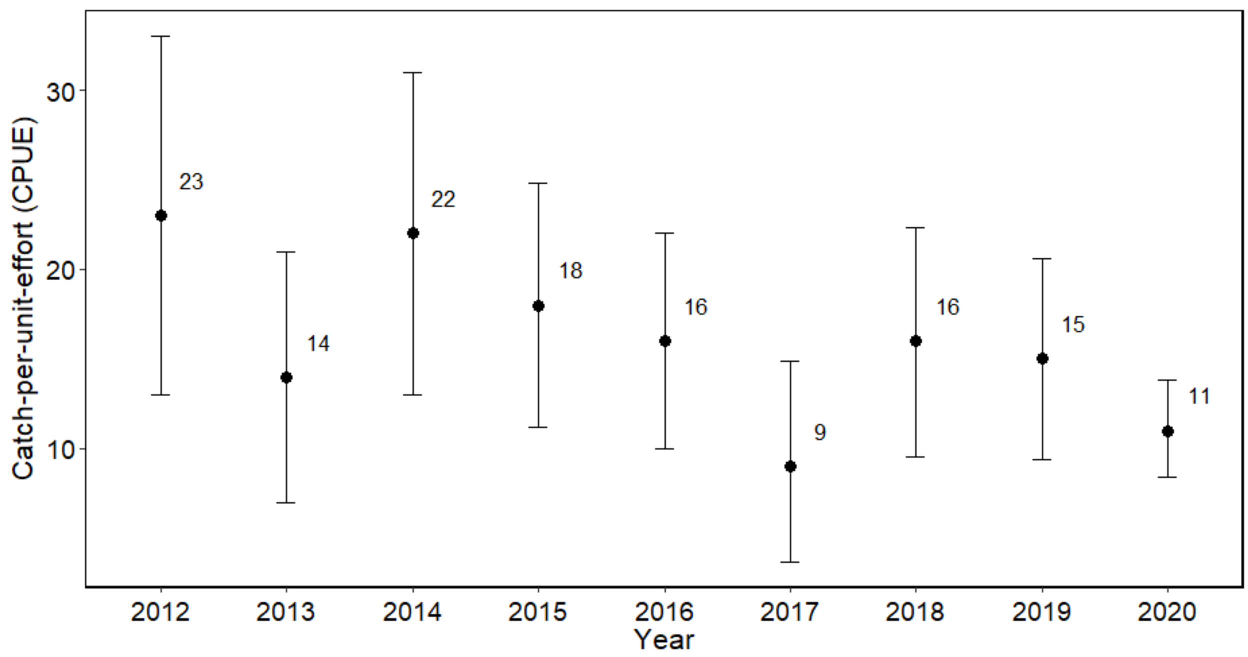

Figure 42. Mean catch-per-unit-effort (CPUE) with 90% confidence intervals for Northern Pikeminnow collected annually in October with gill nets in Lake Cascade, Idaho from 2012 through 2020.

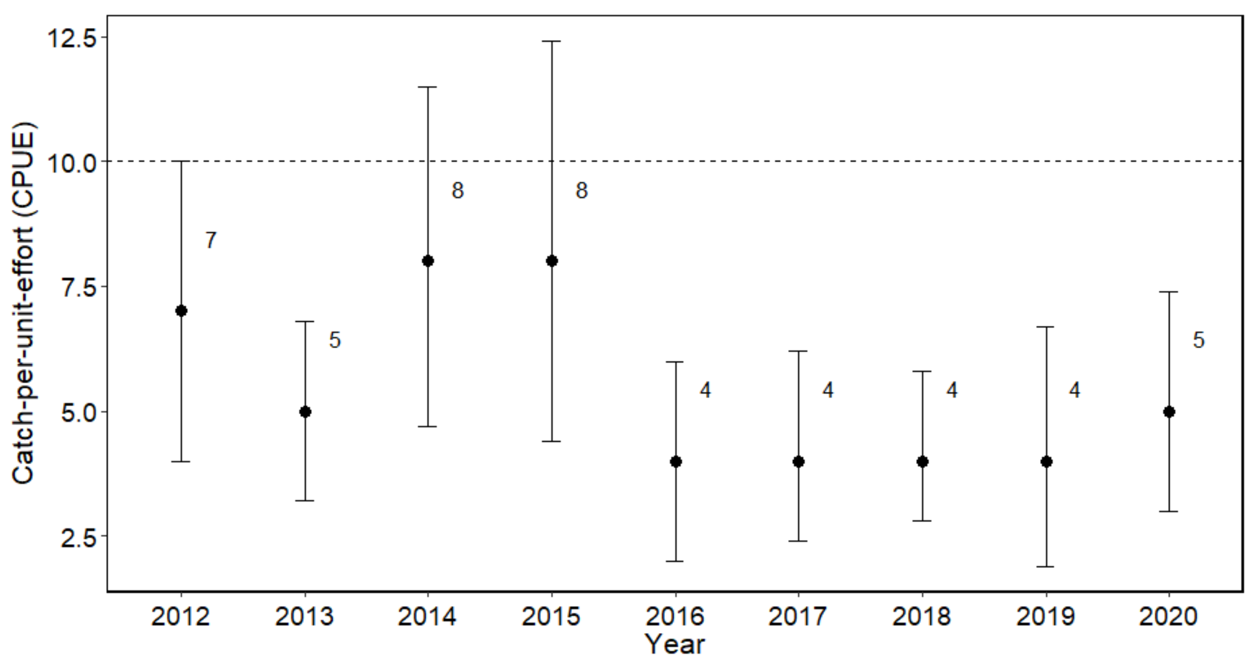

Figure 43. Mean catch-per-unit-effort (CPUE) with 90% confidence intervals for Northern Pikeminnow greater than 350 mm total length collected with gill nets in Lake Cascade, Idaho from October 2012 through 2020. Dashed line represents CPUE threshold outlined in the Fisheries Management Plan, which would trigger management intervention.

