FISHERY MANAGEMENT INVESTIGATIONS

# IDAHO DEPARTMENT OF FISH AND GAME

## FISHERY MANAGEMENT ANNUAL REPORT

Jim Fredericks, Director

## PANHANDLE REGION

## 2020

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February 2024
IDFG 23-106

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# BULL TROUT REDD COUNTS

## ABSTRACT

In 2020, we counted Bull Trout *Salvelinus confluentus* redds as an index of adult abundance in three of the major drainages in northern Idaho's Panhandle Region. A total of 83 redds were detected, including 57 redds in the Upper Priest Lake drainage, 20 redds in the St. Joe River drainage, and six redds in Kootenai River tributaries. Redd count totals in the Priest and St. Joe River drainages were lower, and the Kootenai River was similar, to average counts from the previous ten-year period.

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# INTRODUCTION

Bull Trout *Salvelinus confluentus* were listed by the U.S. Fish and Wildlife Service (USFWS) as a threatened species under the Endangered Species Act in 1998. Thus, monitoring population trends for this species is particularly important for fish management in the Panhandle Region, and throughout Idaho. Redd counts serve as the primary monitoring tool for Bull Trout populations throughout their range. Idaho Department Fish and Game (IDFG) personnel, along with employees of other state and federal agencies, annually count Bull Trout redds in standardized stream reaches within each of the four core recovery areas located in the Panhandle Region (USFWS 2015). Redd counts allow for evaluation of the status of populations in these areas and help in directing future management and recovery activities. Results for redd count surveys conducted in tributaries to Lake Pend Oreille are reported separately (Ransom et al. 2021).

# METHODS

We counted Bull Trout redds in select tributaries of the Upper Priest River, St. Joe River, and Kootenai River drainages where migratory Bull Trout were known or believed to spawn. We located redds visually by walking along standardized sections within each tributary (Ryan et al. 2020a). Bull Trout redd counts in the Priest Lake core area were completed on September 29, 2020. The St. Joe core area was surveyed on September 22, 2020, and the Kootenai River core area was surveyed in mid-October, 2020. Surveys were conducted by experienced redd counters in most cases. Bull Trout redds were defined as areas of clean gravels at least 0.3 x 0.6 m in size with gravels of at least 76 mm in diameter having been moved by fish and with a mound of loose gravel downstream from a depression (Pratt 1984). In areas where one redd was superimposed over another redd, each distinct depression was counted as one redd. Redd surveys were conducted during standardized time periods (late–September to mid-October). In some surveys, redd locations were recorded on maps and/or recorded with a hand-held global positioning system (GPS) unit. We summarized counts by core area and compared Bull Trout redd count totals by core area to prior count years to assess long-term trends in redd abundance. Total redd counts were compared to average counts from the previous ten years of sampling. Trends were assessed qualitatively relative to previous count averages rather than by statistical analysis.

In addition to surveys of index reaches in the St. Joe River core area, a comprehensive redd survey was also completed in areas where Bull Trout spawning has been observed or where environmental DNA (eDNA) indicated Bull Trout were present. These reaches were surveyed during September 15 – October 1, 2020 by IDFG, USFWS, USFS, and the Coeur d’Alene Tribe.

# RESULTS AND DISCUSSION

## Priest Lake

We counted 57 Bull Trout redds across seven standard stream reaches within the Priest River core area (Table 1). The total redd count was lower than the previous year, but similar to the previous 10-year average for combined counts of 59 redds.

### St. Joe River

We continued surveys in index streams with consistent monitoring history (i.e., Wisdom Creek, Medicine Creek, and mainstem St. Joe River [between Heller Creek and St. Joe Lake]). We counted a total of 17 Bull Trout redds among three index reaches in the core area (Table 3). We counted one redd in Medicine Creek, four redds in Wisdom Creek, and 12 redds in the St. Joe River between Heller Creek and St. Joe Lake. Total redds observed in 2020 represented a small increase in redds from the previous year (13 redds), but the total redd abundance remained below the 10-year average for index streams.

The number of streams surveyed each year in the St. Joe River core area has varied considerably over time, therefore we must emphasize cautious interpretation of total count values. We also recommend focusing future survey efforts primarily on index streams to better understand trends in redd abundance.

Of the 24 total reaches (excluding core index reaches) surveyed, a total of 3 redds were counted in two reaches (Table 3). Redds were not observed in 22 reaches. Results from this comprehensive survey indicated that core index reaches surveyed annually by IDFG encompass 85% of spawning activity in the basin. Thus, adding Heller Creek and Red Ives Creek to the annually surveyed core index reaches would encompass 90% of the redd abundance.

### Kootenai River Core Area

A total of six Bull Trout redds were observed in surveyed tributaries of the Kootenai River in Idaho in 2020 (Table 3). The redd count total included survey effort in North Callahan Creek (4 redds) and South Callahan Creek (2 redds).

## MANAGEMENT RECOMMENDATIONS

1. Continue to monitor Bull Trout spawning escapement through completion of redd surveys.

2. Add Heller Creek, Red Ives Creek, and Sherlock Creek to the core index reaches surveyed annually in the St. Joe River.

Table 1. Bull Trout redd counts by stream and count transect from the Upper Priest River, Idaho. Redd counts were reported for 2020. Average redd counts were reported for the previous 10-year period (2010-2019) and the period from 1993 through 2019. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row.

| Stream | Transect Description | Length (km) | 1993-2019 | | 2010-2019 | | 2020 |
|---|---|---|---|---|---|---|---|
| Upper Priest River | Falls to Rock Cr. | 12.5 | 18 | (24) | 26 | (10) | 23 |
| | Rock Cr. to Lime Cr. | 1.6 | 6 | (27) | 14 | (10) | 21 |
| | Lime Cr. to Snow Cr. | 4.2 | 7 | (27) | 9 | (10) | 8 |
| | Snow Cr. to Hughes Cr. | 11.0 | 3 | (26) | 2 | (10) | 1 |
| | Hughes Cr. to Priest Lake | 2.3 | 0 | (8) | 0 | (3) | -- |
| Rock Cr. | Mouth to F.S. trail 308 | 0.8 | 0 | (16) | 0 | (3) | -- |
| Lime Cr. | Mouth upstream 1.2 km | 1.2 | 0 | (18) | 0 | (3) | -- |
| Cedar Cr. | Mouth upstream 3.4 km | 3.4 | 0 | (20) | 0 | (3) | -- |
| Ruby Cr. | Mouth to waterfall | 3.4 | 0 | (9) | 0 | (1) | -- |
| Hughes Cr. | Trail 311 to trail 312 | 2.5 | 1 | (20) | 0 | (3) | -- |
| | F.S. road 622 to Trail 311 | 4.0 | 1 | (27) | 2 | (10) | 2 |
| | F.S. road 622 to mouth | 7.1 | 2 | (25) | 4 | (10) | 2 |
| Bench Cr. | Mouth upstream 1.1 km | 1.1 | 0 | (20) | 0 | (3) | -- |
| Jackson Cr. | Mouth to F.S. trail 311 | 1.8 | 0 | (17) | 0 | (3) | -- |
| Gold Cr. | Mouth to Culvert | 3.7 | 2 | (27) | 2 | (10) | 0 |
| Boulder Cr. | Mouth to waterfall | 2.3 | 0 | (12) | 0 | (2) | -- |
| Trapper Cr. | Mouth upstream 5.0 km | 5.0 | 2 | (18) | 0 | (2) | -- |
| Caribou Cr. | Mouth to old road crossing | 2.6 | 0 | (7) | 0 | (1) | -- |
| All stream reaches combined | | 44.1 | 40 | | 59 | | 57 |

Table 2. Bull Trout redd counts by stream and count transect from the St. Joe River, Idaho. Redd counts were reported for 2020. Average redd counts were reported for the previous 10-year period (2010-2019) and the period from 1992 through 2019. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row.

| Stream | Transect | Length (km) | 1992-2019 | 2010-2019 | 2020 |
|---|---|---|---|---|---|
| Bacon Cr. | Mouth upstream 1.6 km | 1.6 | 0 (4) | 0 (2) | 0 |
| Bad Bear Cr. | Mouth upstream 2.1 km | 2.1 | 0 (4) | 0 (1) | 0 |
| Bean Cr. | Mouth upstream 4.4 km | 4.4 | 0 (6) | 0 (3) | 0 |
| N. F. Bean Cr. | Mouth to Rkm 0.4 | 0.4 | 7 (4) | 7 (4) | 0 |
| Beaver Cr. | Mouth upstream 7.2 km | 7.2 | 0 (20) | 1 (3) | 0 |
| California Cr. | Mouth upstream 2.4 km | 2.4 | 1 (19) | 0 (3) | 0 |
| Cascade Cr. | Mouth upstream to barrier | 0.4 | 1 (2) | 1 (2) | 0 |
| Copper Cr. | Mouth upstream 5.1 km | 5.1 | 0 (8) | 0 (1) | 0 |
| Entente Cr. | Mouth upstream 2.6 km | 2.6 | 0 (4) | 0 (1) | 0 |
| Fly Cr. | Mouth upstream 4.3 km | 4.3 | 1 (17) | 1 (4) | 0 |
| Gold Cr. | Broadaxe Cr. To NF-1231 Rd. | 1.8 | 0 (3) | 0 (1) | 0 |
|  | Rkm 1.3 to Rkm 6.8 | 5.5 | 0 (1) | 0 (1) | 0 |
| Heller Cr. | Mouth upstream 4.3 km | 4.3 | 3 (24) | 5 (8) | 1 |
| Medicine Cr. | Mouth upstream 3.9 km | 3.9 | 30 (28) | 17 (10) | 1 |
| Mill Cr. | Mouth upstream 1.6 km | 1.6 | 6 (3) | 6 (3) | 0 |
| Mosquito Cr. | Mouth to falls | 0.7 | 1 (9) | 0 (1) | 0 |
| My Cr. | Mouth upstream 1.6 km | 1.6 | 0 (2) | 0 (2) | 0 |
| Quartz Cr. | Rkm 2.4 to Entente Cr. | 1.8 | 1 (2) | 1 (1) | 0 |
| Red Ives Cr. | Mouth upstream 3.1 km | 3.1 | 1 (23) | 1 (7) | 0 |
| Ruby Cr. | Mouth upstream 2.8 km | 2.8 | 2 (5) | 0 (2) | 0 |
| Sherlock Cr. | Mouth upstream 4.2 km | 4.2 | 1 (20) | 1 (5) | 0 |
| Simmons Cr. | NF-1279 Rd. to Washout Cr. | 0.3 | 0 (9) | 0 (1) | 2 |
| E. F. Simmons Cr. | Washout Cr. upstream 1.1 km | 1.1 | 0 (2) | -- (0) | 0 |
| St. Joe River | Heller Cr. to St. Joe River falls | 11.7 | 6 (28) | 3 (10) | 12 |

Table 2. (continued)

| Stream | Transect | Length (km) | 1992-2019 | 2010-2019 | 2020 |
|---|---|---|---|---|---|
| | Lodge to Broken Leg Cr. | 7.2 | 4 1 | -- (0) | 0 |
| Tenier Cr. | Mouth upstream 1.6 km | 1.6 | 2 (3) | 2 (3) | 0 |
| Timber Cr. | Mouth upstream 3.2 km | 3.2 | 0 (4) | 0 (1) | 0 |
| Wisdom Cr. | Mouth upstream 4.0 km | 4.0 | 6 (28) | 1 (10) | 4 |
| Yankee Bar Cr. | Mouth upstream 1.1 km | 1.1 | 0 (14) | 1 (2) | 0 |
| All stream reaches combined | | 92.2 | 52 | 33 | 20 |

Table 3. Bull Trout redd counts by stream and count transect from tributaries to the Kootenai River, Idaho. Redd counts were reported for 2020. Average redd counts were reported for the previous 10-year period (2010-2019) and the period from 1993 through 2009. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row.

| Stream | Transect | Length (km) | 2001-2019 | | 2010-2019 | | 2020 |
|---|---|---|---|---|---|---|---|
| North Callahan Cr. | Jill Cr. to waterfall barrier | 3.3 | 11 | 16 | 5 | 8 | 4 |
| South Callahan Cr. | F.S. Rd 4554 to F.S. Rd 414 | 4.3 | 2 | 16 | 1 | 8 | 2 |
| Boulder Cr. | Mouth to waterfall barrier | 1.9 | 0 | 15 | 0 | 6 | -- |
| All stream reaches combined | | 7.6 | 13 | | 6 | | 6 |

# LOWLAND LAKE INVESTIGATIONS

## ABSTRACT

Lowland lake surveys were conducted on Kelso, Shepherd, and Perkins lakes in June 2020. Surveys were conducted using Idaho Department of Fish and Game standard lowland lake methods. We found a moderately diverse fish community in Kelso Lake included Bluegill *Lepomis macrochirus*, Brown Bullhead *Ameiurus nebulosus,* Largemouth Bass *Micropterus salmoides*, Pumpkinseed *Lepomis gibbosus,* Tench *Tinca tinca*, and Yellow Perch *Perca flavescens.* Bluegill and Yellow Perch were the most abundant species sampled, comprising 26% and 24% of the catch. We found common sportfish species were abundant and the fish community was relatively stable suggesting the fishery was meeting management objectives. As such, we recommend no change in Kelso Lake fishery management. Shepherd Lake also exhibited a moderately diverse fish community including Black Crappie *Pomoxis nigromaculatus*, Bluegill, Brown Bullhead, Largemouth Bass, Pumpkinseed, and Yellow Perch. Bluegill were the most abundant species caught comprising 68.5% of the total catch. We estimated total annual mortality of Largemouth Bass in Shepherd Lake was low (18%), suggesting fishing mortality was minimal. No tiger muskellunge *Esox lucius* × *E. masquinongy* were detected in Shepherd Lake despite long-term stocking efforts. We recommend a formal evaluation of the tiger muskellunge stocking effort be completed to determine how to improve the resulting fishing opportunity in Shepherd Lake. The fish community of Perkins Lake was moderately diverse and included Black Crappie, Bluegill, Bluegill x Pumpkinseed hybrids *L. macrochirus x L. gibbosus*, Brook Trout *Salvelinus fontinalis*, Largemouth Bass, Pumpkinseed, and Yellow Perch. Although six species were encountered, we collectively caught few fish among all gear types (*n* = 100). Of the species encountered, Black Crappie represented the majority of the catch (73%). Our observations suggested poor survival and (or) recruitment significantly impacted population productivity in recent years. We recommend a survey of the Perkins Lake fish community be repeated in the near term to determine how populations recover and if supplementation is necessary to reestablish a productive warmwater fishery.

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# INTRODUCTION

Lowland lakes provide a diversity of angling opportunities in the Panhandle Region of Idaho. Lowland lake surveys are conducted periodically to monitor the composition and quality of these fisheries. Many lowland lakes within the Panhandle Region are routinely stocked to enhance fishing opportunities. Therefore, lowland lake surveys also provide a means of evaluating the use of hatchery products for enhancement of these fisheries. In 2020, we completed standardized lowland lake surveys on Kelso, Shepherd, and Perkins lakes.

## Kelso Lake

Kelso Lake is 25.8-ha waterbody located in Bonner County north of the city of Athol. The lands surrounding the lake are primarily privately owned. An Idaho Department of Fish and Game (IDFG) access site provides public access on the north side of the lake. Amenities available include a primitive boat ramp, fishing dock, and vault toilet. Use of motorized watercraft on the lake is limited to electric motors only. The lake is considered a “family fishing water” indicating reasonable access accommodations are present and the fishery provides a good chance of catching fish for novice anglers.

Kelso Lake is managed for a mixed species fishery under general regional bag and possession limits (IDFG 2019). Catchable length Rainbow Trout *Oncorhynchus mykiss* are stocked annually in the lake (IDFG, unpublished data). A warmwater fish community is also present. Prior surveys indicate species found in Kelso Lake include Black Crappie *Pomoxis nigromaculatus,* Bluegill *Lepomis macrochirus*, Brown Bullhead *Ameiurus nebulosus,* Green Sunfish *Lepomis cyanellus*, Largemouth Bass *Micropterus salmoides*, Pumpkinseed *Lepomis gibbosus,* Tench *Tinca tinca*, and Yellow Perch *Perca flavescens* (Fredericks et al. 2009).

## Shepherd Lake

Shepherd Lake is 54.6-ha waterbody located in Bonner County east of the community of Sagle. The lands surrounding the majority of the lake are owned and managed for public access by IDFG. Amenities available include a boat ramp, fishing dock, and vault toilet. Shoreline access is available around a large portion of the lake, but heavy aquatic vegetation surrounding the lake limits fishing opportunity from shore. Use of motorized watercraft on the lake is limited to electric motors only. The lake is considered a “family fishing water”.

Shepherd Lake is managed as a warmwater fishery under general regional bag and possession limits (IDFG 2019). Prior surveys indicate species found in Shepherd Lake include Black Crappie, Bluegill, Brown Bullhead, Largemouth Bass, Pumpkinseed, tiger muskellunge *Esox lucius* × *E. masquinongy*, and Yellow Perch (DuPont et al. 2011). Tiger muskellunge are stocked in Shepherd Lake to provide diverse fishing opportunity and a trophy fishery component (IDFG 2019).

## Perkins Lake

Perkins Lake is a 21.5-ha waterbody located in Boundary County, northeast of the community of Moyie Springs. The lands surrounding the lake are a mix of private and public (U.S. Forest Service; USFS) ownership. A USFS access point provides public access on the northeast side of the lake. Amenities available include a primitive boat ramp, fishing dock, and outhouse. Use of motorized watercraft on the lake is limited to electric motors only.

Perkins Lake has most recently been managed for a warmwater fishery (IDFG 2019). Prior surveys indicated the fish community includes Black Crappie, Bluegill, Largemouth Bass, Pumpkinseed, and Yellow Perch (Liter et al. 2008).

Brook Trout *Salvelinus fontinalis* were historically stocked in the lake (IDFG, unpublished data). Brook Trout stocking was discontinued in the late-1990s, but the rationale for discontinuation was not clear from available literature. While Brook Trout stocking efforts may provide fishery diversity, we did not find information indicating the performance of stocked fish had been evaluated. In recent years, local residents contacted IDFG expressing interest in enhancing a salmonid-based fishery in the lake. Therefore, we incorporated an evaluation of habitat quality in our survey to determine the feasibility of promoting a salmonid-based fishery using hatchery products.