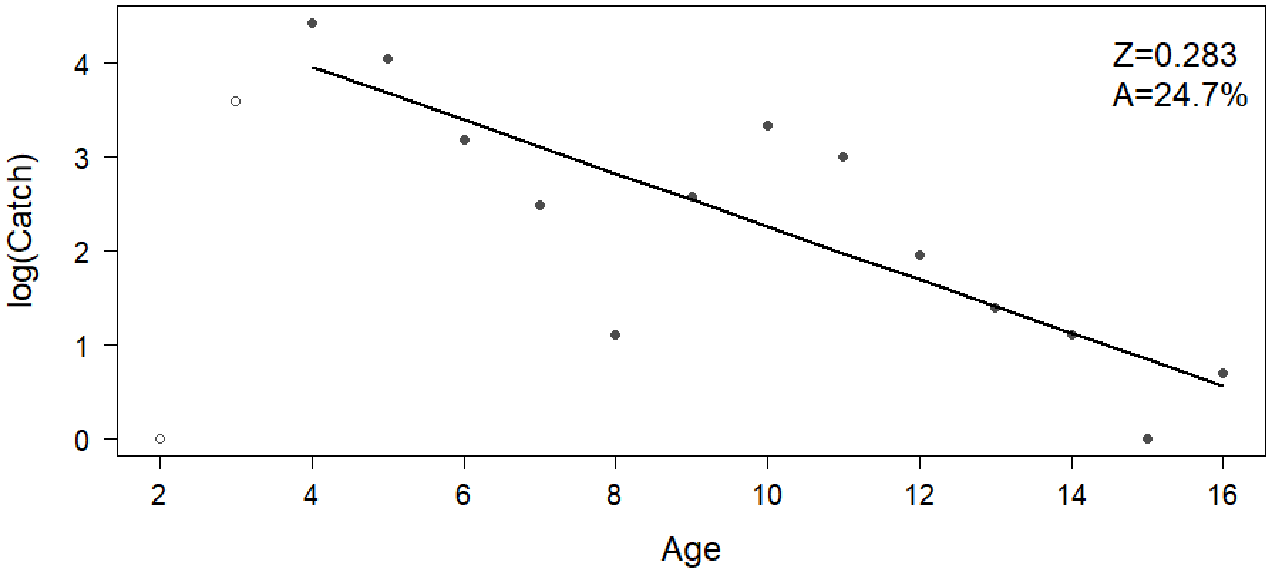

Figure 44. Natural log of catch at estimated ages for Yellow Perch collected in Lake Cascade, Idaho including a best-fit line to ages 4-16. Instantaneous total mortality rate (Z) and total annual mortality rate (A) estimated using weighted regression (catch curve) methods.

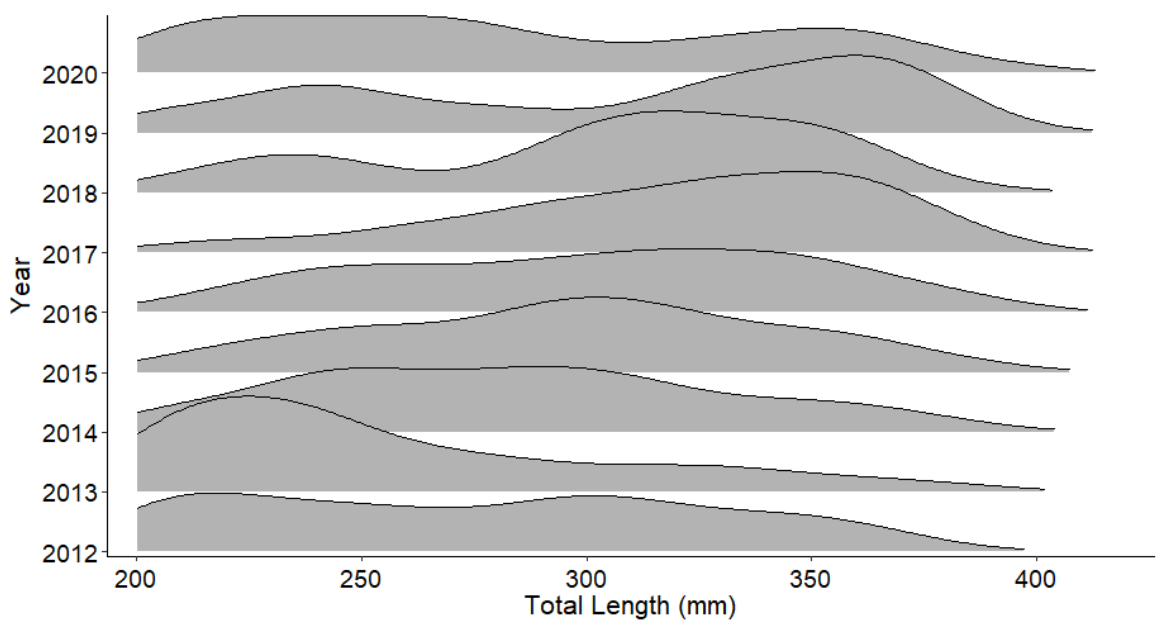

Figure 45. Smoothed relative-density histograms of Yellow Perch lengths collected with gill nets in Lake Cascade, Idaho from 2012 through 2020.

PAYETTE LAKE FISHERY RESTORATION EFFORTS

ABSTRACT

The primary objective in Payette Lake is to reduce Lake Trout *Salvelinus namaycush* abundance to a point at which kokanee salmon *Oncorynchus nerka* survival increases, resulting in increased kokanee abundance and higher Lake Trout body condition. Nearly 2,300 Lake Trout have been removed since suppression efforts began in 2014, most of which (n = 2,008) were removed in the last three years. In 2020, a total of 514 Lake Trout were removed during 5 months of netting. Gill net catch-per-unit-effort (CPUE) averaged 1.3 Lake Trout per net night, similar to 2019 (1.5) for mesh sizes used in both years and less than 2018 (CPUE = 5.2). Since 2018, mean relative weight has increased from 75 to 86. Recent observed changes in CPUE and relative weight suggests positive results from suppression efforts. In 2020, kokanee spawner abundance in the index transect of the North Fork Payette River was the second highest observed since 2009 (n = 1,862).

Authors:

Mike Thomas,
Regional Fisheries Biologist

Jordan Messner,
Regional Fisheries Manager

INTRODUCTION

Located in close proximity to downtown McCall, ID, Payette Lake is a popular waterbody for both recreational boaters and anglers. The current statewide Fisheries Management Plan (2019-2024; IDFG 2018) directs regional staff to reduce Lake Trout *Salvelinus namaycush* abundance through suppression gill netting, in order to improve kokanee salmon *Oncorhynchus nerka* survival. Since 2014, nearly 2,300 Lake Trout have been removed (*n* = 2,299). In that time period, relative abundance of Lake Trout has decreased and body condition has improved significantly (Janssen et al. 2020). These observations led the Idaho Department of Fish and Game (IDFG) to resume an annual stocking program of approximately 400,000 kokanee salmon fingerlings (< 150 mm) in 2020. The goal is to reduce Lake Trout abundance to a point at which kokanee survival increases to establish a balanced sport fishery. In 2020, we continued our suppression efforts and monitored changes in Lake Trout relative abundance, size structure, and body condition. We also continued to monitor the abundance of kokanee spawners in the North Fork Payette River.

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

OBJECTIVES

1. As per the statewide Fisheries Management Plan (2019-2024), reduce Lake Trout abundance through suppression gill netting.

2. Quantify changes in Lake Trout relative abundance, size structure, and body condition to determine effectiveness of suppression efforts.

3. Quantify kokanee spawner abundance in the North Fork Payette River above Payette Lake as an index of effectiveness of suppression efforts on Lake Trout.

METHODS

Gillnets used in 2020 were built by Hickey Brothers Research (Sturgeon Bay, WI). Nets were sinking-style, 91.5 m long, and were 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 with 91.5-m nets tied together. Netting sites were subjectively chosen to maximize catch efficiency and were dispersed throughout the southwest basin, southeast basin, and the narrows. 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 91.5-m nets fished per night. Catch-per-unit-effort (CPUE) was quantified as the number of fish caught per net-night. The netting period in 2020 spanned 20 weeks, from May 19 to October 1.

All netted Lake Trout were enumerated, measured (mm, total length), and weighed (g). Mesh size and type of entanglement (i.e. gilled versus tooth-hooked) was recorded for each fish. Non-target fish were not measured or enumerated. Lake Trout size structure was summarized using proportional stock density (PSD) standard length categories: stock (≥280 mm), quality (≥500 mm), preferred (≥700 mm), memorable (≥850 mm), and trophy (≥1,000 mm; Piccolo et al. 1993). Body condition of Lake Trout was evaluated using relative weight. Mean relative weight and 95% confidence intervals (±CI's) were calculated for all Lake Trout greater than 400 mm to compare between years. All Lake Trout were euthanized in 2020. Sex and maturity (immature/mature/ripe) were recorded for all euthanized fish.

The North Fork Payette River (above Payette Lake) was visually surveyed on foot twice weekly during the kokanee spawning run from the mouth of Fisher Creek (W 45.037496 N -116.057979) downstream approximately 3,400 m (W 45.021131 N -116.062573). All live spawners were counted during surveys. 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 514 Lake Trout were captured across 134 net-nights in 2020. All nets in poor condition (e.g., numerous large holes) at time of setting were excluded from CPUE calculations (*n* = 19 net nights). Mean CPUE across all sizes of mesh was 1.3, which is the lowest catch rate since removal efforts began (Table 19). By comparison, mean catch rates varied from three to six fish per net-night from 2006 to 2018 (Figure 46), though net construction and mesh sizes were not consistent throughout that period. Two mesh sizes have been consistent since 2018 (51 and 64 mm), allowing valid CPUE comparisons. CPUE for those two mesh sizes in 2020 was 1.6, a 69% decline in relative abundance from 2018 (5.2) and a 16% decline from 2019 (1.9). In total, 2,299 Lake Trout have been removed from Payette Lake since 2014.

Gill netted Lake Trout caught in 2020 ranged in length from 193 to 1,018 mm (mean ± SE; 507 ± 9 mm; Figure 47). The majority of Lake Trout captured were quality length (proportional stock density [PSD] = 40, PSD-preferred = 24, PSD-memorable = 9, PSD-trophy = 1). Mean relative weight (± 95% CI) for Lake Trout greater than 400 mm in 2020 was 86 ± 1.6, showing a steady increase since suppression efforts began in 2014 (Figure 48). The sex ratio of Lake Trout captured in 2020 was 0.9 (males per female); sex was undetermined for 191 fish.

We completed four kokanee spawner counts on the North Fork Payette River in 2020. The first count was made on September 2 and the last on September 10. The peak count (1,070) was made on September 2. The total spawning run estimate in 2020 was 1,862 (1,070*1.73) fish (Table 20; Figure 49). Spawning fish ranged in length from 387 to 572 mm with a mean (± 95% CI) of 459 ± 25 mm based on a random sample of carcasses (*n* = 14; Table 20; Figure 49).