## METHODS

We surveyed Kelso Lake on June 4-9, Shepherd Lake on June 3-9; and Perkins Lake on June 23-24. Surveys were conducted following IDFG standard lowland lakes methods (IDFG 2012). In all lakes we completed five trap net nights, four gill-net nights (two floating and two sinking standard-experimental gill nets), and electrofished the entire shoreline at night (Table 4). Electrofishing was conducted in 10-minute units and reported as fish per hour. Net sets were overnight with time fished varying from 15 to 18 hours. Net catch rates were reported as fish per net.

Fish collected during surveys were identified, measured (total length, mm) and weighed (g). We estimated relative abundance as catch per unit effort (CPUE) for electrofishing (fish/h) and netting (fish/net) samples. Variation around CPUE estimates was described as one standard deviation (SD) about the mean estimates. We described the general structure of the fish community in each lake as the relative percentage of each species in the sample and the relative percentage of biomass of each species in the sample. Size structure of sampled species was described using length-frequency histograms and proportional stock density indices (PSD; Anderson and Neumann 1996) for primary species targeted. We used Fisheries Analysis and Modeling Simulator (FAMS; Slipke and Maceina 2014) software to calculate PSD values. Mean relative weight ($W_r$; Wege and Anderson 1978) was used to describe the condition of fish. We reported one standard deviation of $W_r$ estimates as a description of variation in our estimates.

Hard structures were collected from a subsample of targeted species caught during our surveys of each lake and used to develop length-at-age relationships. Length-at-age information was used to describe patterns of growth, mortality, and recruitment. Dorsal spines were collected from Largemouth Bass and Black Crappie. We targeted three to five structures per centimeter length group for each species. Dorsal spines were mounted in epoxy, cross sectioned on a Buehler Isomet saw (Illinois Tool Works Inc., Lake Bluff, Illinois), sanded for viewing clarity, and viewed on a compound microscope under 10 x to 30 x magnification. Length-at-age at time of capture was reported as an index of growth where applicable. Age-length keys were used to predict ages for an entire sample using subsampled age estimates. Age-length key development and age assignment was done in R (Isermann and Knight 2005; R Core Team 2021). We used a frequency of catch by age for sampled fish in describing general patterns of recruitment and in estimating Total annual mortality ($A$). Total annual mortality was estimated using weighted catch curve analyses in FAMS.

We sampled zooplankton from Perkins Lake to evaluate the quality and quantity of available forage for planktivorous fishes. Zooplankton samples were collected on September 2, 2020 from three randomly selected locations distributed throughout the lake. Zooplankton were collected using three 0.5 m plankton nets fitted with small (153 µm), medium (500 µm) and large (750 µm) mesh at each site. Nets were lowered to the bottom for each tow. Each sample was transferred from the net cup to a sample jar and preserved in denatured ethyl alcohol. We processed samples in the lab using methods described by Teuscher (1999). Mean zooplankton density (g/m) was described from collections of the 153 µm net. We used the zooplankton ratio method (ZPR) to assess zooplankton quantity, where ZPR was equal to the ratio of zooplankton catch weight from 750 µm and 500 µm nets (Teuscher 1999). We also assessed zooplankton quality using the zooplankton quality index (ZQI) estimated as the product of ZPR and the sum of catch weight from 500 µm and 750 µm nets (Teuscher 1999). We described variation around ZPR and ZQI estimates as one standard deviation about mean estimates. Zooplankton collections were paired with measured temperature and dissolved oxygen profiles. We used a Hydrolab sonde to measure temperature and dissolved oxygen profiles (Hach Hydromet, Loveland, CO). These water quality measures were used to describe the general condition of habitat in the lake during a period potentially limiting for coldwater fishes, such as Rainbow Trout.

## RESULTS

### Kelso Lake

We found a moderately diverse fish community in Kelso Lake, including Bluegill, Brown Bullhead, Green Sunfish *Lepomis cyanellus*, hatchery Rainbow Trout, Largemouth Bass, Pumpkinseed, Tench, and Yellow Perch (Table 4). Bluegill and Yellow Perch were the most abundant species sampled and composed 26% and 24% of the catch, respectively. Largemouth Bass were also abundant and comprised 19% of the catch. Green Sunfish and Tench were not abundant with few individuals of either species observed. A majority of the biomass in the lake was comprised of Bluegill (19%; Table 4), hatchery Rainbow Trout (20%), and Largemouth Bass (19%). Electrofishing was the most efficient method of capture for most species, and catch rates suggested most species encountered were abundant (Table 5). Floating gill nets efficiently sampled Rainbow Trout (23.5 fish/net; Table 5) and trap nets efficiently captured Tench (1.6 fish/net; Table 5).

Rainbow Trout caught in our sample were representative of recently stocked catchable length fish. Mean length of Rainbow Trout was 296 mm with measured lengths varying from 220 to 350 mm (Table 4). We did not observe Rainbow Trout of length or condition representative of stocking events in prior years.

Largemouth Bass were abundant in Kelso Lake, but generally had poor size structure. Total length of collected fish varied from 68 to 552 mm with a length distribution represented by a PSD of 15 (Table 4; Figure 1). Largemouth Bass grew to quality length (i.e., 300 mm) in six to seven years (Figure 2), and generally exhibited moderate condition. Mean (±1 SD.) $W_r$ of Largemouth Bass stock length and larger was 84 (± 7.9). Estimated $A$ of the population from analysis of the weighted catch curve for ages 3 to 11 was 57.2% (Figure 3).

The size structure of both Bluegill and Pumpkinseed reflected balanced populations with PSD values of 66 and 59, respectively (Table 4; Figure 1). Total length of Bluegill varied from 47 to 223 mm in our sample. Mean $W_r$ of Bluegill was 99. Pumpkinseed total length varied from 75 to 168 mm. Pumpkinseed also exhibited above average body condition ($W_r$ = 103).

Yellow Perch were abundant in our survey, but generally had poor size structure (Table 4, Figure 1). Total length of Yellow Perch varied from 126 to 275 mm and was represented by a PSD of 17. However, these fish exhibited good body condition with a $W_r$ of 95.

## Shepherd Lake

Shepherd Lake exhibited a moderately diverse fish community, including Black Crappie, Bluegill, Brown Bullhead, Largemouth Bass, Pumpkinseed, and Yellow Perch (Table 6). Bluegill were the most abundant species caught, comprising 68.5% of the total catch by number and 35.7% by weight. Largemouth Bass were less common, comprising 6.7% of the catch, but representing 41.2% of the biomass. Composition of the catch from other species varied from 0.5 to 12.7%. Black Crappie were present, but only three fish were caught. All species except Black Crappie were detected in our electrofishing effort (Table 7). Electrofishing was the most effective method of capture for Largemouth Bass and Yellow Perch at catch rates of 29.1 and 23.1 fish/h, respectively. Trap nets effectively captured Bluegill (40.2 fish/net), Brown Bullhead (3.8 fish/net), and Pumpkinseed (6.0 fish/net; Table 7). Largemouth Bass were the only species caught in gill nets and few fish were caught in this gear collectively (0.5 fish/net; floating gill net).

Bluegill lengths varied from 40 to 198 mm (mean = 149; Table 6; Figure 4). Length distribution based of our catch represented a PSD of 57. Bluegill mean $W_r$ (±1 SD) was 90 (10.8).

Largemouth Bass varied in length from 129 to 534 mm (mean = 361 mm; Table 6; Figure 4). Length distribution of our catch represented a PSD of 83. Largemouth Bass grew to quality length (i.e., 300 mm) in four to five years (Figure 5). Largemouth Bass $W_r$ (±1 SD) was 87 (6.9). We caught Largemouth Bass representing age-1 to age-14 year classes (Figure 5). Although a wide range of ages was observed, the catch-at-age frequency from our sample suggested recruitment was variable. Age-6 fish were the most abundant in the catch (Figure 6). Total annual mortality, estimated from ages 6 to 14, was 16.6%.

The size distributions of other species sampled in our survey were variable (Table 6; Figure 4). For example, the mean length of Brown Bullhead was 288 mm and represented a PSD of 97. In contrast, Pumpkinseed and Yellow Perch had poor relative size distributions with representative PSD values of 20 and 23, respectively. Condition of all three of these species was near average with $W_r$ values from 91 to 102.

## Perkins Lake

The fish community of Perkins Lake was moderately diverse and included Black Crappie, Bluegill, Bluegill x Pumpkinseed hybrid *L. macrochirus x L. gibbosus*, Brook Trout, Largemouth Bass, Pumpkinseed, and Yellow Perch (Table 8). Although six species were encountered, we collectively caught few fish among all gear types ($n$ = 100). Of the species encountered, Black Crappie represented the majority of the catch both by count (73%) and biomass (71%). Black Crappie were captured in all gear types. However, electrofishing (40.5 fish/h) and gill nets (18.0 fish/net, floating gill net; 4.0 fish/net, sinking gill net) caught the majority of fish (Table 9). Catch rates for other species were low for all gear types and reflected the limited catch in our survey (Table 9).

Black Crappie caught in our survey varied in age from two to seven, but a majority were found to be from the age-5 and age-6 year classes (Figure 8). The length of fish in our sample reflected the limited age distribution we observed. Total lengths varied from 146 to 232 mm (mean

= 204; Table 8; Figure 7). The length distribution of Black Crappie was represented by a PSD of 73. Black Crappie grew to quality length (i.e., 200 mm) in five to six years (Figure 9). Mean $W_r$ (±1 SD) was 90 (6.6).

None of the remaining species caught in our survey were represented by many individuals or wide distributions of length (Table 8; Figure 7). In general, condition was good for these species with $W_r$ values varying from 78 to 99. Largemouth Bass represented the lower end condition values observed with an estimated mean $W_r$ of 78. Only two Largemouth Bass were encountered.

Mean zooplankton density was 1 g/m. Mean (±1 SD) ZPR and ZQI values were 0.20 (0.14) and 0.07 (0.03), respectively. The lake appeared be stratified to approximately 1.5 meters in early September. Water temperature at the surface was 19.2°C (Figure 10). Anoxic hypolimnetic conditions and warm epilimnetic water temperatures were present at the time of measurements.

## DISCUSSION

### Kelso Lake

The Kelso Lake fish community was stable relative to the documented sampling history (Fredericks et al. 2009; Table 10). Catch composition varied little for most species present and the majority of species sampled were abundant. Historical descriptions of size distribution were limited, but suggested moderate shifts in size structure occurred. Mean length of Bluegill increased, as did corresponding PSD. Mean length of Largemouth Bass also increased, but PSD values demonstrated a slight reduction in the proportion of quality length and larger fish. Condition of Bluegill remained relatively stable while condition of Largemouth Bass improved. Kelso Lake is managed as a consumptive fishery with simple “family friendly” regulations (IDFG 2019). Collectively, our observations suggested the Kelso Lake fish community is capable of supporting a consumptive fishery and therefore is meeting fishery management objectives.

Catch of Rainbow Trout in our survey suggested spring stocking events should provide a seasonally viable fishery in Kelso Lake. Rainbow Trout were abundant in our survey and represented a significant portion of the biomass observed in the lake at that time. Qualitatively, their abundance suggested stocking efforts provided a quality fishing opportunity for cool water periods. Prior evaluation of angler exploitation on Rainbow Trout in Kelso Lake suggested use of the fishery was high (>60%) and justified stocking in this lake (Hardy et al. 2010). We recommend stocking of Rainbow Trout continue at existing rates to provide a seasonal fishery opportunity.

We did not detect carryover Rainbow Trout from stocking events in prior years. Rainbow Trout in Kelso Lake were likely influenced by late-summer habitat availability. Although we did not measure habitat conditions (i.e., temperature and dissolved oxygen), they were likely poor for coldwater fishes in mid- to late-summer. Kelso Lake is relatively shallow and heavily vegetated, characteristics lending to warm water and low dissolved oxygen during warm weather periods, as occurs in many Panhandle Region lowland lakes (Horner and Rieman 1984).

Total annual mortality of Largemouth Bass in Kelso Lake was estimated to be high (57.2%) relative to other regional waters (Ryan et al. 2018; see Shepherd Lake in this report). Ryan et al. (2018), previously estimated *A* of Largemouth Bass in Kelso Lake at a more comparable rate of 30.9%. In that survey, they estimated *A* from a catch-at-age frequency including age-2 to age-13 year classes. In comparison, our estimate of *A* included year classes from age-3 to age-7. However, our age frequency was truncated and excluded potentially older age classes detected in our sample. Our collection of age structures did not include four large (420-550 mm) individuals and prohibited confident assignment of age. Total annual mortality was likely biased positively as a result of missing age classes. As such, interpretation of *A* from this survey should acknowledge this limitation.

Green Sunfish caught in our survey represented the first detection of the species in Kelso Lake. Green Sunfish are not common in the Panhandle Region, but were present in other lowland lakes, including Upper and Lower Twin lakes and Fernan Lake (Ryan et al. 2020a). Kelso Lake does not have an extensive sampling history and our observations of Green Sunfish were limited (*n* = 2). As such, it is unclear if our observation represented a species introduction or simply the first acknowledgement of their presence. The origin of Green Sunfish in regional waters has not been clearly described and no regional stocking record (IDFG unpublished data; 1913 to current year) was found to indicate an intentional stocking event occurred in any regional waterbody.

## Shepherd Lake

The fish assemblage of Shepherd Lake was generally similar to prior surveys in years that followed the establishment of Bluegill (Table 11). Bluegill were introduced to Shepherd Lake in the late-1980s and early-1990s and were the dominant species in surveys conducted in 1997 and 2007 (Fredericks et al. 2000; DuPont et al. 2011). Although Bluegill were dominant in our survey, we found the proportion of the catch made up of Bluegill increased approximately 20% from prior surveys. However, size structure and condition was similar. In contrast, the proportion of catch represented by both Largemouth Bass and Pumpkinseed noticeably declined. While Largemouth Bass were proportionally less abundant, the size structure and condition of the population improved.

Total annual mortality of Largemouth Bass in Shepherd Lake was estimated as 18%, which is low relative to populations throughout the Panhandle Region. For example, Ryan et al. (2018) found *A* varied from 18.9% to 43.8% in six lowland lakes across the region. While our estimate of *A* may be reasonable, we also noted the sampled population was generally dominated by older fish, which suggests recruitment of Largemouth Bass may have been irregular in recent years. As such, the age structure of the population potentially influenced our ability to accurately estimate *A* and may have biased our estimate (Ricker 1975).

The age structure of Largemouth Bass found in Shepherd Lake in 2020 was unique relative to population characteristics of Largemouth Bass in other regional waters. In comparison, Largemouth Bass populations in the Panhandle Region of Idaho typically exhibit age distributions dominated by young age classes and reflect moderate *A* (see Kelso Lake results). While we noted the potential influence of irregular recruitment on estimates of *A*, other factors may be influential. For example, we observed both low *A* and a dominant proportion of relatively large and old individuals in the population, which are characteristics aligning with unexploited fish populations (Goedde and Coble 1981; Hessenauer et al. 2014). Although we did not evaluate angler exploitation in our work, these population characteristics were not typical of populations experiencing meaningful angling mortality and provided some evidence exploitation may be limited. We did not evaluate the frequency of ages of other species in our survey, but generally observed patterns in length suggesting older individuals likely dominated populations of Bluegill and Pumpkinseed as well. It is unclear why exploitation of the Shepherd Lake fish community would be unique but may be an indication angling effort is limited. Angler access to Shepherd Lake is good, so that does not explain the potentially low fishing effort. Based on these findings we recommend angler exploitation of Largemouth Bass in Shepherd Lake be estimated to better understand angler influences on the population.

We did not detect tiger muskellunge in our survey of Shepherd Lake despite regular stocking in years prior to our survey (IDFG, unpublished data). Similarly, DuPont et al. (2011) did not detect tiger muskellunge in a 2007 lowland lake survey of Shepherd Lake. Tiger muskellunge were stocked periodically in Shepherd Lake from 1989 to 2014 and annually since 2014. Stocking rates were low during the majority of the recent stocking history (0.5 fish/ha; 2015-2019). However, tiger muskellunge stocking rate was increased in 2020 in an effort to establish a more reliable fishing opportunity. Tiger muskellunge were stocked in Shepherd Lake at 4.2 fish/ha following our survey, and a stocking request of 6 fish/ha was proposed for future years. While stocking rate may have historically influenced abundance, survival of tiger muskellunge and Muskellunge *Esox masquinongy* post-stocking has been shown to be influenced by hatchery rearing and stocking practices. Specifically, sensitivity to water temperature increases, body condition, length, and season at time of stocking all were known to influence survival post-stocking (Larscheid et al. 1999; Mather et al. 1986; Stein et al. 1981). We recommend a targeted evaluation of tiger muskellunge performance be completed in Shepherd Lake to better determine how increased stocking rates influence the tiger muskellunge fishery. We also recommend a review of hatchery rearing and stocking practices be completed to understand what factors may be influencing survival rates post-stocking.

### Perkins Lake

The most pronounced observation from our survey of Perkins Lake was the limited abundance and size distribution of all species sampled. Our observations suggested poor survival and (or) recruitment significantly impacted population productivity in recent years. The previous survey of the lake found higher abundance of all species, suggesting this is a newer condition (Table 9; Liter et al. 2008). There was no evidence, such as patterns of size distribution, to suggest harvest related mortality was a factor. We did measure low dissolved oxygen levels throughout a large portion of the water column in September. While this condition was unlikely limiting for warmwater fishes during the summer period, it may be indicative of a limiting condition during periods of ice cover. Perkins Lake is relatively shallow with a mean depth of 3 m (Horner et al. 1988), and we found the lake to be heavily vegetated around its entire perimeter. We hypothesize that significant oxygen depletion due to organic decay may occur during long periods of ice cover. We recommend mid-winter oxygen levels be investigated to evaluate if poor water quality is impacting survival in the Perkins Lake fish community. We also recommend a fishery survey be completed in two to three years to understand if natural recruitment may reestablish fish populations (e.g., Largemouth Bass) or if supplementation should be considered.

Historically, Brook Trout were stocked in Perkins Lake and theoretically could provide a unique element of diversity to this regional fishery. We found no reported evaluation of the performance of prior Brook Trout stocking events. However, Horner et al. (1988) indicated water quality (e.g., temperature and dissolved oxygen) was likely unsuitable for coldwater fishes and did not detect Brook Trout in a gill-net survey of the lake. Despite this finding, Brook Trout were stocked in Perkins Lake relatively consistently until the late-1990s (IDFG, unpublished data). While we found a single Brook Trout in our sample, our water quality measurements suggested the combination of temperature and oxygen were sufficiently limiting to consistent carryover of trout in the lake. In addition, both zooplankton quality and quantity were low, thus further limiting the potential for growth and survival of put-and-grow hatchery products (Teuscher 1999). As such, we recommend management of the Perkins Lake fishery continue to focus on warmwater species.

## MANAGEMENT RECOMMENDATIONS

1. Continue current Rainbow Trout stocking rates and frequencies in Kelso Lake.

2. Estimate exploitation of Largemouth Bass in Shepherd Lake.

3. Complete a targeted evaluation of tiger muskellunge stocking rates and fishery success in Shepherd Lake to better determine how to best use tiger muskellunge in this lake and other regional fisheries.

4. Complete a review of tiger muskellunge hatchery rearing and stocking practices to understand what factors may be influencing post-stocking survival rates.

5. Measure mid-winter oxygen levels in Perkins Lake to determine if oxygen depletion may be limiting fish survival.

6. Complete a fishery survey of Perkins Lake in two to three years to understand if natural recruitment may reestablish fish populations in the lake or if supplementation should be considered.

7. Maintain a warmwater fishery management focus for Perkins Lake.

Table 4. Descriptive statistics of species sampled from Kelso Lake in June 2020. Summarized statistics included catch, proportion of catch by number (% Catch) and biomass (% Biomass), mean total length (TL, mm), minimum and maximum total length, proportional stock density (PSD), and relative weight (Wr).

| Species | Catch | % Catch | % Biomass | Mean TL | Min-max TL | PSD | $W_r$ |
|---|---|---|---|---|---|---|---|
| Bluegill | 174 | 26% | 19% | 163 | 47-223 | 66 | 99 (8.9) |
| Brown Bullhead | 60 | 9% | 13% | 243 | 183-305 | 92 | 92 (6.0) |
| Green Sunfish | 2 | 0% | 0% | 195 | 195-195 | -- | 103 (10.5) |
| Hatchery Rainbow Trout | 64 | 10% | 20% | 296 | 220-350 | -- | -- |
| Largemouth Bass | 125 | 19% | 19% | 207 | 68-552 | 15 | 84 (7.9) |
| Pumpkinseed | 76 | 11% | 5% | 139 | 75-168 | 59 | 103 (25.6) |
| Tench | 9 | 1% | 11% | 406 | 235-480 | -- | -- |
| Yellow Perch | 159 | 24% | 13% | 175 | 126-275 | 17 | 95 (10.6) |

Table 5. Catch rates (± 1 SD) by species from electrofishing (fish/h), floating gill net (fish/net), sinking gill net (fish/net), and trap net (fish/net) effort during a survey of Kelso Lake in June 2020.

| Species | Electrofishing | Floating gill net | Sinking gill net | Trap net |
|---|---|---|---|---|
| Bluegill | 136.8 (35.5) | 0.5 (0.71) | 0.0 | 2.6 (4.2) |
| Brown Bullhead | 23.9 (8.5) | 0.5 (0.71) | 0.0 | 6.2 (7.8) |
| Green Sunfish | 1.7 (2.9) | 0.0 | 0.0 | 0.0 |
| Hatchery Rainbow Trout | 6.8 (8.1) | 23.5 (10.6) | 4.0 (1.4) | 0.2 (0.5) |
| Largemouth Bass | 105.0 (64.9) | 0.0 | 1.0 (0) | 0.0 |
| Pumpkinseed | 56.4 (25.9) | 0.0 | 0.5 (.71) | 1.8 (3.5) |
| Tench | 0.9 (2.3) | 0.0 | 0.0 | 1.6 (2.3) |
| Yellow Perch | 71.0 (61.4) | 5.0 (7.1) | 12.0 (17.0) | 8.4 (13.5) |

Table 6. Descriptive statistics of species sampled from Shepherd Lake in June 2020. Summarized statistics included catch, proportion of catch by number (% Catch) and biomass (% Biomass), mean total length (TL, mm), minimum and maximum total length, proportional stock density (PSD), and relative weight ($W_r$).

| Species | Count | % Catch | % Biomass | Mean TL | Min-max TL | PSD | $W_r$ |
|---|---|---|---|---|---|---|---|
| Black Crappie | 3 | 0.5% | 0.5% | 209 | 154-242 | 67 | 74 (33.5) |
| Bluegill | 419 | 68.5% | 35.7% | 149 | 40-198 | 57 | 90 (10.8) |
| Brown Bullhead | 39 | 6.4% | 16.4% | 288 | 163-321 | 97 | 91 (8.4) |
| Largemouth Bass | 41 | 6.7% | 41.2% | 361 | 129-534 | 83 | 87 (6.9) |
| Pumpkinseed | 78 | 12.7% | 4.8% | 127 | 43-186 | 20 | 102 (12.5) |
| Yellow Perch | 32 | 5.2% | 1.4% | 135 | 75-218 | 23 | 95 (17.1) |

Table 7. Catch rates (± 1 SD) by species from electrofishing (fish/h), floating gill net (fish/net), sinking gill net (fish/net), and trap net (fish/net) effort during a survey of Shepherd Lake in June 2020.

| Species | Electrofishing | Floating gill net | Sinking gill net | Trap net |
|---|---|---|---|---|
| Black Crappie | 0.0 | 0.0 | 0.0 | 0.6 (1.3) |
| Bluegill | 161.3 (90.0) | 0.0 | 0.0 | 40.2 (35.5) |
| Brown Bullhead | 14.8 (14.9) | 0.0 | 0.0 | 3.8 (3.9) |
| Largemouth Bass | 29.1 (18.1) | 0.5 (0.7) | 0.0 | 0.2 (0.4) |
| Pumpkinseed | 35.6 (21.5) | 0.0 | 0.0 | 6 (5.1) |
| Yellow Perch | 23.1 (19.8) | 0.0 | 0.0 | 0.2 (0.4) |

Table 8. Descriptive statistics of species sampled from Perkins Lake in June 2020. Summarized statistics included catch, proportion of catch by number (% Catch) and biomass (% Biomass), mean total length (TL, mm), minimum and maximum total length, proportional stock density (PSD), and relative weight ($W_r$).

| Species | Count | % Catch | % Biomass | Mean TL | Min-max TL | PSD | $W_r$ |
|---|---|---|---|---|---|---|---|
| Black Crappie | 73 | 73.0% | 71.0% | 204 | 146-232 | 73 | 90 (6.6) |
| Bluegill | 11 | 11.0% | 7.0% | 155 | 120-187 | 55 | 95 (7.8) |
| Bluegill x Pumpkinseed hybrid | 1 | 1.0% | 1.2% | 188 | 188 | -- | -- |
| Brook Trout | 1 | 1.0% | 2.1% | 299 | 299 | -- | 80 (--) |
| Largemouth Bass | 2 | 2.0% | 8.3% | 351 | 349-352 | -- | 78 (4.5) |
| Pumpkinseed | 4 | 4.0% | 3.8% | 173 | 146-184 | 75 | 94 (5.1) |
| Yellow Perch | 8 | 8.0% | 6.7% | 195 | 179-213 | 25 | 99 (11.4) |

Table 9. Catch rates (± 1 SD) from electrofishing (fish/h), floating gill net (fish/net), sinking gill net (fish/net), and trap net (fish/net) effort during a survey of Perkins Lake in June 2020.

| Species | Electrofishing | Floating gill net | Sinking gill net | Trap net |
|---|---|---|---|---|
| Black Crappie | 40.5 (66.0) | 18.0 (14.1) | 4.0 (4.2) | 0.4 (0.9) |
| Bluegill | 13.3 (13.0) | 0.5 (0.7) | 0.0 | 0.0 |
| Bluegill x Pumpkinseed Hybrid | 1.5(2.9) | 0.0 | 0.0 | 0.0 |
| Brook Trout | 0.0 | 0.0 | 0.5 (0.7) | 0.0 |
| Largemouth Bass | 3.0 (3.4) | 0.0 | 0.0 | 0.0 |
| Pumpkinseed | 7.3(14.6) | 0.0 | 0.0 | 0.0 |
| Yellow Perch | 5.9(8.3) | 0.0 | 1.5 (2.1) | 0.2 (0.4) |

Table 10. Summary of lowland lake survey metrics from past and present surveys of Kelso Lake. Metrics included percent of catch by number (% Catch), percent of catch by weight (% Biomass), proportional stock density (PSD), mean total length (TL, mm), and mean relative weight ($W_r$).

| Year | Species | % Catch | % Biomass | PSD | Mean TL | $W_r$ |
|---|---|---|---|---|---|---|
| 1995 | Black Crappie | not present | | -- | -- | -- |
| 2008 | Black Crappie | <1% | 1% | -- | -- | -- |
| 2020 | Black Crappie | 0% | 0% | -- | -- | -- |
| 1995 | Bluegill | present | -- | 26 | -- | -- |
| 2008 | Bluegill | 35% | 18% | 48 | 141 | 105 |
| 2020 | Bluegill | 26% | 19% | 66 | 163 | 99 |
| 1995 | Brown Bullhead | present | -- | -- | -- | -- |
| 2008 | Brown Bullhead | 0% | 0% | -- | -- | -- |
| 2020 | Brown Bullhead | 9% | 13% | 92 | 243 | 92 |
| 1995 | Hatchery Rainbow Trout | present | -- | -- | -- | -- |
| 2008 | Hatchery Rainbow Trout | 2% | 4% | -- | -- | -- |
| 2020 | Hatchery Rainbow Trout | 10% | 20% | -- | 296 | -- |
| 1995 | Largemouth Bass | present | -- | 24 | -- | -- |
| 2008 | Largemouth Bass | 25% | 35% | 22 | 201 | 56 |
| 2020 | Largemouth Bass | 19% | 19% | 15 | 207 | 86 |
| 1995 | Pumpkinseed | present | -- | -- | -- | -- |
| 2008 | Pumpkinseed | 22% | 7% | -- | -- | -- |
| 2020 | Pumpkinseed | 11% | 5% | 59 | 139 | 103 |
| 1995 | Tench | present | -- | -- | -- | -- |
| 2008 | Tench | 2% | 19% | -- | -- | -- |
| 2020 | Tench | 1% | 11% | -- | 406 | -- |
| 1995 | Yellow Perch | present | -- | -- | -- | -- |
| 2008 | Yellow Perch | 13% | 16% | -- | -- | -- |
| 2020 | Yellow Perch | 24% | 13% | 17 | 175 | 95 |

Table 11. Summary of lowland lake survey metrics from past and present surveys of Shepherd Lake. Metrics included percent of catch by number (% Catch), percent of catch by weight (% Biomass), proportional stock density (PSD), mean total length (TL, mm), and mean relative weight (Wr).

| Year | Species | % of Catch | % of Biomass | PSD | Mean TL | $W_r$ |
|---|---|---|---|---|---|---|
| 1992 | Black Crappie | 30% | 16% | -- | -- | -- |
| 1997 | Black Crappie | 5% | 2% | -- | -- | -- |
| 2007 | Black Crappie | 3% | 3% | -- | -- | -- |
| 2020 | Black Crappie | >1% | >1% | 67 | 208 | 74 |
| 1992 | Bluegill | 0% | -- | -- | -- | -- |
| 1997 | Bluegill | 50% | 33% | 46 | -- | 96 ($W_r$- 200 mm) |
| 2007 | Bluegill | 42% | 23% | 51 | 136 | -- |
| 2020 | Bluegill | 68% | 36% | 57 | 149 | 91 |
| 1992 | Brown Bullhead | 1% | -- | -- | -- | -- |
| 1997 | Brown Bullhead | -- | -- | -- | -- | -- |
| 2007 | Brown Bullhead | 2% | 5% | | | |
| 2020 | Brown Bullhead | 6% | 16% | 97 | 288 | 91 |
| 1992 | Largemouth Bass | 11% | 12% | -- | -- | -- |
| 1997 | Largemouth Bass | 17% | 38% | 49 | -- | -- |
| 2007 | Largemouth Bass | 11% | 47% | 30 | 275 | 63 |
| 2020 | Largemouth Bass | 7% | 41% | 83 | 361 | 87 |
| 1992 | Pumpkinseed | 31% | 23% | -- | -- | -- |
| 1997 | Pumpkinseed | 23% | 13% | -- | -- | -- |
| 2007 | Pumpkinseed | 35% | 17% | | 130 | |
| 2020 | Pumpkinseed | 13% | 5% | 20 | 127 | 102 |
| 1992 | Yellow Perch | 31% | 47% | -- | -- | -- |
| 1997 | Yellow Perch | 4% | 1% | -- | -- | -- |
| 2007 | Yellow Perch | 7% | 5% | -- | -- | -- |
| 2020 | Yellow Perch | 5% | 1% | 23 | 135 | 95 |

Table 12. Summary of lowland lake survey metrics from past and present surveys of Perkins Lake. Metrics included percent of catch by number (% Catch), percent of catch by weight (% Biomass), proportional stock density (PSD), mean total length (TL, mm), and mean relative weight ($W_r$).

| Year | Species | % of Catch | % of Biomass | PSD | Mean TL | $W_r$ |
|---|---|---|---|---|---|---|
| 1987 | Black Crappie | 30% | -- | -- | 219 | -- |
| 2005 | Black Crappie | 9% | 11% | -- | -- | -- |
| 2020 | Black Crappie | 73% | 71% | 75 | 204 | 90 |
| 1987 | Bluegill | 0% | -- | -- | -- | -- |
| 2005 | Bluegill | 1% | 4% | -- | -- | -- |
| 2020 | Bluegill | 11% | 7% | 55 | 155 | 95 |
| 1987 | Brown Bullhead | 4% | -- | -- | -- | -- |
| 2005 | Brown Bullhead | -- | -- | -- | -- | -- |
| 2020 | Brown Bullhead | -- | -- | -- | -- | -- |
| 1987 | Largemouth Bass | 48% | -- | -- | 225 | -- |
| 2005 | Largemouth Bass | 23% | 23% | 12 | -- | -- |
| 2020 | Largemouth Bass | 2% | 8% | -- | 351 | 78 |
| 1987 | Pumpkinseed | 19% | -- | -- | 193 | -- |
| 2005 | Pumpkinseed | 8% | 15% | -- | -- | -- |
| 2020 | Pumpkinseed | 4% | 4% | 75 | 173 | 94 |
| 1987 | Yellow Perch | -- | -- | -- | -- | -- |
| 2005 | Yellow Perch | 59% | 47% | -- | -- | -- |
| 2020 | Yellow Perch | 8% | 7% | 25 | 195 | 99 |

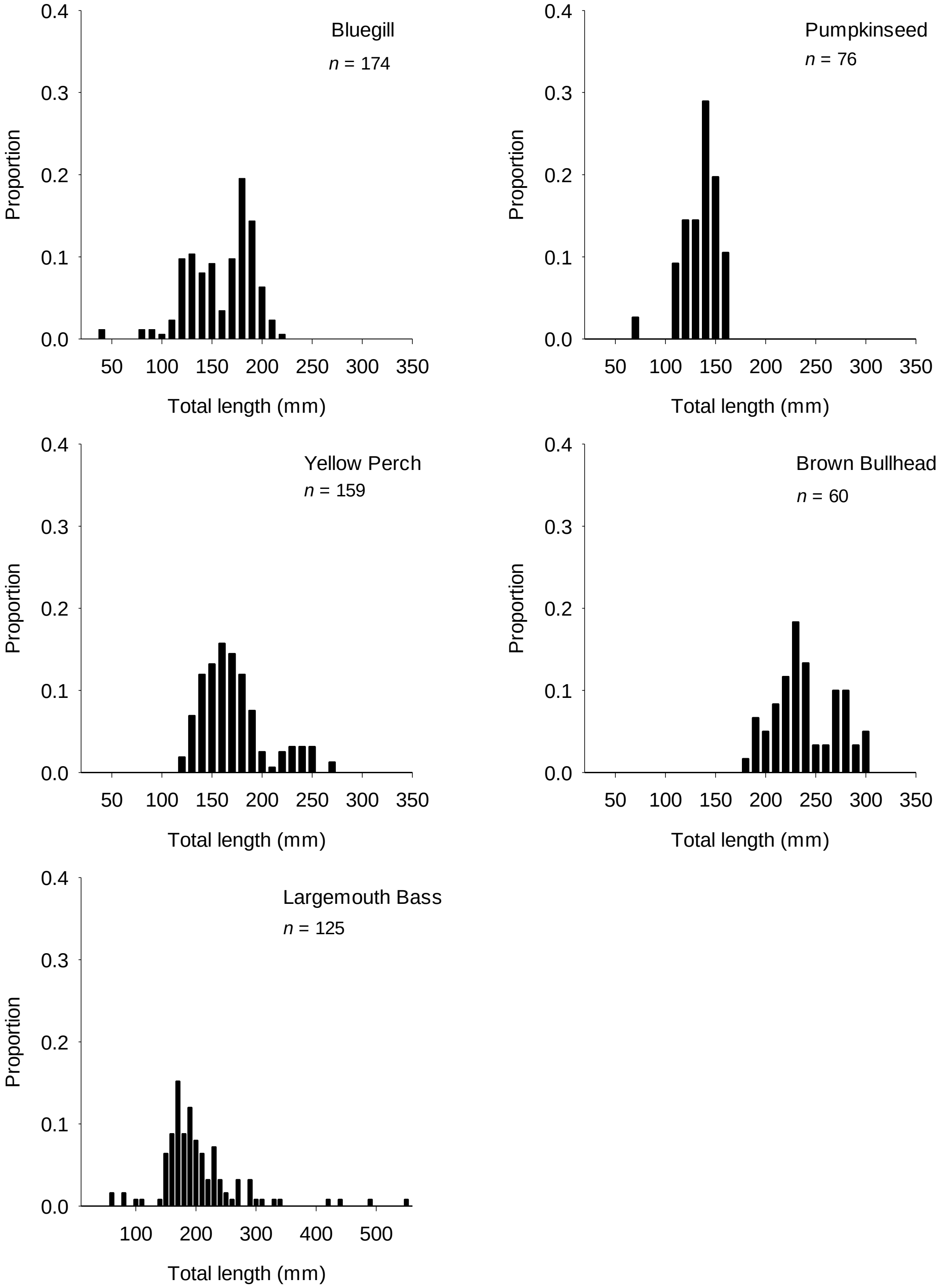

Figure 1. Length distributions (proportion %) of Bluegill, Pumpkinseed, Yellow Perch, Brown Bullhead, and Largemouth Bass sampled using boat electrofishing, gill nets, and trap nets from Kelso Lake in June 2020.