DISCUSSION

Nearly 2,300 Lake Trout have been removed from Payette Lake since suppression efforts began in 2014. Following a sharp decline in relative abundance between 2018 and 2019, CPUE continues to decrease and remains comparatively low (1.6 fish per net night). Likely as a result of reduced Lake Trout density, body condition has been increasing significantly each year since suppression began (Figure 48). This is likely due to reduced intraspecific competition and higher kokanee abundance (Ng et al. 2016), resulting in increased forage availability for the remaining Lake Trout population. In future years, we will spaghetti tag and live-release all Lake Trout greater than 813 mm in length to preserve a component of the trophy Lake Trout fishery and evaluate angler exploitation (Janssen et al. 2018). The IDFG TYI reporting system will be used to gather information from anglers who catch tagged fish. We anticipate high survival rates of released fish since the majority (96%) of large Lake Trout (i.e., > 508 mm) are tooth-hooked (i.e., entangled) in the net upon capture, and no Lake Trout greater than 813 mm have been observed gilled or wedged in the net.

Although the current Lake Trout suppression results are encouraging, our ultimate goal remains to reduce and maintain the Lake Trout population such that kokanee survival and growth can be improved, restoring a more balanced fishery. Based on these observations in the Lake Trout population, we resumed stocking 400,000 kokanee fingerlings in 2020. In future years, kokanee survival and abundance will be the primary measure of the overall efficacy of Lake Trout suppression efforts.

For over 30 years, we have assessed kokanee trends using index spawner counts in the North Fork Payette River (Table 20; Figure 49). Unfortunately, due to a reduction in the availability of early-spawning kokanee (the dominant life-history in Payette Lake), late-spawning kokanee were stocked in 2020. Late-spawning kokanee are known to have a higher propensity to spawn around the shoreline than early-spawners and any stream spawning that does occur will happen when snow and ice make count surveys difficult. Therefore, we will employ a new annual trend survey using kokanee-specific curtain nets beginning in 2021 to track survival of these late-spawning kokanee. In addition, a Summer Profundal Index Netting (SPIN; Sandstrom and Lester, 2009) survey will be initiated as well for Lake Trout in Payette Lake. This effort, in combination with continued spawner counts for naturally-produced early-strain kokanee, will help us determine the effectiveness of kokanee stocking and Lake Trout suppression efforts and guide our future management efforts in Payette Lake.

MANAGEMENT RECOMMENDATIONS

1. Continue with suppression efforts to reduce Lake Trout abundance through the current FMP period (2019-2024).

2. Continue kokanee fingerling stocking, and evaluate differences in survival between various stocking strategies to determine most appropriate strategy for meeting management objectives.

3. Implement new annual gill netting survey to track survival of stocked kokanee and Payette Lake fish community as a whole.

Table 19. Lake Trout gill net catch by stretch mesh size collected from Payette Lake, Idaho from summer through fall 2020. Catch-per-unit-effort (CPUE) expressed as catch per net-night. Catch rates are also shown for 2018 and 2019, only for mesh sizes used in both years.

Mesh size (mm)	Nights[1]	Fish caught	CPUE/night
	2020		
38	115	94	0.82
51	115	189	1.64
64	115	173	1.50
Total	345	456	1.32
	2019		
38	179	119	0.66
51	179	371	2.07
64	179	294	1.64
Total	537	784	1.46
	2018		
51	18	102	5.67
64	24	115	4.79
Total	42	217	5.17

[1] A net-night is for 91.5 m of net.

Table 20. Payette Lake, Idaho kokanee salmon spawner counts and estimated spawning run size and biomass from 1988 through 2020 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[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[c]	--
1997	36,300[e]	64,891[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[f]	15,690[g]	30,144	17.6	250[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[h]
2013	304	526	0.3	--	384/458[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[h]
2018	420	727	0.4	--	442/519[h]
2019	1,955	3,382	2.0	--	424
2020	1,076	1,862	0.6	--	459

[1] 1,717 ha usable kokanee habitat in Payette Lake (Area with depth greater than 40 feet).
[a] Estimate made from stream and weir counts (Frost and Bennett, 1994)
[b] From gill net data of captured spawners in Payette Lake during lake survey.
[c] From trawling collections made in September 1996.
[d] Includes 2,092 fish spawned and removed by Nampa Fish Hatchery.
[e] Does not include 2,092 fish spawned and removed by Nampa Fish Hatchery.
[f] Includes 3,000 fish spawned and removed by Nampa Fish Hatchery.
[g] Does not include 3,000 fish spawned and removed by Nampa Fish Hatchery.
[h] Two distinct age classes.

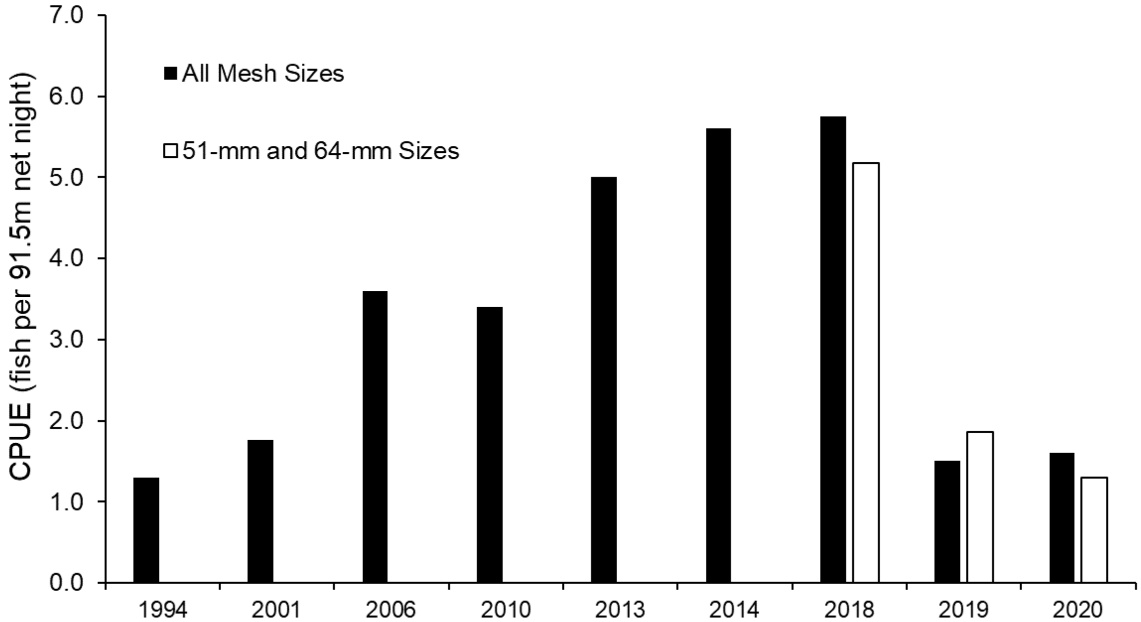

Figure 46. Lake Trout catch-per-unit-effort (CPUE; fish per 91.5 m net-night) in Payette Lake, Idaho, 1994 through 2020, for all mesh sizes and comparison for mesh sizes used in 2018 through 2020.

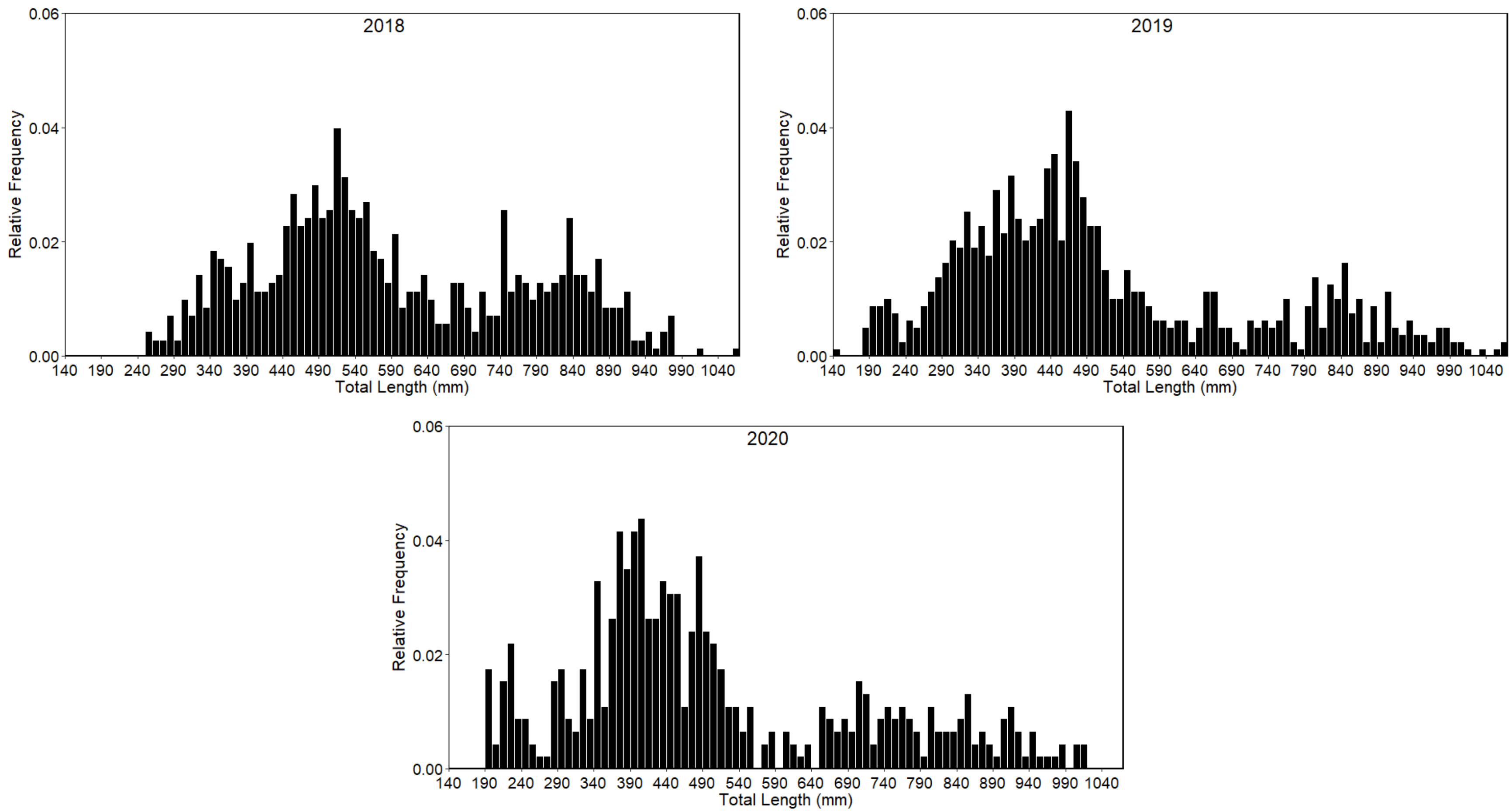

Figure 47. Length-frequency histograms for all Lake Trout captured in Payette Lake, Idaho in 2018, 2019, and 2020. Note: different mesh sizes were used in 2018.