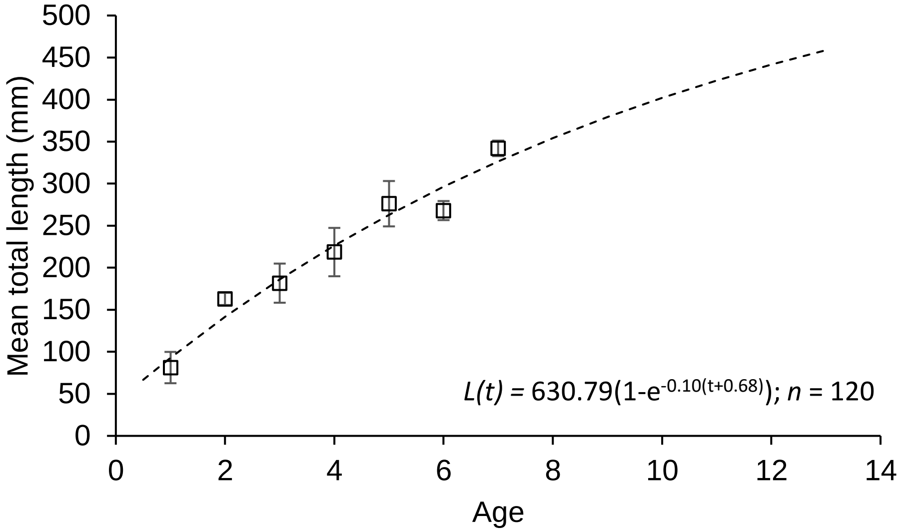

Figure 2. Mean total length-at-age for Largemouth Bass sampled in a lowland lake survey of Kelso Lake, Idaho in 2020. Error bars represent one standard deviation about the mean. The plotted line represents estimated mean length-at-age from the von Bertalanffy growth function.

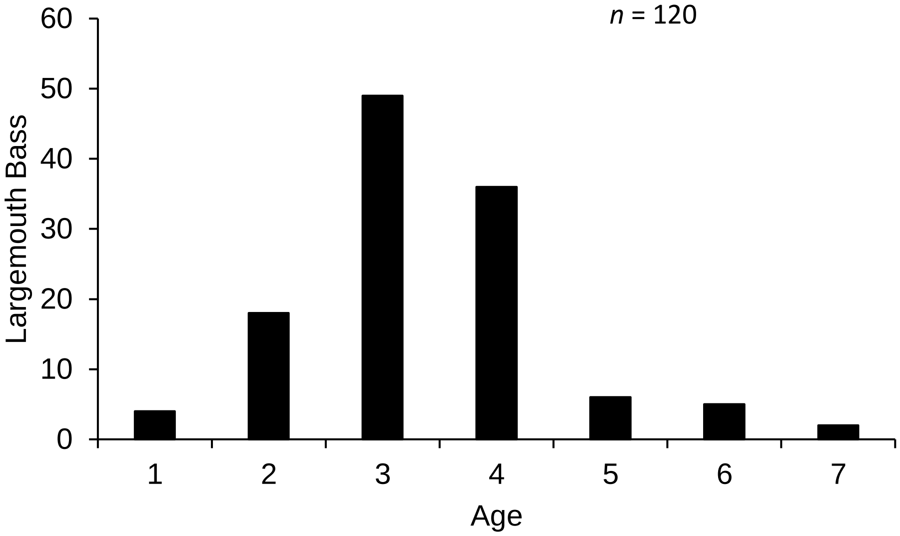

Figure 3. Age-frequency of Largemouth Bass sampled using boat electrofishing, gill nets, and trap nets from Kelso Lake in June 2020.

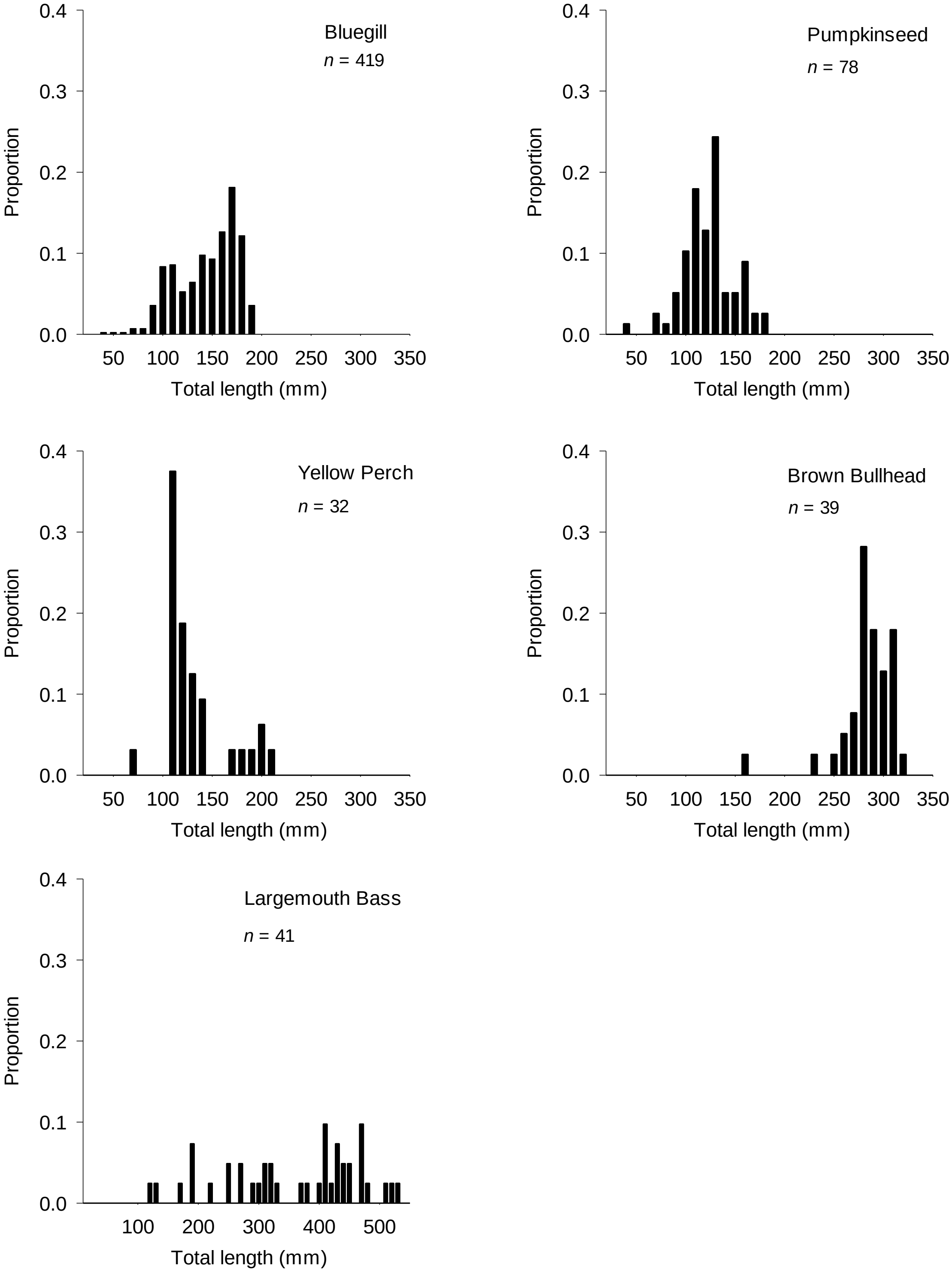

Figure 4. Length distributions (proportion %) of Bluegill, Pumpkinseed, Yellow Perch, Brown Bullhead, and Largemouth Bass sampled using boat electrofishing, gill nets, and trap nets from Shepherd Lake in June 2020.

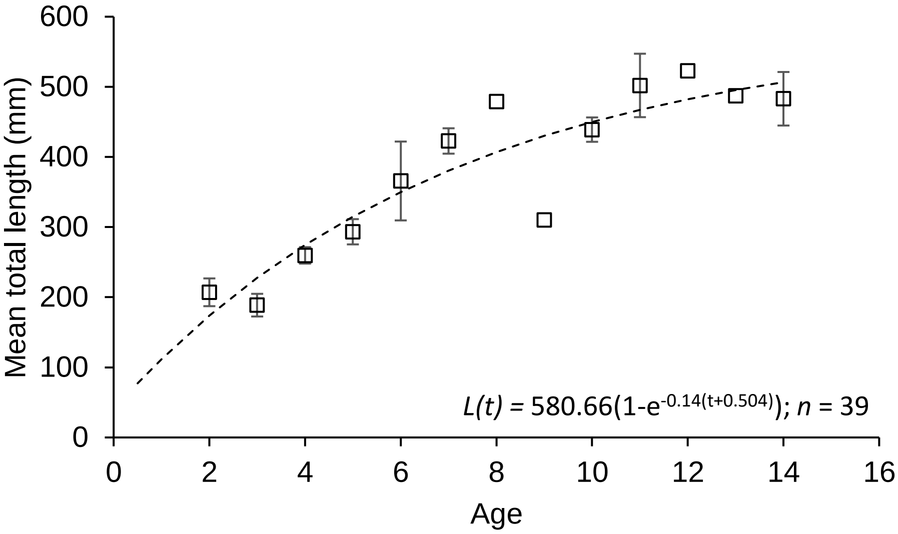

Figure 5. Mean total length-at-age for Largemouth Bass sampled in a lowland lake survey of Shepherd Lake, Idaho in 2020. Error bars represent one standard deviation about the mean. The plotted line represents estimated mean length at age from the von Bertalanffy growth function.

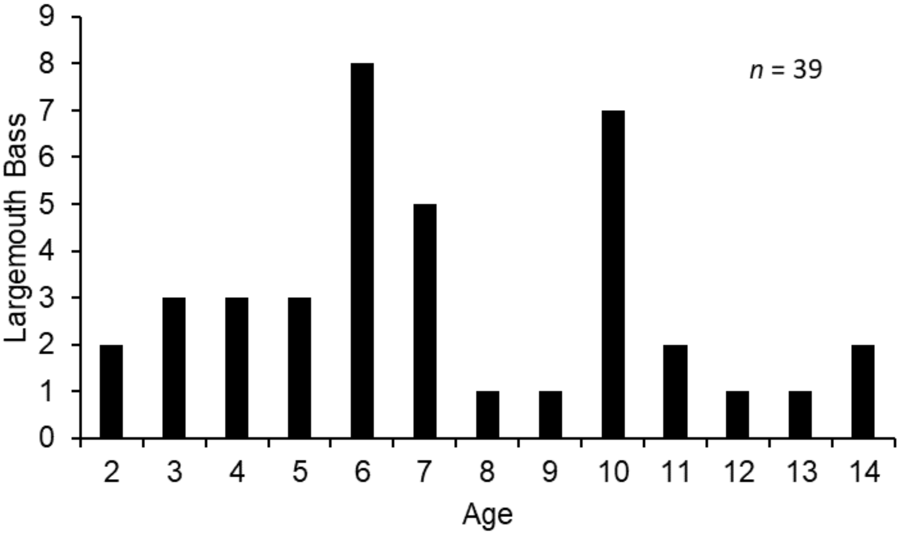

Figure 6. Age-frequency distribution of Largemouth Bass sampled using boat electrofishing, gill nets, and trap nets from Shepherd Lake in June 2020.

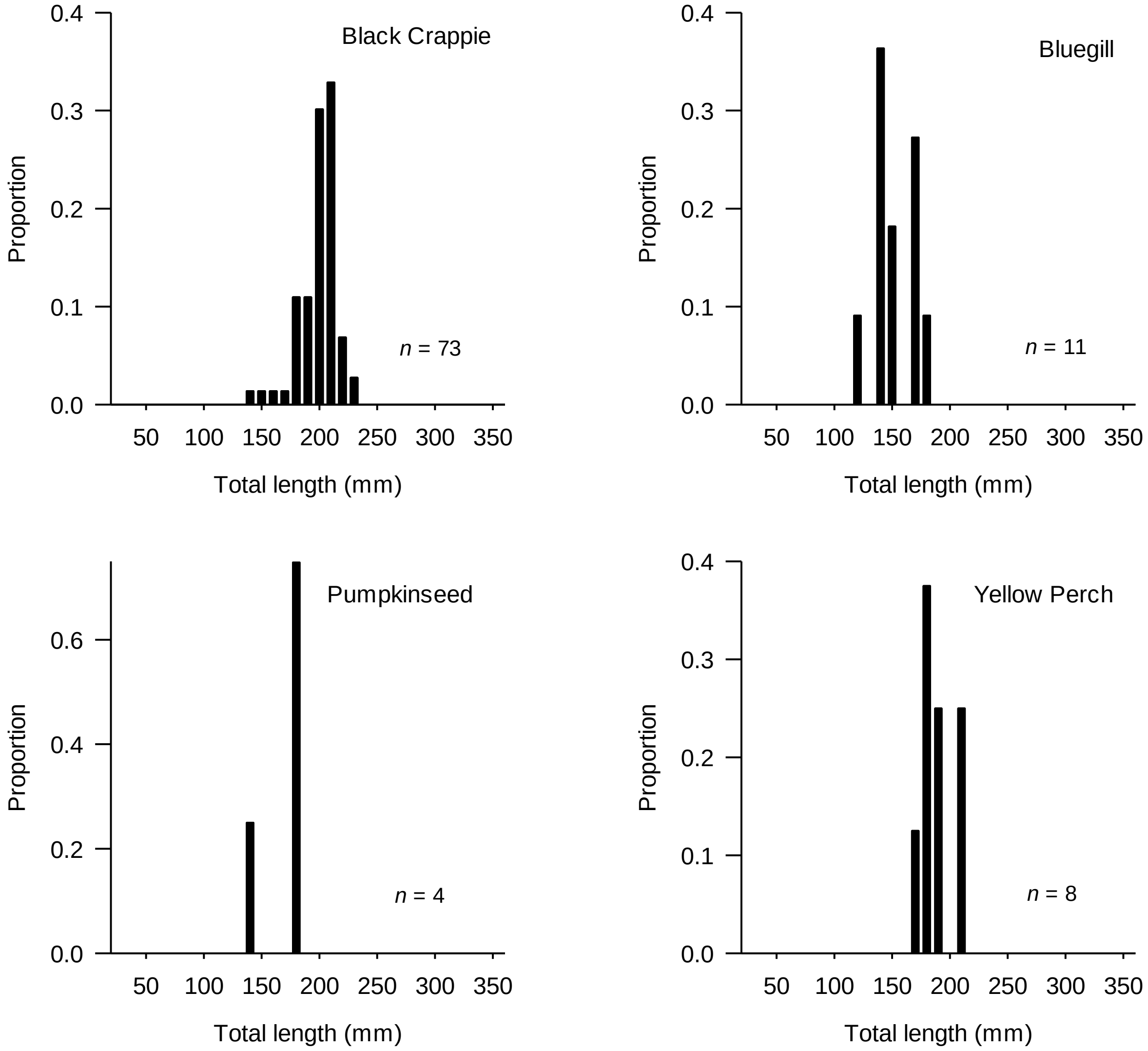

Figure 7. Length-frequency distributions (proportion %) of Black Crappie, Bluegill, Pumpkinseed, and Yellow Perch sampled using boat electrofishing, gill nets, and trap nets from Perkins Lake in June 2020.

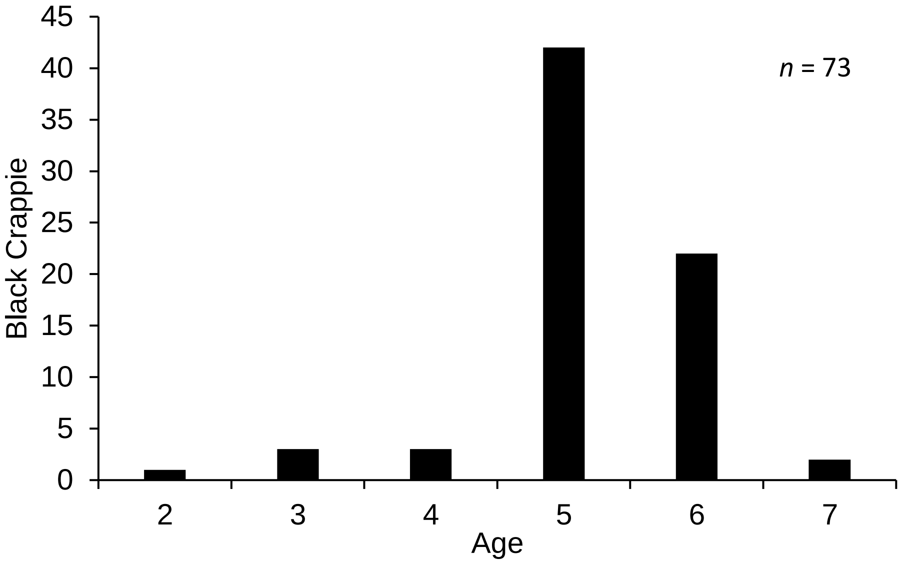

Figure 8. Age-frequency distribution of Black Crappie sampled using boat electrofishing, gill nets, and trap nets from Perkins Lake in June 2020.

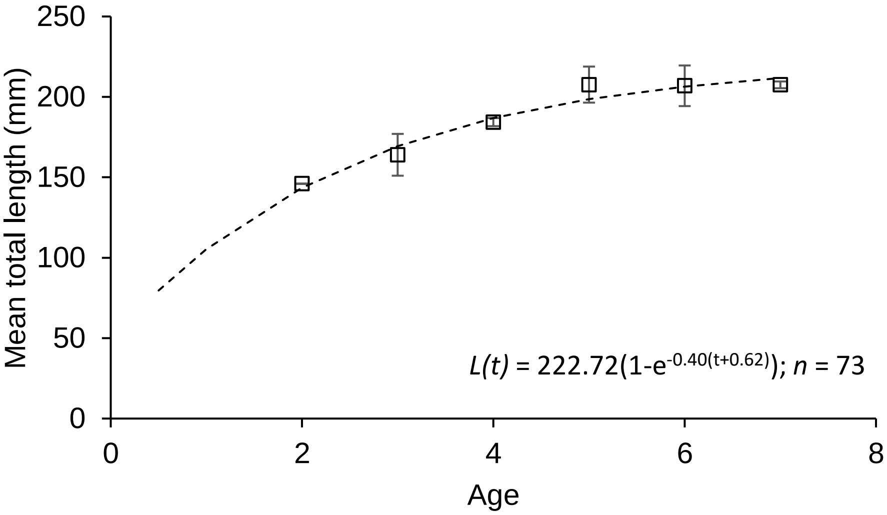

Figure 9. Mean total length-at-age for Black Crappie sampled in a lowland lake survey of Perkins Lake, Idaho in 2020. Error bars represent one standard deviation about the mean. The plotted line represents estimated mean length at age from the von Bertalanffy growth function.

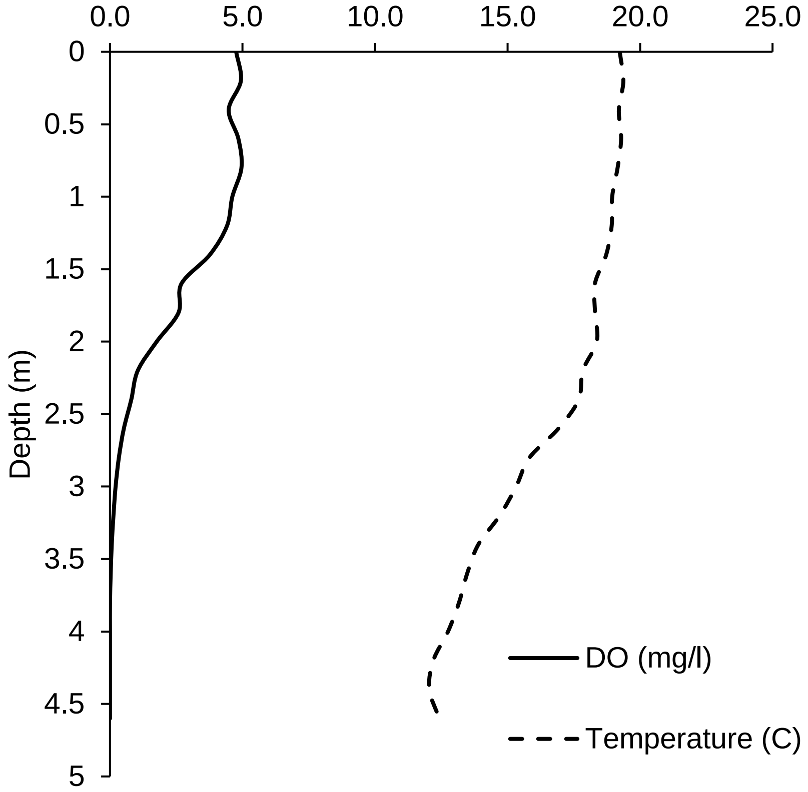

Figure 10. Temperature (°C) and dissolved oxygen (mg/l) profiles from Perkins Lake on September 2, 2020.

## LAKE TROUT MANAGEMENT IN UPPER PRIEST LAKE

## ABSTRACT

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

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# INTRODUCTION

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

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

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

Suppression programs employing gill net removals to manage Lake Trout abundance have been applied in other western waters (Dux et al. 2019, Syslo et al. 2011, Syslo et al. 2013). Evaluations of these suppression programs suggested effort, gear type, and gear configuration were all influential factors in achieving population suppression goals (Hansen et al. 2019, Syslo et al. 2013). Lake Trout removal efforts on Upper Priest Lake thus far have demonstrated an ability to manage population growth. However, past effort and gear configuration may not have maximized suppression potential. Hansen et al. (2019), suggested the targeted removal of large mature Lake Trout was important for increasing the efficiency of Lake Trout suppression in Lake Pend Oreille, Idaho. In that suppression program, removal efforts in fall periods focused on spawning locations with large mesh gill nets to remove mature Lake Trout. Spawning locations were identified using telemetry (Wahl et al 2011). In 2019 and 2020, we used acoustic telemetry methods to investigate potential Lake Trout spawning locations in Upper Priest Lake. The intent of these investigations was to identify locations where targeted fall removals of mature Lake Trout could be evaluated in Upper Priest Lake.

## OBJECTIVE

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

## STUDY SITE

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

## METHODS

### Lake Trout Removal

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

Monofilament sinking gill nets were used to capture and remove Lake Trout from Upper Priest Lake. Individual gill net dimensions were 91 m long by 2.7 m high. Multiple nets were tied together end-to-end to create a single net gang. Collectively, the net gang was comprised of a range of mesh sizes. Standardized mesh sizes (stretch-measure) were 45, 51, 64, 76, 89, 102, 114, and 127 mm (Table 13). Fishing effort was measured in units defined as net boxes. Boxes were used to transport nets onboard the boat and each box of net was equivalent to approximately 273 m or three 91 m nets. Daily effort was split between morning and afternoon sets. The combined effort per day was 30 boxes of gill net. A total of 240 boxes of gill net was placed over nine days. Both morning and afternoon sets were made on each day, except the first and last days during which only one set was made on each date. The combined total effort for the first and last day was 30 boxes of net. Typically, 18 boxes of net were set in the morning and 12 boxes of net were set in the afternoon. The combined effort by mesh size was consistent within morning and afternoon sets, respectively. The time between net placement and initiating net lifting varied from two to five hours for all sets. Gill nets were set throughout Upper Priest Lake over the course of the project at depths varying from 10 to 31 m. Placement of nets in and around the primary inlets and outlet of Upper Priest Lake was avoided to reduce bycatch of Bull Trout and Westslope Cutthroat Trout.

Relative abundance of Lake Trout in Upper Priest Lake was measured as average daily catch per unit of effort (CPUE) or fish per net box per day for catch associated with

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

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

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

### Lake Trout Telemetry

Acoustic telemetry tags were surgically implanted in the abdominal cavity of Lake Trout collected from Upper Priest Lake in May of 2019 and 2020 during annual Lake Trout removal efforts. We attempted to tag mature Lake Trout by only tagging fish ≥550 mm (Ng et al. 2016). We used Lotek MM-series acoustic telemetry tags, with temperature and pressure sensors (Lotek Wireless Incorporated; Newmarket, Ontario; MM-M-16-33-TP). Tags were preprogramed from the manufacturer with a 90-day delayed start and 90-day on off cycle. Pressure sensors were rated for 1-150 psi. Temperature sensors were rated for -6-34 °C. We anticipated tags would be active for two fall spawning periods, based on the manufacture's predicted battery life. Each tag had a unique code allowing identification of individual fish.

We used paired, boat-mounted directional hydrophones and a MAP 600RT P2 receiver (Lotek Wireless Inc., Newmarket, Ontario) to mobile-track tagged Lake Trout (Wahl et al. 2011). MAPHOST software allowed simultaneous decoding of multiple signals and provided direction of arrival of the transmitters' acoustic signals. Additionally, we deployed a WHS 3250D stationary receiver (Lotek Wireless Inc., Newmarket, Ontario) in the lower portion of the Thorofare, upstream of Priest Lake. This receiver was positioned to detect movement of tagged fish out of Upper Priest Lake during the tracking periods.

Mobile tracking occurred weekly to describe where and when Lake Trout spawning occurred in Upper Priest Lake. We anticipated tracking would identify concentrations of fish at isolated near shore locations, suggesting spawning was occurring at those locations. We expected Lake Trout spawning in Upper Priest Lake would occur between late-August and early-November, based on observations from other systems (Dux et al. 2011, Fredenberg et al. 2017). As such, tracking events occurred from August 23 through November 7 in 2019 and from September 24 through October 21 in 2020. Fall drawdown of Priest Lake made boat access to Upper Priest Lake via the Thorofare impossible by early-November 2019 and late-October 2020, influencing the duration of tracking in both years. One loop around the lake was completed during each tracking session to locate tagged fish. The remote nature of Upper Priest Lake limited the number of tracking events and influenced the time during which tracking occurred. Tracking typically occurred between 10 AM and 2 PM.

Tag locations identified during tracking efforts were summarized in ArcMap (Environmental Systems Research Institute). Tag locations were grouped by calendar week. Tag locations in 2020 were combined with those from the corresponding week in 2019 because data from 2020 were limited. Weekly kernel density maps, created in ArcMap, were used to generally describe concentrations of fish. We qualitatively assessed distribution patterns to determine the period during which fish were most concentrated nearshore.

## RESULTS

### Lake Trout Removal

We caught 2,726 Lake Trout during the nine-day gillnetting effort in 2020 (Table 14). Average daily catch rate from 51-, 64-, and 76-mm mesh sizes combined was 10.2 fish/box (± 3.0, 80% C.I.; Figure 11) which continued to demonstrate a long-term negative trend in catch ($n = 11$; $P = 0.01$, $r = -0.76$; Figure 11). Mesh-specific catch rates were quite similar to those observed in 2019 for most mesh sizes, but catch rates were greater in 2020 for the 89- and 102-mm mesh sizes (Figure 12).

Total length of Lake Trout varied from 117 to 1026 mm and averaged 461 mm (Figure 13). In general, fish length increased with increasing gill net mesh size (Table 13). Catch rates were greatest in 45- and 89-mm mesh sizes and accounted for 57% of the total catch. However, these mesh sizes only represented 27% of total effort expended.

Incidentally caught species included Bull Trout, kokanee *Oncorhynchus nerka*, Longnose Sucker *Catostomus catostomus*, Largescale Sucker *C. macrocheilus*, Northern Pikeminnow *Ptychocheilus oregonensis*, Peamouth *Mylocheilus caurinus* and Westslope Cutthroat Trout. We caught 21 Bull Trout, representing an average daily catch rate of 0.08 fish per box of net. This catch rate was below the average rate observed over the previous ten years (0.16 Bull Trout per box, Figure 13). Bull Trout total length varied from 238 mm to 795 mm and averaged 488 mm. The majority of Bull Trout caught in gill nets were in good or fair condition upon capture. These fish were PIT tagged and released. Direct mortality of bycaught Bull Trout in gill nets was 29%.

### Lake Trout Telemetry

Fifteen Lake Trout were tagged in the 2019 tagging effort. Five additional acoustic telemetry tags were implanted in Lake Trout in 2020. Two tags were recovered from fish tagged in 2019 and were subsequently implanted in Lake Trout caught in May of 2020. One of these recovered tags was detected leaving Upper Priest Lake through the Thorofare in 2019. This fish was later caught by an angler in 2019 and the tag was returned. The second recovered tag was collected from a mortality during our 2020 Lake Trout removal efforts on Upper Priest Lake. Tagged Lake Trout varied in total length (TL) from 570 to 800 mm (mean TL= 683).

We completed 17 tracking events in 2019 and 5 tracking events in 2020. In 2019, we detected 12 of the 15 tagged fish in all tracking events (Table 14). One tag was never detected and was assumed to be defective, or the fish left Upper Priest Lake while the tag was inactive. Another tag was detected during mobile-tracking events seven times, but was later detected leaving Upper Priest Lake in the fall of 2019. One tag was detected in 12 tracking events, but was not detected in the last five tracking events. This fish was recaptured during the 2020 Lake Trout removal efforts and the tag was implanted in a new fish. Three tags were detected in similar locations throughout all 2019 tracking events and were assumed to be expelled or the fish died.

Detection rates were generally lower in 2020 (Table 14). Fifteen tags were detected during at least three of the five tracking events. Seven of those tags were detected in all five tracking events. Four of those tags were previously assumed to be inactive in 2019. An inactive states likely indicated the tag was either expelled or the fish died. In addition, two tags active in 2019 were assumed to be inactive in 2020 based on a lack of movement. Two tags placed in fish in 2020 were never detected.

Weekly locations of tagged fish suggested distribution was relatively scattered from week 34 through week 44 (Figure 15). In general, Lake Trout were observed most frequently along the western shoreline of the lake in all weeks. A confined grouping of fish was observed near shore in week 45 along the northwestern shoreline of the lake and was considered a potential spawning aggregation. Lake Trout were also detected adjacent to the historic Navigation Mine adit on the southwestern shoreline of the lake in most weeks. While we did not observe a distinct nearshore congregation at this location, it likely represented a common area of use by Lake Trout in the fall. Mean depth of detected tags varied from 5.7 to 9.7 m (Figure 16). Water temperature associated with tag detections varied from 6.0 to 8.5 °C (Figure 16).

## DISCUSSION

### Lake Trout Removal

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

Although Lake Trout catch rates showed stability in relative abundance overall, we observed higher catch rates in 89- and 102-mm mesh sizes. Mesh-specific catch rates provide insight into fine-scale changes in the Lake Trout size structure. However, identifying a specific cause for minor shifts in mesh-specific catch rates is difficult. We hypothesize potential causes may include immigration, influences on catchability due to growth within a cohort, seasonal influences on catchability (e.g., water temperature), or random catch rate fluctuation. Immigration of Lake Trout from Priest Lake to Upper Priest Lake is known to occur (Fredericks and Venard 2001) and likely influenced Lake Trout abundance in Upper Priest Lake, but to what extent is unknown.

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

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

### Lake Trout Telemetry

Telemetered locations of Lake Trout in Upper Priest Lake suggested spawning likely occurred in late-October and early-November along the northwestern shoreline of the lake. Our interpretation of the spawning period in Upper Priest Lake was similar to observations from other Lake Trout populations in the western United States, including Lake McDonald and Quartz Lake in Montana’s Flathead River drainage (Dux et al. 2011, Fredenberg et al. 2017). In contrast, Lake Trout are believed to spawn primarily in September in Lake Pend Oreille, but utilize deeper spawning habitat than most Lake Trout populations (Wahl et al. 2011). Our observations of presumed spawning locations differed from prior telemetry efforts on Upper Priest Lake. Fredericks et al. (2000) tracked seven mature Lake Trout in Upper Priest Lake throughout the expected spawning window. They found minimal congregation during most periods, but suggested fish locations in week 40 near main-lake points on the east side of Upper Priest Lake potentially represented spawning locations. While we did detect fish on the eastern shoreline of the lake, few fish were regularly detected in that zone throughout our tracking period.

Mean depth of tag detections in our study did not suggest Lake Trout were closely associated with the shoreline during any tracking period, creating some uncertainty in identifying spawning periods. A concentration of Lake Trout was observed during week 36, but most detected locations were not closely oriented to the shoreline and as a result were not thought to represent spawning activity. In general, tag locations in week 45 were not only concentrated, but were closer to shore than prior observations, suggesting spawning activity occurred in this period. Our tracking occurred primarily during mid-day periods and may have influenced preferred depth.

Our ability to track tagged Lake Trout throughout the potential spawning window was limited by water depth in the Thorofare. Low water level prohibited access to Upper Priest Lake by early-November 2019 and late-October 2020. Priest Lake water level management in 2019 and 2020 likely caused variation in drawdown timing. As such, our telemetry access experience highlighted potential limitations for future attempts at targeted fall netting. Therefore, we recommend any targeted fall gill net removal efforts be initially approached on a pilot level. And due to access limitations, we recommend conducting the netting evaluation prior to November to understand if netting before peak spawning concentrations could be effective at removing mature Lake Trout.

## MANAGEMENT RECOMMENDATIONS

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

2. Evaluate the effectiveness of targeted fall Lake Trout removal effort at identified spawning locations on Upper Priest Lake.

Table 13. Gillnet effort and Lake Trout (LKT) catch by gillnet mesh size in Upper Priest Lake, Idaho during 2020. Size of Lake Trout by mesh size is depicted as average total length (Avg TL) and standard deviation (SD TL) of total length.

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

Table 14. Summary of acoustic telemetry tag detections from Lake Trout tagged and released in Upper Priest Lake, Idaho in 2019 and 2020. Data include mean (± 1 SD) depth (m) and temperature (°C) of detected tags among all detections.

| Tag ID | Total length (mm) | Year tagged | Tracking year | Detections | Mean depth (m) | Mean temp (°C) | Fate |
|---|---|---|---|---|---|---|---|
| 42300 | 570 | 2019 | 2019 | 17 | 5.9±2.0 | 7.6±1.6 | |
| 42400 | 674 | 2019 | 2019 | 17 | 9.7±0.5 | 5.2±0.0 | Dead |
| 42500 | 687 | 2019 | 2019 | 17 | 9.6±6.3 | 5.8±0.6 | |
| 42600 | 578 | 2019 | 2019 | 17 | 5.6±2.5 | 7.6±1.7 | |
| 42700 | 580 | 2019 | 2019 | 17 | 32.8±6.2 | 6.1±0.4 | |
| 42800 | 785 | 2019 | 2019 | 17 | 4.5±1.5 | 7.3±1.4 | |
| 42900 | 670 | 2019 | 2019 | 7 | 4.5±2.4 | 8.6±2.3 | Detected Leaving |
| 43000 | 674 | 2019 | 2019 | 12 | 5.7±2.4 | 7.8±1.7 | Lost Signal |
| 43100 | 723 | 2019 | 2019 | 17 | 3.3±2.5 | 7.8±1.5 | |
| 43200 | 645 | 2019 | 2019 | 17 | 5.1±2.3 | 8.5±1.3 | |
| 43300 | 773 | 2019 | 2019 | 17 | 3.3±2.6 | 6.4±1.1 | |
| 43400 | 671 | 2019 | 2019 | 17 | 9.8±0.1 | 5.3±0.2 | Dead |
| 43500 | 672 | 2019 | 2019 | 17 | 7.5±0.6 | 6.0±0.6 | Dead |
| 43600 | 725 | 2019 | 2019 | 17 | 4.4±3.1 | 8.1±2.4 | |
| 43700 | 740 | 2019 | 2019 | -- | -- | -- | No Detection |
| 42300 | 570 | 2019 | 2020 | 5 | 5.1±0.7 | 8.7±0.7 | |
| 42400 | 674 | 2019 | 2020 | 3 | 9.8±0.0 | 6.0±0.0 | Dead |
| 42500 | 687 | 2019 | 2020 | 5 | 7.7±0.0 | 6.3±0.5 | Dead |
| 42700 | 580 | 2019 | 2020 | 3 | 26.6±13.3 | 6.8±0.0 | |
| 42800 | 800 | 2020 | 2020 | 4 | 5.4±1.0 | 8.0±0.8 | |
| 42900 | 690 | 2020 | 2020 | 5 | 3.9±2.1 | 8.2±1.9 | |
| 43000 | 674 | 2019 | 2020 | 5 | 3.3±1.9 | 10.8±2.8 | |
| 43100 | 723 | 2019 | 2020 | 5 | 3.0±2.1 | 9.8±1.8 | |
| 43200 | 645 | 2019 | 2020 | 5 | 9.1±0.0 | 7.6±0.0 | Dead |
| 43400 | 671 | 2019 | 2020 | 4 | 9.8±0.0 | 6.2±0.4 | Dead |
| 43500 | 672 | 2019 | 2020 | 4 | 8.9±0.3 | 6.6±0.4 | Dead |
| 43600 | 725 | 2019 | 2020 | 4 | 3.6±1.5 | 10.8±1.6 | |
| 43900 | 708 | 2020 | 2020 | 4 | 4.5±3.4 | 8.4±1.6 | |
| 44100 | 590 | 2020 | 2020 | 5 | 3.5±1.5 | 9.8±0.9 | |
| 44200 | 645 | 2020 | 2020 | 3 | 2.1±1.8 | 10.8±1.6 | |
| 43800 | 775 | 2020 | 2020 | -- | -- | -- | No Detection |
| 44000 | 655 | 2020 | 2020 | -- | -- | -- | No Detection |