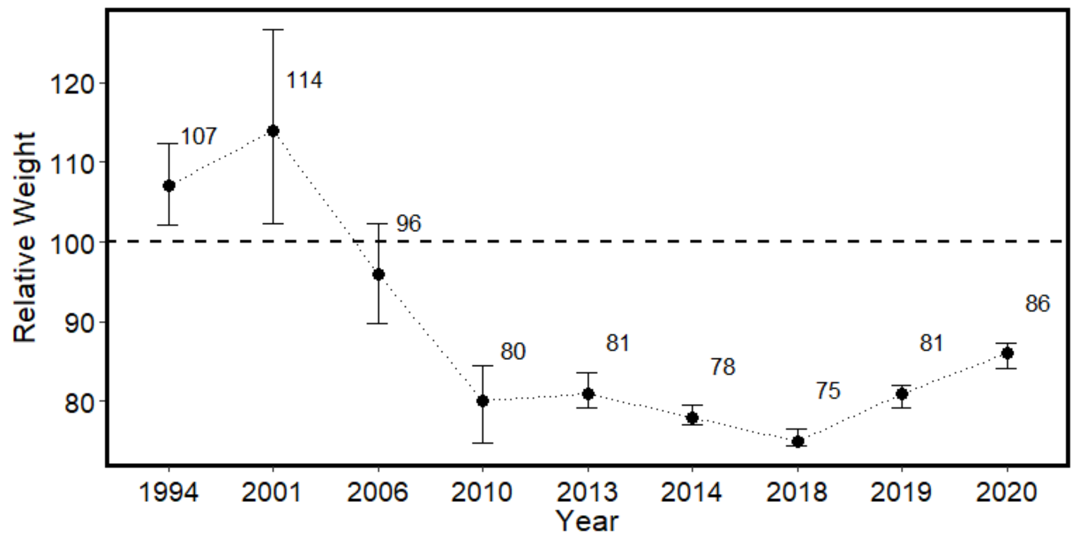

Figure 48. Mean relative weights (±95% confidence intervals) for Lake Trout (> 400 mm TL) captured in Payette Lake, Idaho, 1994 through 2020. Dashed line represents a relative weight of 100.

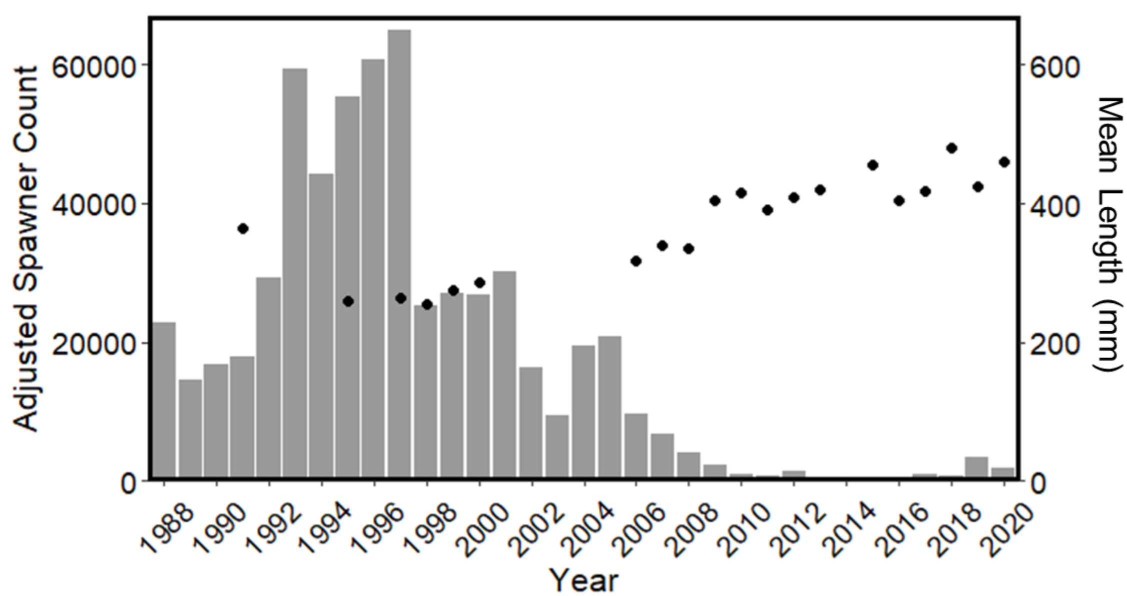

Figure 49. Spawning run size estimates (adjusted spawner count) and mean length of carcasses (mm) for kokanee salmon in the North Fork Payette River, Idaho from 1988 through 2020.

LITERATURE CITED

Baker, E.A. and McComish, T.S., 1998. Precision of ages determined from scales and opercles for yellow perch Perca flavescens. Journal of Great Lakes Research, 24:658-665.

Baty, F., Ritz, C., Charles, S., Brutsche, M., Flandrois, J.P. and Delignette-Muller, M.L., 2015. A toolbox for nonlinear regression in R: the package nlstools. Journal of Statistical Software, 66:1-21.

Bennett, D. H. 2004. Interactions of Northern Pikeminnow and Yellow Perch in Lake Cascade, Idaho. Final Report to Idaho Department of Fish and Game and U.S. Bureau of Reclamation. Department of Fish and Wildlife. University of Idaho, Moscow.

Blackwell, B. G., M. L. Brown, and D. W. Willis. 2000. Relative Weight (W_r) Status and Current Use in Fisheries Assessment and Management. Reviews in Fisheries Science, 8:1-44

Bonar, S.A., Hubert, W.A. and Willis, D.W., 2009. Standard methods for sampling North American freshwater fishes.

Branigan, P.R., Meyer, K.A. and Cassinelli, J.D., 2021. Relative Cost and Post-Release Performance of Hatchery Catchable Rainbow Trout Grown to Two Target Sizes. Fisheries.

Buckmeier, D. L., and R. G. Howells. 2003. Validation of otoliths for estimating ages of Largemouth Bass to 16 years. North American Journal of Fisheries Management 32:590-593.

Crump, M.L., N.J. Scott, Jr. 1994. Visual Encounter Surveys in Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC.

Dembkowski, D.J., Chipps, S.R. and Blackwell, B.G., 2014. Response of walleye and yellow perch to water-level fluctuations in glacial lakes. Fisheries Management and Ecology, 21:89-95.

Dembkowski, D.J., Willis, D.W. and Wuellner, M.R., 2016. Synchrony in larval yellow perch abundance: the influence of the Moran Effect during early life history. Canadian Journal of Fisheries and Aquatic Sciences, 73:1567-1574.

Fitzgerald, T. J., T. L. Margenau, and F. A. Copes. 1997. Muskellunge scale interpretation: the question of aging accuracy. North American Journal of Fisheries Management 17:206-209.

Forney, J. 1971. Development of dominant year classes in a Yellow Perch population. Transactions of the American Fisheries Society, 100:739-749.

Frost, F. O., and D. H. Bennett. 1994. Determination of Kokanee Incubation Success, Potential Egg Deposition, and Fry Production from the North Fork of the Payette River. Idaho Department of Fish and Game, Boise, ID, USA.

Gabelhouse, D. W., Jr. 1984. A length categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Griswold, R.G., Bjornn, T.C. and Fish, I.C., 1992. Development of indices of yellow perch abundance in Cascade Reservoir, Idaho. Master's thesis, University of Idaho.

Guy, C.S. and D. W. Willis. 1991. Seasonal variation in catch rate and body condition for four fish species in a South Dakota natural lake. Journal of Freshwater Ecology, 6:281-292.

Grunder, S.A. and D.R. Anderson. 1991. Regional Fisheries Management Investigations Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 1990. Idaho Department of Fish and Game, Boise, ID, USA.

Heidinger, R. C., and K. Clodfelter. 1987. Validity of the otolith for determining age and growth of Walleye, Striped Bass, and Smallmouth Bass in power plant cooling ponds. Pages 241-252 *in* R. C. Summerfelt, editor. Age and growth of fish. Iowa State University Press, Ames.

Hillman, W. P. 1982. Structure and dynamics of unique Bluegill populations. Master's thesis. University of Missouri, Columbia.

Hyatt, M.W. and Hubert, W.A., 2001. Proposed standard-weight equations for brook trout. North American Journal of Fisheries Management, 21:253-254.

Idaho Department of Fish and Game (IDFG). 1995. Fisheries Management Plan 1996-2000. Idaho Department of Fish and Game, Boise, ID, USA.

Idaho Department of Fish and Game (IDFG). 1999. Fisheries Management Plan 2000-2004. Idaho Department of Fish and Game, Boise, ID, USA.

Idaho Department of Fish and Game (IDFG). 2012. Standard Fish Sampling Protocol for Lowland Lakes and Reservoirs in Idaho. Idaho Department of Fish and Game, Boise, ID, USA.

Idaho Department of Fish and Game (IDFG). 2018. Fisheries Management Plan 2019-2024: a Comprehensive Guide to Managing Idaho's Fisheries Resources. Idaho Department of Fish and Game, Boise, ID, USA.

Isermann, D. A., J. R. Meerbeek, G. D. Scholten, and D. W. Willis. 2003. Evaluation of three different methods used for Walleye age determination with emphasis on removal and processing time. North American Journal of Fisheries Management 23:625-631.

Janssen, P. J. and D. R. Anderson. 1994. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 1991-1992. Idaho Department of Fish and Game, Boise, Idaho, USA.

Janssen, P., K. Apperson and D. Anderson. 1997. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. Idaho Department of Fish and Game, Boise, Idaho, USA.

Janssen, P.J., K. Apperson, and D.R. Anderson. 1998. Regional Fisheries Management Investigations Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 1997-1998. Idaho Department of Fish and Game, Boise, ID, USA.

Janssen, P.J., K. A. Apperson and D. R. Anderson. 2000. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 1996. Program F-71-R-21, Idaho Department of Fish and Game, Boise, ID, USA.

Janssen, P., D. Allen, D. Teuscher, K. Apperson, and L. Hostettler. 2002. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 2001. Idaho Department of Fish and Game, Boise, Idaho, USA.

Janssen, P. J., K. Apperson, D. Anderson, L. Hostettler, and K.S. Buelow. 2003. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 1999. Program F-71-R-24. Idaho Department of Fish and Game, Boise, ID, USA.

Janssen, P., D. Allen, and T. Tumelson. 2006. Idaho Department of Fish and Game Southwest Region-McCall. 2003. Idaho Department of Fish and Game, Boise, Idaho, USA.

Janssen, P. J., D. Allen, K. Apperson, P. Mitchell, and T. Folsom. 2008. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 2006. Idaho Department of Fish and Game, Boise, ID, USA.

Janssen, P., D. Allen, K. Apperson, M. Ackerman, N. Dyson, and T. Folsom. 2009. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 2004-2005. Idaho Department of Fish and Game, Boise, Idaho, USA.

Janssen, P. J., A. Osler, and D. Allen. 2016a. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 2014. Idaho Department of Fish and Game, Boise, ID, USA.

Janssen, P. J., N. Munn, and D. Allen. 2016b. Fishery Management Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 2015. Idaho Department of Fish and Game, Boise, ID, USA.

Janssen, P.J., J. Poole, M. Thomas, and J. Messner. 2020. Regional Fisheries Management Investigations Annual Report. Idaho Department of Fish and Game Southwest Region-McCall. 2019. Idaho Department of Fish and Game, Boise, ID, USA.

Kerns, J. A., and L. A. Lombardi-Carlson. 2017. History and importance of age and growth information. Pages 1-8 *in* M. C. Quist and D. A. Isermann, editors. Age and growth of fishes: principles and techniques. American Fisheries Society, Bethesda, Maryland.

Klein, Z. B., T. F. Bonvechio, B,. R. Bowen, and M. C. Quist. 2017. Precision and accuracy of age estimates obtained from anal fin spines, dorsal fin spines, and sagittal otoliths for known-age Largemouth Bass. Southeastern Naturalist 16:225-234.

Koenig, M.K., Meyer, K.A., Kozfkay, J.R., DuPont, J.M. and Schriever, E.B. 2015. Evaluating the Ability of Tiger Muskellunge to Eradicate Brook Trout in Idaho Alpine Lakes. North American Journal of Fisheries Management. 35:659-670.

Kolander, T.D., Willis, D.W. and Murphy, B.R., 1993. Proposed revision of the standard weight (Ws) equation for smallmouth bass. North American Journal of Fisheries Management, 13:398-400.

Kruse, C.G. and Hubert, W.A., 1997. Proposed standard weight (W_s) equations for interior cutthroat trout. North American Journal of Fisheries Management, 17:784-790.