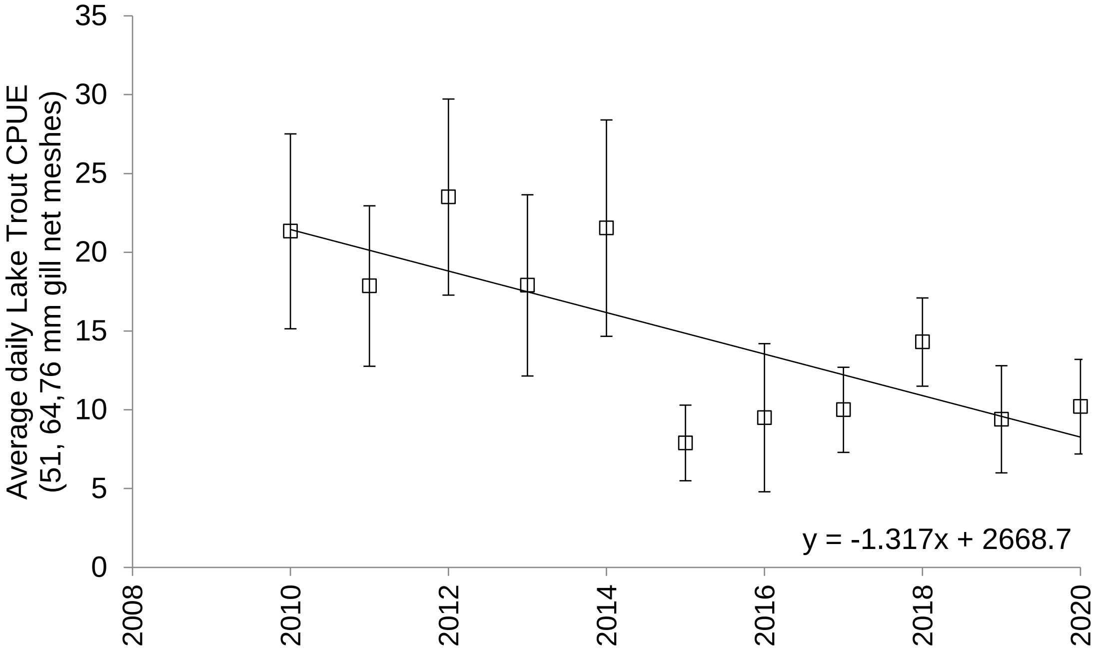

Figure 11. Average daily Lake Trout catch rates and 80% confidence intervals by year from combined standard gill net mesh sizes (51, 64, and 76 mm) fished in Upper Priest Lake, Idaho from 2010 through 2020.

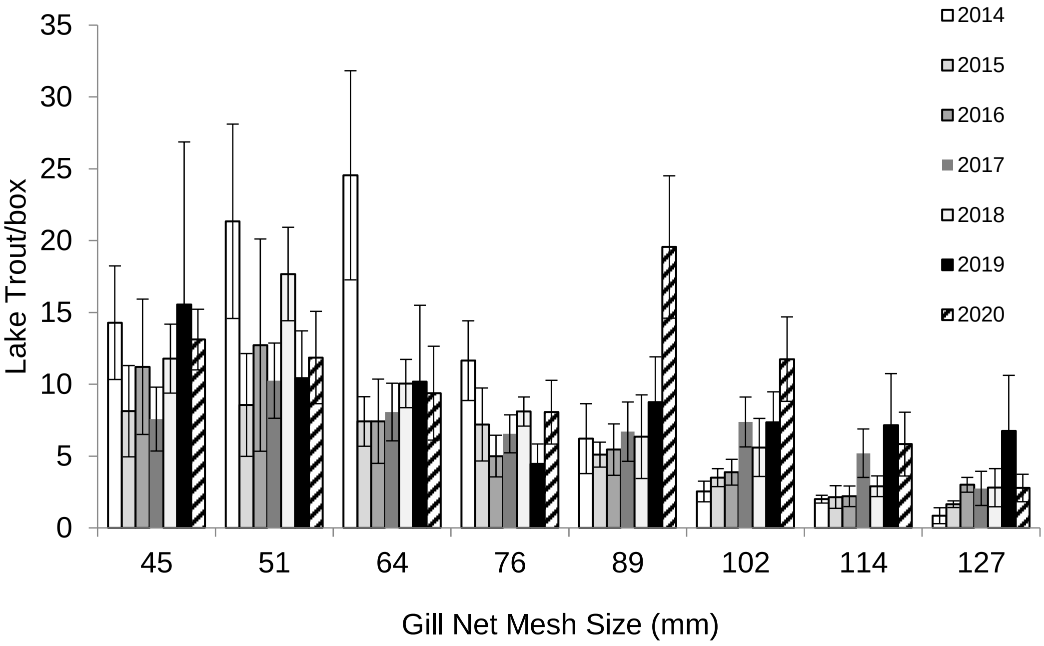

Figure 12. Average daily Lake Trout catch rate (Lake Trout/box) and 80% confidence intervals by mesh size from all standardized gill nets fished in Upper Priest Lake, Idaho from 2014 through 2020.

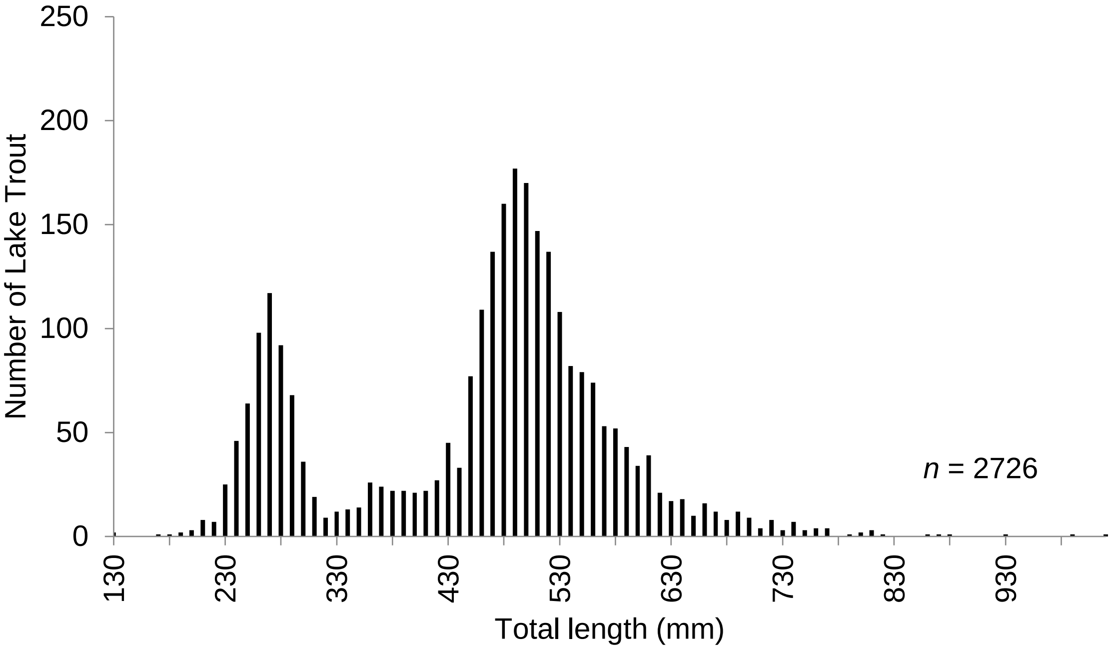

Figure 13. Length-frequency distribution of Lake Trout sampled in Upper Priest Lake, Idaho during 2020.

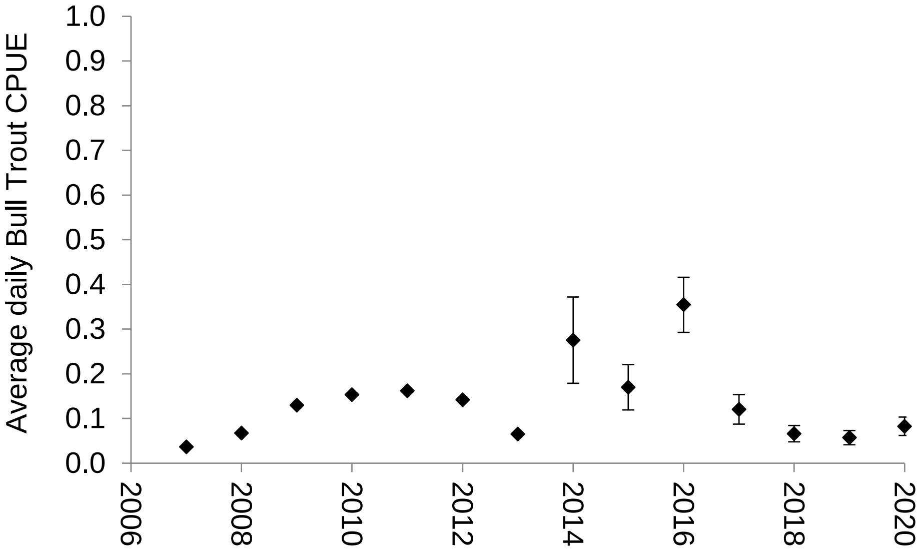

Figure 14. Average daily Bull Trout catch rate (Bull Trout/box) and 80% confidence intervals from all gill net mesh sizes fished in Upper Priest Lake, Idaho from 2007 through 2020. Confidence intervals (80%) were only estimated for years in which gill nets mesh and effort were standardized.

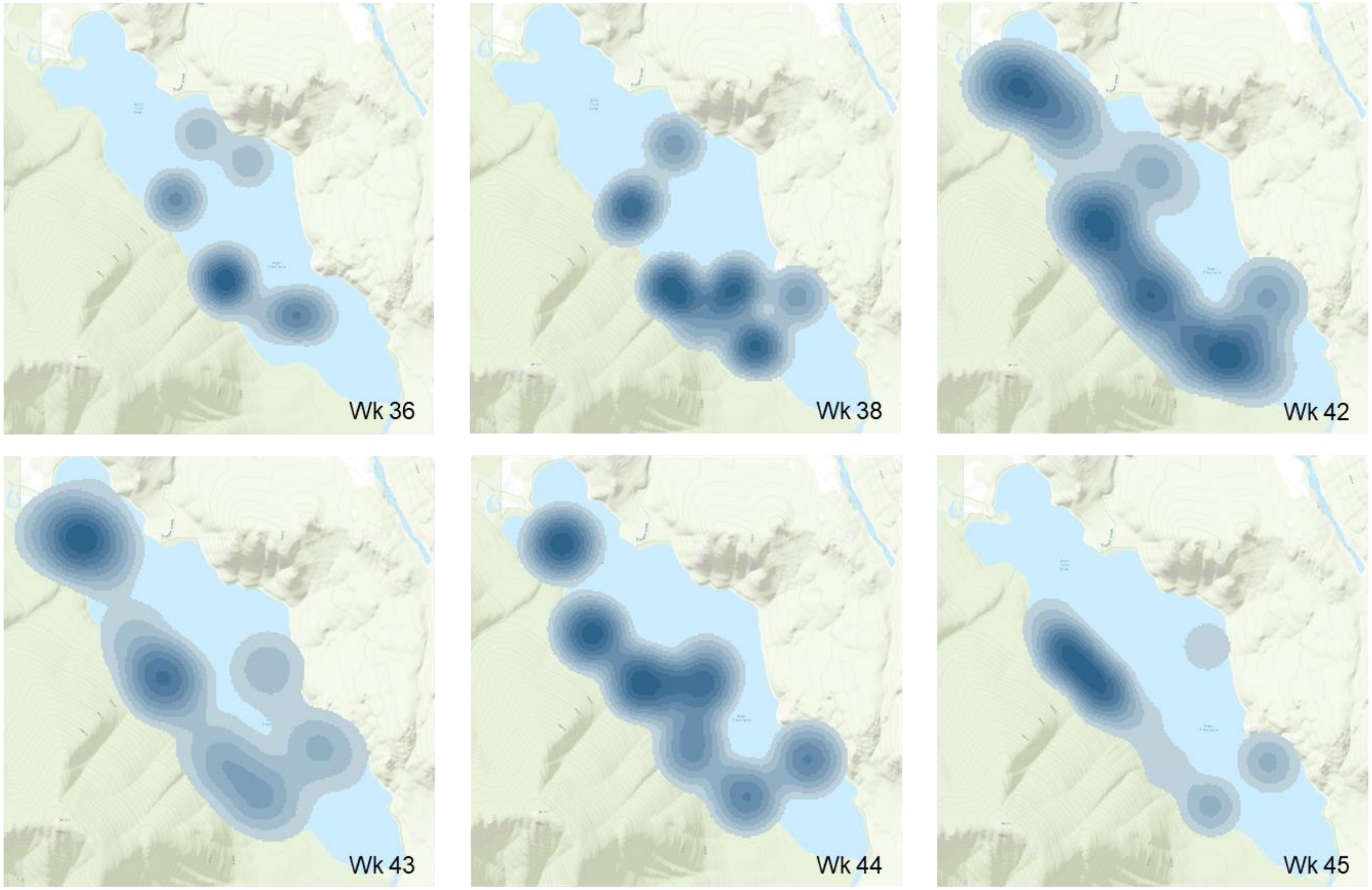

Figure 15. Kernel density plots of Lake Trout telemetry locations on Upper Priest Lake, Idaho from selected calendar week 36 through week 45. Plots include telemetry location data collected in 2019 and 2020.

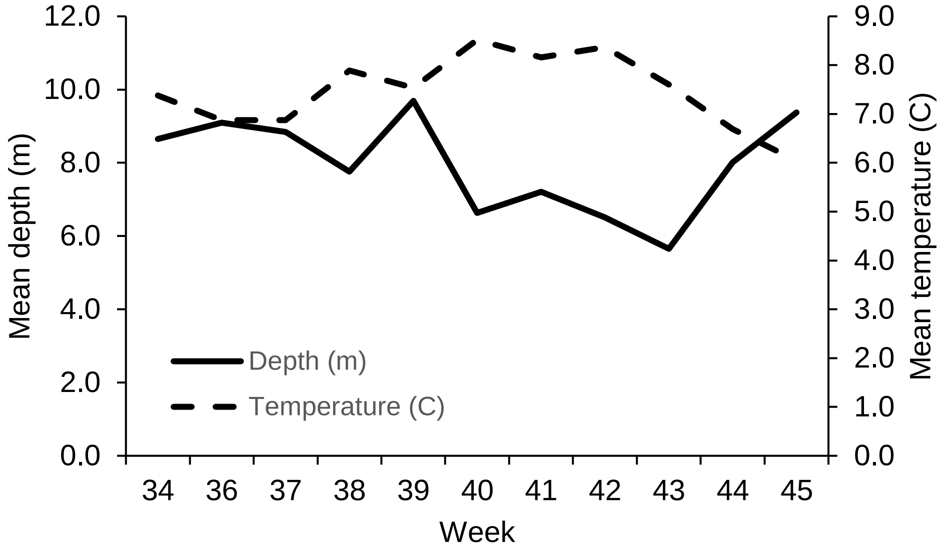

Figure 16. Mean depth and temperature of acoustic telemetry tags implanted in Lake Trout in Upper Priest Lake, Idaho by calendar week. Weekly mean values include data points collected in 2019 and 2020.

# PRIEST LAKE AND UPPER PRIEST LAKE FISHERY INVESTIGATIONS

## ABSTRACT

In 2020, we investigated Priest Lake and Upper Priest Lake kokanee *Oncorhynchus nerka* abundance in an effort to describe population trends. This was the first time kokanee abundance was estimated in Upper Priest Lake. We conducted lake-wide acoustic surveys in both lakes in August 2020 to estimate kokanee abundance. We monitored kokanee spawner abundance in Priest Lake by counting mature spawning adults at five standard shoreline areas in November. In addition, we estimated mysid shrimp *Mysis diluviana* density from vertical plankton tows. Estimated density of Priest Lake kokanee was 39 fry/ha and six age-1 to age-4 fish/ha. Estimated density of kokanee in Upper Priest Lake was 252 fry/ha and 28 age-1 to age-4 fish/ha. A total of 3,325 kokanee adults was observed along standard shoreline transects. Mean density of immature and adult mysids was 0.1 mysids/m$^2$. The combined observations from kokanee surveys suggested density remained low and kokanee density in Upper Priest Lake was greater than observed in Priest Lake. Estimated mysid density suggested the population continued a declining trend and was potentially near functional collapse.

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# INTRODUCTION

Priest Lake is located in Idaho's Panhandle Region approximately 28 km south of the Canadian border. Surface area of the lake is 9,446 ha with 8,190 ha of pelagic habitat greater than 12 m deep. Historically, Priest Lake provided fisheries for Bull Trout *Salvelinus confluentus*, Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, and Mountain Whitefish *Prosopium williamsoni*. Introductions of kokanee *Oncorhynchus nerka*, Lake Trout *Salvelinus namaycush,* Largemouth Bass *Micropterus salmoides,* Smallmouth Bass *Micropterus dolomieu*, and Yellow Perch *Perca flavescens* created additional fishing opportunities that are present today (Watkins et al. 2018).

Priest Lake fisheries management has changed significantly since the early 1900s. Bull Trout and Westslope Cutthroat Trout were once the primary target of anglers. However, due to declines in Bull Trout abundance and perceived declines in Westslope Cutthroat Trout abundance, angling for both species has been regulated under a "no harvest" scenario since the late-1980s. Kokanee also once offered the primary fishery in the lake and a significant harvest opportunity. However, kokanee abundance declined through the 1970s and 80s resulting in fishery closure. Kokanee densities in the lake remain low, but a harvest fishery was re-established in 2011 and initially gained considerable interest among anglers (Fredericks et al. 2013). Lake Trout, once less common in the catch, provided a trophy opportunity prior to kokanee collapse. However, increased Lake Trout abundance between the 1970s and 90s led to shifting management objectives and the current yield fishery (IDFG 2013). Recently, Smallmouth Bass were unintentionally established in Priest Lake and have gained angler interest. Mysid shrimp *Mysis diluviana* (mysids) were introduced to Priest Lake in the 1960s and are assumed to have positively influenced Lake Trout and negatively influenced other once–abundant fish species (i.e., kokanee, Bull Trout, Westslope Cutthroat Trout; IDFG 2013).