Le Cren, E. D. 1947. The determination of the age and growth of the perch (*Perca fluviatilis*) from the opercular bone. The Journal of Animal Ecology, 188-204.

Maceina, M.J. and Stimpert, M.R., 1998. Relations between reservoir hydrology and crappie recruitment in Alabama. North American Journal of Fisheries Management, 18:104-113.

Maceina, M. J., J. Boxrucker, D. L. Buckmeier, R. S. Gangl, D. O. Lucchesi, D. A. Isermann, J. R. Jackson, and P. J. Martinez. 2007. Current status and review of freshwater fish aging procedures used by state and provincial agencies with recommendations for future directions. Fisheries 32:329-340.

Meyer, K. A., F. S. Elle, J. A. Lamansky, E. R. J. M. Mamer, and A. E. Butts. 2012. A Reward-Recovery Study to Estimate Tagged-Fish Reporting Rates by Idaho Anglers. North American Journal of Fisheries Management 32:696-703.

Neumann, R.M. and Murphy, B.R., 1991. Evaluation of the relative weight (W_r) index for assessment of white crappie and black crappie populations. North American Journal of Fisheries Management, 11:543-555.

Neumann, R. M., Guy, C. S. and D. W. Willis. 2012. Length, weight, and associated indices. Pages 637 – 670 in C. S. Guy and M. L. Brown, editors. Fisheries Techniques, 3rd edition. American Fisheries Society, Bethesd.

Ng, E. L., J. P. Fredericks, and M. C. Quist. 2016. Population Dynamics and Evaluation of Alternative Management Strategies for Nonnative Lake Trout in Priest Lake, Idaho. North American Journal of Fisheries Management 32:40-54.

Niewinski, B. C., and P. C. Ferreri. 1999. A comparison of three structures for estimating the age of Yellow Perch. North American Journal of Fisheries Management 19:872-877.

Ogle DH, Doll JC, Wheeler P, Dinno A (2021). FSA: Fisheries Stock Analysis. R package version 0.9.1, https://github.com/droglenc/FSA.

Piccolo, J. J., W. A. Hubert, and R. A. Whaley. 1993. Standard Weight Equation for Lake Trout. North American Journal of Fisheries Management 13:401-404.

Phelps, Q. E., S. J. Tripp, M. J. Hamel, R. P. Koenigs, and Z. J. Jackson. 2017. Choice of structure for estimating fish age and growth. Pages 81-106 *in* M.C. Quist and D. A. Isermann, editors. Age and growth of fishes: principles and techniques. American Fisheries Society, Bethesda, Maryland.

Power, M. and van den Heuvel, M.R., 1999. Age-0 yellow perch growth and its relationship to temperature. Transactions of the American Fisheries Society, 128:687-700.

Quist, M. C., M. A. Pegg, and D. R. Devries. 2012. Age and growth. Pages 667-731 *in* A. V. Zale, D. L. Parrish, and T. M. Sutton, editors. Fisheries techniques, 3rd edition. American Fisheries Society, Bethesda, Maryland.

Quist, M. C., and D. A. Isermann, editors. 2017. Age and growth of fishes: principles and techniques. American Fisheries Society, Bethesda, Maryland.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Reid, W. and T. Welsh. 1978. Fishery Management Annual Report. Idaho Department of Fish and Game. 1977. Idaho Department of Fish and Game, Boise, Idaho, USA.

Reid, W. and D. Anderson. 1982. Idaho Department of Fish and Game. 1981. Idaho Department of Fish and Game, Boise, Idaho, USA.

Ricker, W. L. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Robillard, S. R., and J. E. Marsden. 1996. Comparison of otolith and scale ages for Yellow Perch from Lake Michigan. Journal of Great Lakes Research 22:429-435.

Sanderson, B.L., Hrabik, T.R., Magnuson, J.J. and Post, D.M., 1999. Cyclic dynamics of a yellow perch (Perca flavescens) population in an oligotrophic lake: evidence for the role of intraspecific interactions. Canadian Journal of Fisheries and Aquatic Sciences, 56:1534-1542.

Schneidervin, R. W., and W. A. Hubert. 1986. A rapid technique for otolith removal from salmonids and catostomids. North American Journal of Fisheries Management 6.2:287-287.

Simpkins, D. G., & Hubert, W. A. (1996). Proposed revision of the standard-weight equation for rainbow trout. Journal of Freshwater Ecology, 11:319-325.

Sotola, V. A., G. A. Maynard, E. M. Hayes-Pontius, T. B. Mihuc, M. H. Malchoff, and J. E. Marsden. 2014. Precision and bias of using opercles as compared to otoliths, dorsal spines, and scales to estimate ages of Largemouth and Smallmouth Bass. Northeastern Naturalist 21:565-573.

Vandergoot, C. S., M. T. Bur, and K. A. Powell. 2008. Lake Erie Yellow Perch age estimation based on three structures: precision, processing times, and management implications. North American Journal of Fisheries Management 28:563-571.

Von Bertalanffy, L. 1938. A quantitative theory of organic growth (inquiries on growth laws II). Human Biology 10:181-213.

Wege, G.J. and R. O. Anderson. 1978. Relative weight (W_r): a new index of condition for largemouth bass. New approaches to the management of small impoundments. American Fisheries Society, North Central Division, Special Publication, 5:79-91.

Yates, J.R., Watkins, C.J. and Quist, M.C., 2016. Evaluation of hard structures used to estimate age of common carp. Northwest Science, *90*:195-205.

Prepared By:

Mike Thomas
Regional Fisheries Biologist

Josh Poole
Regional Fisheries Biologist

Isaac Fournier
Fisheries Biologist

Steven Hughes
Fisheries Technician

Approved By:
Idaho Department of Fish and Game

Joseph R. Kozfkay
State Fishery Manager

J. Lance Hebdon
Chief of Fisheries