Mysids were stocked in multiple Idaho lakes and reservoirs in the mid- to late-1960s in an attempt to increase forage availability for sportfish (Heimer 1970). Self-sustaining populations were established from that effort in three northern Idaho lakes (Priest Lake, Hayden Lake, and Lake Pend Oreille). In northern Idaho, mysids were primarily intended to benefit kokanee *Oncorhynchus nerka* and trout species *Oncorhynchus spp*.

In Priest Lake, mysids were credited with increasing kokanee growth (Irizarry 1974). However, the kokanee fishery subsequently collapsed. Kokanee collapse in Priest Lake was linked to predation from an increasing Lake Trout population. Mysids were implicated as a contributing factor in the expansion of Lake Trout as they provided abundant forage for Lake Trout and increased juvenile survival. The resulting Lake Trout fishery in Priest Lake largely replaced fisheries for kokanee and Westslope Cutthroat Trout (Liter et al. 2009). As the Priest Lake fishery transitioned over time, angler effort declined by approximately 50% (Watkins et al. 2018).

Current management of the Priest Lake fishery is primarily focused on providing a yield fishery for Lake Trout, which makes up most of the fishing effort. To the extent possible, management also strives to provide a mix of angling opportunities to include species such as kokanee and Westslope Cutthroat Trout. While Lake Trout have provided the primary fishery in Priest Lake for some time, our understanding of trends in the population is limited. In 2020, a Lake Trout survey was initiated in Priest Lake aimed at describing trends in abundance and population dynamics. Reporting of the 2020 Lake Trout survey effort was withheld, to be combined with continued survey effort in 2021. In addition, we conducted surveys of kokanee abundance to describe current population trends and the opportunity kokanee provide to anglers. We completed a complimentary acoustic survey of kokanee abundance on Upper Priest Lake. Although kokanee are known to occur in Upper Priest Lake, little was known about the population in that lake. We also investigated mysid densities in Priest Lake to better understand population-level fluctuations and their potential influence on Lake Trout and kokanee in the system.

## METHODS

### Acoustic Kokanee Survey

We conducted a lake-wide mobile acoustic survey on Priest Lake to estimate kokanee abundance on the night of August 17, 2020. We used a Simrad EK60 split-beam echosounder with a 120 kHz transducer to estimate kokanee abundance. Ping rate was set at 0.3 to 0.5 seconds per ping. A pole-mounted transducer was located 0.66 m below the surface, off the port side of the boat, and pointed downward. The echosounder was calibrated prior to the survey using a 23 mm copper calibration sphere to set the gain and to adjust for signal attenuation to the sides of the acoustic axis. Prior to our survey, we measured one temperature profile as a calibration of signal speed and as a reference of the expected zone of occupancy for kokanee. Water temperature was measured at one-meter increments using a Hydrolab sonde (Hach Hydromet, Loveland, CO). Mean water temperature for depths from zero and nine meters was used in system calibration. We used Simrad ER60 software (Simrad Yachting) to determine and input the calibration settings.

Standardized transects were followed during our acoustic survey (Maiolie et al. 2013). We followed a uniformly spaced zigzag pattern of 15 transects stretching from shoreline to shoreline (Figure 17). The zigzag pattern was used to maximize the number of transects that could be completed in one night. The pattern followed the general rule of using a triangular design (zigzags) when the transect length was less than twice the transect spacing (Simmonds and MacLennan 2005). The starting point of the first transect at the northern end of the lake was originally chosen at random. Boat speed was approximately 2.4 m/s.

Kokanee abundance was determined using echo integration techniques. Echoview version 8 (Echoview Software Pty Ltd) was used to view and analyze the collected data. A box was drawn around the kokanee layer on each of the echograms and integrated to obtain the nautical area scattering coefficient (NASC) and analyzed to obtain the mean target strength of all returned echoes. This integration accounted for fish that were too close together to detect as a single target (MacLennan and Simmonds 1992). Densities were then calculated by the equation:

$$\text{Density (fish/ha)} = (\text{NASC} / 4\pi 10^{TS/10})\ 0.00292$$

where:

NASC is the total backscattering in $m^2$/nautical mile$^2$

TS is the mean target strength in dB for the area sampled.

Kokanee density was estimated directly from the echograms. A pelagic layer of approximately 5 to 30 m was defined as the analysis region within each echogram. All fish in the observed pelagic fish layer were identified as kokanee if target strengths of the observed fish were within the expected size range. Size ranges were based on Love's equation, which describes a relationship between target strength and length (Love 1971). A total kokanee density for all fish was calculated by echo integration. A virtual echogram was built of the corrected target strengths. We then multiplied the total kokanee density estimate on each transect by the percentage of small targets (-60 dB to -45 dB) to estimate the density of kokanee fry. The percentage of large targets (-44 dB to -30 dB) was used to estimate density of kokanee age classes one to four. Target strength bins were determined using the frequency of single target detections by target strength.

We calculated kokanee abundance by multiplying estimated densities by the area of usable pelagic habitat in Priest Lake. Pelagic kokanee habitat in Priest Lake was previously estimated at 8,190 ha (Maiolie et al. 2013). Eighty percent confidence intervals were calculated for the estimates of fry and older age classes of kokanee. Confidence intervals calculated for arithmetic mean densities utilized a Student's T distribution. The entire lake was considered one section without stratification by area.

A lake-wide acoustic survey was also completed on Upper Priest Lake on August 18, 2020 to estimate kokanee abundance. We used the same methods and equipment employed during the acoustic survey of Priest Lake. However, only five transects were followed during the survey (Figure 18). This survey represented the first effort to quantify kokanee abundance of all age classes in Upper Priest Lake. Kokanee are commonly observed in the lake during annual Lake Trout removal efforts, but little was known about their status.

### Shoreline Kokanee Count

Shoreline kokanee abundance was estimated in Priest Lake on November 3, 2020. Spawning kokanee were observed and counted at five standard nearshore areas, including Copper Bay, Hunt Creek, Cavanaugh Bay, Indian Creek, and Huckleberry Bay. We collected a sample of spawning kokanee adjacent to the mouth of Hunt Creek using a monofilament gill net. One gill net was set for 15 minutes. The monofilament gill net was 46 m long with variable mesh panels from 1.9- to 6.4-mm bar mesh. Sex of each kokanee was determined by examining external characteristics. All fish were measured to total length (mm). We used average total length of male kokanee to describe trends in spawner size.

### Mysid Survey

Mysid shrimp were sampled to estimate their density in Priest Lake on June 1, 2020. All sampling occurred at night. A total of twelve random sites was sampled. We attempted to select sites *a priori* from a depth zone equal or greater than 46 m. Vertical net tows were made from a depth of 46 m to the surface. In the field, if a selected site was not 46 m deep, we looked for the desired depth range in close proximity to the site or made a tow from the maximum depth available if no deeper zone was present. A 1-m hoop net of 1,000-micron mesh and a 500-micron bucket was used for all tows. Area of the net mouth was 0.8 $m^2$. Each mysid collected was counted and classified as either young-of-the-year (YOY) or immature/adult based on relative size and physical characteristics. We calculated density as mysids per square meter based on the area of the net mouth. We reported arithmetic mean density and 80% confidence intervals around each estimate.

## RESULTS

### Acoustic Kokanee Monitoring

Estimated density of Priest Lake kokanee in August 2020 was 39 kokanee fry/ha (±23.7; 80% C.I.) and 6±1.8 age-1 to age-4 kokanee/ha (Table 15). Abundance estimates, expanded from density, were 368,387 kokanee fry and 46,614 kokanee ages 1 to 4. Estimated kokanee densities were relatively consistent with prior estimates dating back to 2012 (Figure 19).

Estimated density of Upper Priest Lake kokanee in August 2020 was 252 kokanee fry/ha (± 233.7; 80% C.I.) and 28 ± 21 age-1 to age-4 kokanee/ha (Table 16). Abundance estimates, expanded from density, were 2,060,418 kokanee fry and 230,349 kokanee ages 1 to 4.

### Shoreline Kokanee Count

We counted a total of 3,325 kokanee along five shoreline areas of Priest Lake in 2020 (Table 17; Figure 20). Length of spawning adult kokanee collected near Hunt Creek varied from 373 to 427 mm. Mean total length was 403 ($n$ = 30) and 375 mm ($n$ = 1) for males and females, respectively.

### Mysid Survey

Density of immature and adult mysids in Priest Lake varied by sample location from zero to 1.2 mysids/m$^2$ (Table 18) with a mean (± 80% C.I.) of 0.1±0.1 mysids/m$^2$ (Figure 21). Immature and adult mysid density declined from 2013 through 2020 ($n$ = 7, $P$ = 0.04, $r$ = -0.79; Figure 21).

## DISCUSSION

Kokanee abundance and spawner counts described in our surveys continued to reflect a low-density kokanee population in Priest Lake. Our acoustic estimate of kokanee abundance was within the observed variability of recent estimates and suggests the population has been fairly stable. (Ryan et al. 2023). Kokanee spawner counts decreased from 2019 and remained low relative to peak counts (Ryan et al. 2023). Average length of male kokanee increased marginally from 2019, likely the result of a small decrease in abundance, which is a typical pattern observed over the time series of spawner counts. While kokanee density remained relatively stable, we recommend periodic monitoring of abundance continue as it informs an understanding of kokanee status relative to lake-wide trends in fish populations and other influential factors (e.g., mysid density).

Kokanee density in Upper Priest Lake was estimated to be greater than kokanee density in Priest Lake. Our results were consistent with observations from annual Lake Trout removal efforts on Upper Priest Lake where kokanee are routinely observed as bycatch (see Lake Trout Management in Upper Priest Lake chapter in this report). In contrast, catches of kokanee in previous Priest Lake investigations, even in targeted efforts, were generally low and infrequent (Ryan et al. 2020a). This survey was the first effort to estimate kokanee abundance in Upper Priest Lake. As such, no comparison of kokanee abundance within the lake over time was possible. We recommend periodic monitoring of Upper Priest Lake kokanee to better understand trends in abundance.

Upper Priest Lake kokanee abundance estimates had some inherent uncertainty. We did not collect physical samples from the fish community in Upper Priest Lake to apportion our acoustic estimate. While this is not a standard practice in monitoring of kokanee in Priest Lake, differences in lake size and structure may uniquely influence acoustic estimates in each lake. Specifically, Upper Priest Lake is small and relatively uniform in depth with a comparatively small pelagic zone. As such, the potential for overlap in acoustic detections of similar sized, but littoral oriented non-target fish species may be greater than in a large and deep waterbody where a majority of each acoustic survey transect is away from the littoral zone. Fish species including Westslope Cutthroat Trout, Northern Pikeminnow, and Peamouth are present in Upper Priest Lake and may be similar in size to kokanee. Our kokanee abundance estimate may have been positively biased because we were unable to exclude non-target species in our estimate. We recommend a follow-up survey using suspended gill nets (Klein et al. 2019) be completed on Upper Priest Lake to quantify species composition in the pelagic zone and improve our understanding of acoustic kokanee abundance estimates. In addition, physical sampling methods would provide additional opportunity to evaluate kokanee population characteristics of Upper Priest Lake. For example, we hypothesize kokanee growth in Upper Priest Lake may be slow relative to Priest Lake due to higher overall density. Collectively, strengthening our understanding of the Upper Priest Lake kokanee population would allow for a clearer evaluation of management actions on the lake and the fishing opportunities they provide.

Mysid density estimates suggested abundance in Priest Lake continued a negative trend observed since 2013. Estimated density in 2020 was very low and potentially reflected a functional collapse of the population. Causal factors of the mysid decline were not clear from our work and no solutions to mediate negative trends were evident. While the cause of mysid decline was not known, understanding future trends in the population has value as mysids influence fish populations in Priest Lake. As such, we recommend continued monitoring mysid density on a regular basis to better understand long-term patterns in abundance in Priest Lake and regionally.

## MANAGEMENT RECOMMENDATIONS

1. Periodically monitor kokanee abundance on Priest Lake as it informs an understanding of kokanee status relative to lake-wide trends in fish populations and other influential factors (e.g., mysid density).

2. Periodically monitor kokanee abundance on Upper Priest Lake to provide an understanding of trends in the kokanee population.

3. Complete a follow-up survey using suspended gill nets on Upper Priest Lake to quantify species composition in the pelagic zone, improving interpretations of acoustic kokanee abundance estimates and informing a clearer understanding of population characteristics.

4. Continue monitoring Priest Lake mysid density to understand trends in abundance.

Table 15. Results from an acoustic survey of kokanee abundance in Priest Lake, Idaho on August 17, 2020.

| Transect | Single targets | NASC | Mean TS | Total density (fish/ha) | % Fry | Fry density | % Ages 1-4 | Age 1-4 density |
|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 4.80 | -42.53 | 20 | 85% | 17 | 15% | 3 |
| 2 | 18 | 6.72 | -38.81 | 12 | 50% | 6 | 50% | 6 |
| 3 | 15 | 4.09 | -37.83 | 6 | 67% | 4 | 33% | 2 |
| 4 | 7 | 3.55 | -38.69 | 6 | 86% | 5 | 14% | 1 |
| 5 | 8 | 12.07 | -41.68 | 41 | 63% | 26 | 38% | 15 |
| 6 | 22 | 12.16 | -40.31 | 30 | 86% | 26 | 14% | 4 |
| 7 | 26 | 7.65 | -51.64 | 259 | 96% | 249 | 4% | 10 |
| 8 | 15 | 1.57 | -49.12 | 30 | 87% | 26 | 13% | 4 |
| 9 | 15 | 5.14 | -41.12 | 15 | 93% | 14 | 7% | 1 |
| 10 | 7 | 4.92 | -51.74 | 171 | 100% | 171 | 0% | 0 |
| 11 | 14 | 54.05 | -29.83 | 12 | 14% | 2 | 86% | 10 |
| 12 | 23 | 71.17 | -31.64 | 24 | 30% | 7 | 70% | 17 |
| 13 | 9 | 23.65 | -33.85 | 13 | 56% | 7 | 44% | 6 |
| 14 | 3 | 3.78 | -38.34 | 6 | 0% | 0 | 100% | 6 |
| 15 | 6 | 1.03 | -50.78 | 29 | 100% | 29 | 0% | 0 |
|  |  |  | Mean density | 45 |  | 39 |  | 6 |

Table 16. Results from an acoustic survey of kokanee abundance in Upper Priest Lake, Idaho on August 18, 2020.

| Transect | Single targets | NASC | Mean TS | Total density (fish/ha) | % Fry | Fry density | % Ages 1-4 | Age 1-4 density |
|---|---|---|---|---|---|---|---|---|
| 1 | 17 | 2.32 | -53.51 | 121 | 100% | 121 | 0% | 0 |
| 2 | 30 | 10.49 | -44.51 | 69 | 90% | 62 | 10% | 7 |
| 3 | 81 | 51.34 | -40.08 | 122 | 35% | 42 | 65% | 80 |
| 4 | 40 | 29.65 | -41.97 | 108 | 50% | 54 | 50% | 54 |
| 5 | 47 | 14.37 | -54.67 | 979 | 100% | 979 | 0% | 0 |
| | | | Mean density | 280 | | 252 | | 28 |

Table 17. Kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 to 2020.

| Year | Cavanaugh Bay | Copper Bay | Huckleberry Bay | Hunt Creek | Indian Creek Bay | Total |
|---|---|---|---|---|---|---|
| 2001 | 523 | 588 | 200 | 232 | 222 | 1,765 |
| 2002 | 921 | 549 | 49 | 306 | 0 | 1,825 |
| 2003 | 933 | 1,237 | 38 | 624 | 0 | 2,832 |
| 2004 | 1,673 | 1,584 | 359 | 2,060 | 441 | 6,117 |
| 2005 | 916 | 906 | 120 | 2,961 | 58 | 4,961 |
| 2006 | 972 | 1,288 | 43 | 842 | 0 | 3,145 |
| 2007 | 463 | 308 | 38 | 1,296 | 40 | 2,145 |
| 2008 | 346 | 223 | 0 | 884 | 27 | 1,480 |
| 2009 | 550 | 400 | 37 | 1,635 | 15 | 2,637 |
| 2010 | 331 | 37 | 18 | 1,410 | 49 | 1,845 |
| 2011 | 1,340 | 750 | 90 | 16,103 | 1,050 | 19,333 |
| 2012 | 3,135 | 7,995 | 665 | 14,570 | 830 | 27,195 |
| 2013 | 2,295 | 1,070 | 340 | 26,770 | 1,270 | 31,745 |
| 2014 | 838 | 1,960 | 525 | 7,530 | 2,750 | 13,603 |
| 2015 | 1,155 | 1,885 | 7 | 2,550 | 520 | 6,117 |
| 2016 | 710 | 524 | 34 | 2,987 | 670 | 4,925 |
| 2017 | 660 | 415 | 80 | 1,340 | 184 | 2,679 |
| 2018 | 545 | 670 | 0 | 2,995 | 185 | 4,395 |
| 2019 | 303 | 480 | 0 | 5,463 | 800 | 7,046 |
| 2020 | 249 | 196 | 0 | 2,555 | 325 | 3,325 |

Table 18. Mysid density estimates from Priest Lake, Idaho on June 1, 2020 by sample location and life stage (young-of-year (YOY) and combined immature/adult).

| Sample site | Latitude | Longitude | YOY/m$^2$ | Immature and adult/m$^2$ |
|---|---|---|---|---|
| 1 | 48.69992 | -116.84776 | 0.0 | 0.0 |
| 2 | 48.68216 | -116.87552 | 2.4 | 0.0 |
| 3 | 48.66442 | -116.85066 | 4.9 | 0.0 |
| 4 | 48.63652 | -116.85791 | 3.7 | 0.0 |
| 5 | 48.61052 | -116.87714 | 19.6 | 1.2 |
| 6 | 48.58261 | -116.85108 | 24.5 | 0.0 |
| 7 | 48.56513 | -116.90790 | 3.7 | 0.0 |
| 8 | 48.55167 | -116.87752 | 51.4 | 0.0 |
| 9 | 48.55634 | -116.85088 | 47.7 | 0.0 |
| 10 | 48.51097 | -116.85129 | 11.0 | 0.0 |
| 11 | 48.50232 | -116.87905 | 7.3 | 0.0 |
| 12 | 48.59182 | -116.83867 | 2.4 | 0.0 |
| | | Mean density | 14.9 | 0.1 |

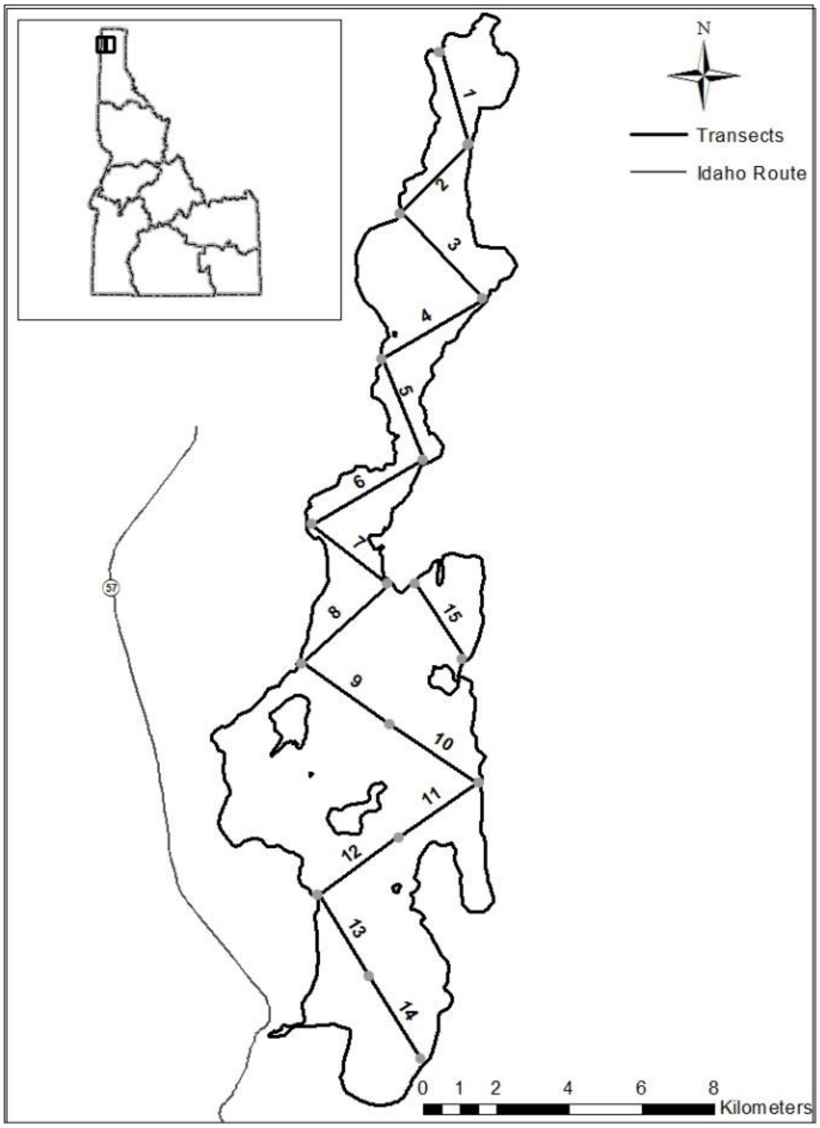

Figure 17. Standard transects on Priest Lake, Idaho used in an acoustic survey of kokanee abundance on August 17, 2020.

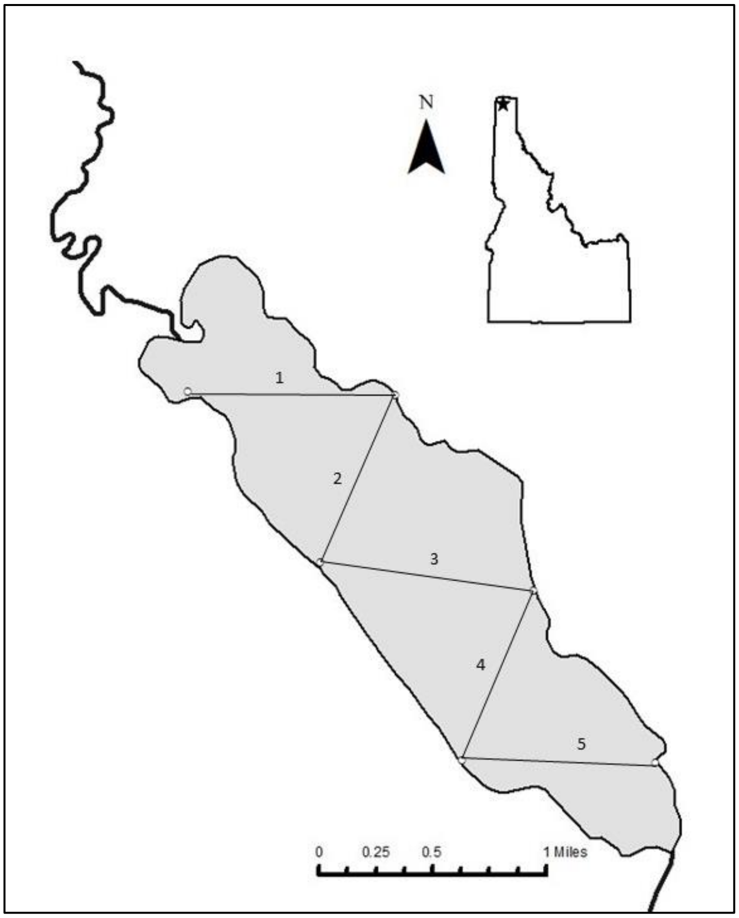

Figure 18. Acoustic transects on Upper Priest Lake, Idaho used in a survey of kokanee abundance on August 18, 2020.

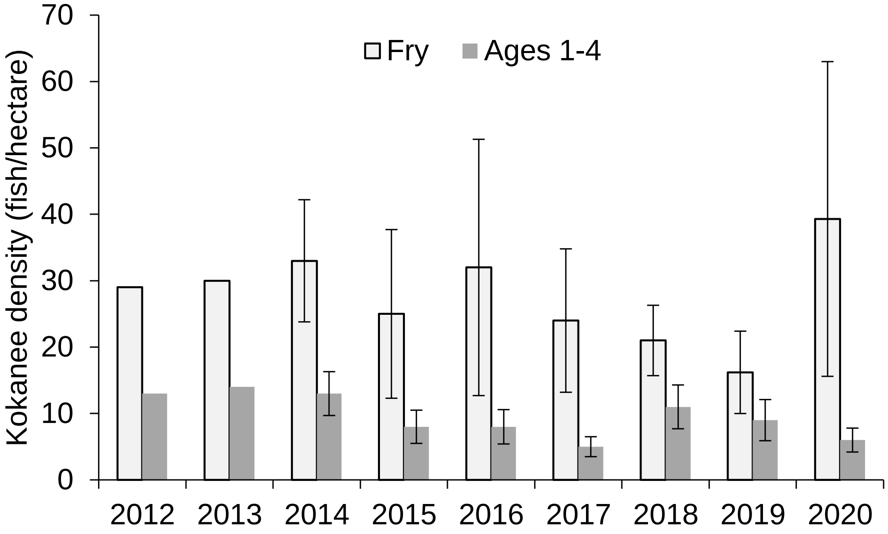

Figure 19. Kokanee density estimates from Priest Lake, Idaho acoustic surveys from 2012 through 2020.

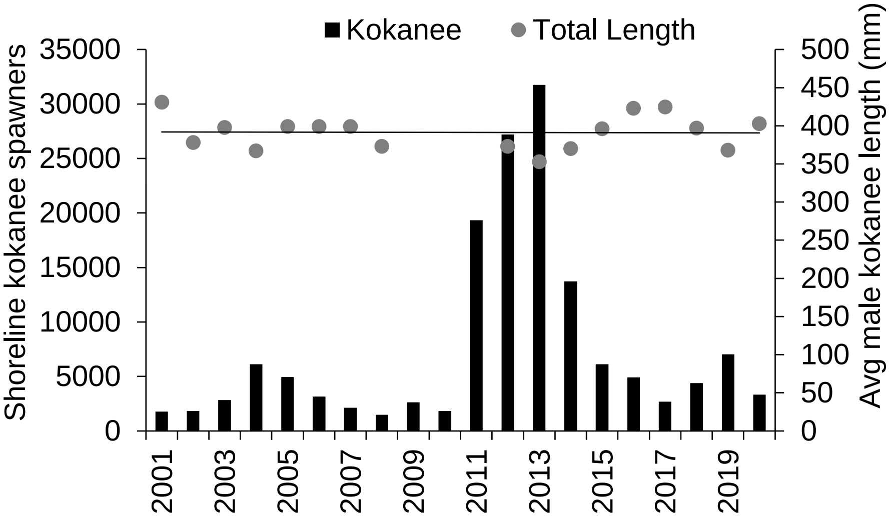

Figure 20. Adult kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 through 2020 and corresponding length of male kokanee spawners.

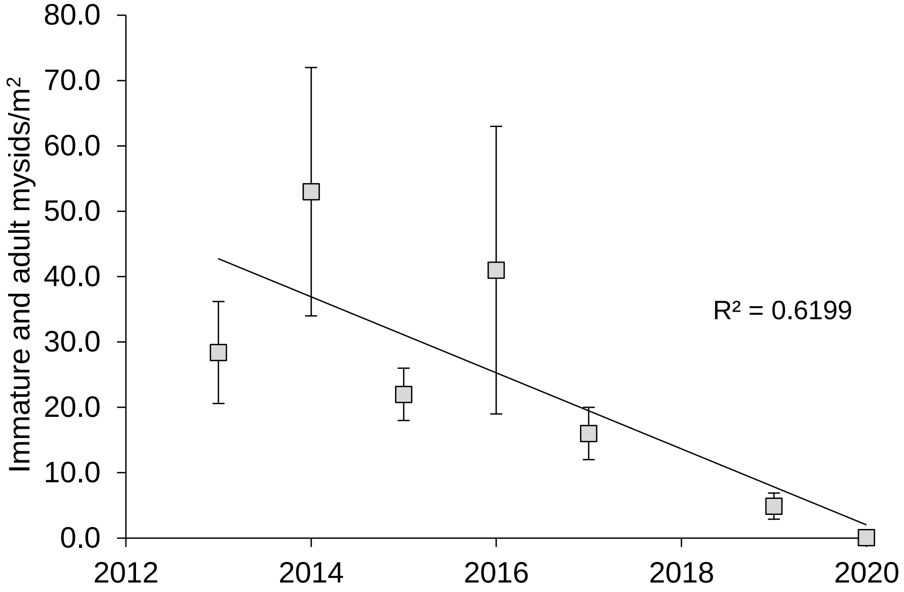

Figure 21. Estimated mean densities of immature and adult mysids in Priest Lake from 2013 through 2020. Error bars represent 80% confidence intervals. No survey was conducted in 2018.

# PEND OREILLE BASIN WALLEYE MONITORING

## ABSTRACT

Non-native fish colonization has been recognized as a threat to native fish communities across the western U.S., including in the Pend Oreille basin of Idaho. Walleye *Sander vitreus* were a relatively recent introduction to this basin and their future status is uncertain. Fall Walleye index netting (FWIN) surveys of Lake Pend Oreille and the Pend Oreille River in 2011, 2014, and 2017 suggested the Walleye population expanded in both abundance and distribution. In 2020, we repeated the FWIN survey in the Pend Oreille basin as a continuation of the Walleye monitoring effort. Catch rate of Walleye in our survey was 2.5 fish/net. Mean visceral fat index values were 2.8 and 4.1 for male and female Walleye, respectively. Eleven age classes were present in the catch, representing Walleye of age 0 through age 12. Age-at-50%-maturity was 1.6 and 3 years for male and female Walleye, respectively. Walleye catch rate represented a decline in relative abundance from the prior survey. However, Walleye growth, condition, and age-at-maturity observed across FWIN surveys of the Pend Oreille basin continued to suggest resources were not limiting Walleye production. The observed decline in the Walleye population suggests that management actions aimed at controlling their population growth are likely having the intended effect.

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## INTRODUCTION

Unintended colonization of non-native fishes has been recognized as a fishery management challenge relative to conservation of native fish communities, as well as sustaining non-native sport fisheries. This is true in many fish communities across the western U.S., including the Pend Oreille basin (Dux et al. 2019; Hansen et al. 2008; PBTAT 1998). Introduced Lake Trout *Salvelinus namaycush* in Lake Pend Oreille (LPO) are heavily studied and currently being suppressed in an effort to enhance kokanee *Oncorhynchus nerka* and both native and recreationally-valued non-native fish populations that are supported by kokanee. Introduced Walleye *Sander vitreus* are also present in LPO. Walleye expanded exponentially in the Pend Oreille basin following their introduction (Ryan et al. 2021). The expansion of Walleye in the basin has provided an additional sport fishing opportunity. However, Walleye have the potential to negatively impact salmonid fish assemblages where these populations overlap, thus creating concern for managers (Baldwin et al. 2003; Yule et al. 2000).

Walleye are non-native in the Pend Oreille basin and were first formally documented during a fishery survey of the Pend Oreille River (POR) in 2005 (Schoby et al. 2007). Subsequently, Walleye were documented in LPO in spring gill nets set near the Pack River from 2007 through 2010 (IDFG, unpublished data). Walleye were illegally established in the upstream waters of the lower Clark Fork River within Noxon Reservoir, Montana in the early-1990s and now exist at high density (Horn et al. 2009). This upstream population is believed to be the source of introduction into LPO and the POR. In 2011, 2014, and 2017 standardized Walleye monitoring was completed to better describe the current status of the population. These surveys documented an exponential increase in Walleye abundance throughout the basin (Ryan et al. 2020b). In response, experimental Walleye suppression using gill nets was initiated in 2018 and incentivized angler harvest was instituted in 2019 (Rust et al. 2020).

Our objective in 2020 was to continue a Walleye monitoring program to improve understanding of current abundance, distribution, and population characteristics of Walleye in LPO and the POR. Continued monitoring of the Walleye population is essential for fisheries managers to understand how this now established piscivorous species may impact the existing fish community and evaluate ongoing management actions for controlling Walleye abundance in the Pend Oreille basin.

## METHODS

We completed a survey of Walleye abundance, distribution, and population characteristics in LPO and the POR following standardized fall Walleye index netting (FWIN) protocols described in the FWIN manual (Morgan 2002). Sampling locations were randomly selected, but were focused primarily within the northern portion of LPO (Clark Fork River delta to POR mouth) and the POR (Figure 22). These areas contained water depths typically associated with Walleye habitat and consistent with the FWIN protocol. Much of LPO was not compatible with the selected sampling protocol due to existing bathymetry. However, a limited portion of the southern end of LPO (Idlewilde and Scenic Bays) was also surveyed to help describe distribution on a larger scale (Figure 1). Selected sampling zones were defined within the 15 m depth contour. The total area included in the survey was approximately 10,000 ha. We targeted a total of 48 net sets based on sample size recommendations described in the FWIN manual and prior knowledge of catch rate variability described in previous FWIN surveys in this waterbody.

We used monofilament experimental gill nets to sample fish. Nets were 1.8 m tall, 61.0 m long, and had eight monofilament panels (each 7.6 m long) with 25-, 38-, 51-, 64-, 76-, 102-, 127-, and 152-mm stretched mesh. Net sets were equally divided between two depth strata, including 2–5 and 5–15 m depths. All nets were placed perpendicular to the shoreline. Netting was conducted at water temperatures between 10 and 15°C. Net sets were approximately 24 hours in duration. Mean catch per unit effort (CPUE) was calculated as fish per net and was used to describe relative abundance of Walleye and other species.

All Walleye caught were measured for total length (TL; mm) and weighed (g). All non-target species were measured for TL and a subsample was weighed. Walleye gonads and visceral fat were each removed and weighed. We also collected otoliths from all Walleye for age estimation. Age of individual fish was estimated from sectioned otoliths. Otoliths were mounted in epoxy, sectioned centrally at the origin using a Buehler Isomet saw (Illinois Tool Works Inc., Lake Bluff, Illinois), sanded for viewing clarity, and viewed on a compound microscope under 40x to 100x magnification. Walleye growth patterns were evaluated using estimated fish ages to determine mean length-at-age at time of capture by sex. Growth rates were described using the von Bertalanffy growth model (1938) with variables estimated in Fisheries Analysis and Modeling Simulator (FAMS; Slipke and Maceina 2014) from mean values of total length-at-age observed in our sample. Length at infinity ($L_\infty$) was held constant using approximate maximum lengths observed in our survey to account for limited catch of older age classes (Slipke and Maceina 2014).

Catch-at-age was reported as a depiction of annual recruitment. Patterns in recruitment were also described using a recruitment variability index (RVI):

$$\mathrm{RVI} = [CRF/(N_m+N_p)]-N_m/N_p,$$

where $CRF$ = cumulative relative frequency, $N_m$ = number of missing year classes, and $N_p$ = number of year-classes present. (Guy and Willis 1995, Maceina and Pereira 2007). RVI values range from -1 to 1 with increasing value indicating greater recruitment stability. Only Walleye age-2 and older were incorporated in RVI estimates.

We used two indices to describe the body condition of Walleye. A visceral fat index (VFI) was estimated as the ratio of visceral fat weight to body weight, described as a percentage. Visceral fat indices are good descriptors of lipid body content, a measure of condition (Kaufman et al. 2007), and are positively correlated to age-at-maturity in Walleye (Henderson and Morgan 2002). VFI was calculated and reported by sex. We also used a gonadal somatic index (GSI) as a measure of condition. GSI was calculated as the ratio of gonad weight to body weight. We compared VFI and GSI values from our survey to all prior survey years by sex to described potential shifts in body condition. A one-way analysis of variance (ANOVA) was used to compare mean values among years ($\alpha$ = 0.20; Sigma Plot, Systat Software, Inc.). A Tukey's all-pairwise comparison was used to describe differences between years where significant differences were detected ($\alpha$ = 0.20; Sigma Plot, Systat Software, Inc.).

We estimated rate of sexual maturity in captured Walleye by examining gonads and classifying maturity based on gonad development (Duffy et al. 2000). Maturation rates are inversely related to growth and may reflect shifting population dynamics (Gangl and Pereira 2003, Schneider et al. 2007). We determined total length and age-at-50%-maturity ($A_{50}$) using logistic regression (Quinn and Deriso 1999). We also calculated a female diversity index value based on the Shannon diversity index to describe the diversity of the age structure of mature females (Gangl and Pereira

2003). The female diversity index has been shown to be sensitive to changes in population structure (Gangl and Pereira 2003).

Bycatch in our FWIN survey was common and provided measures of relative abundance for multiple fish species in the system. We used catch rates of commonly caught non-target fish species in our survey to describe trends in fish abundance. Trends in abundance were evaluated by comparing catch rates in our survey to prior FWIN surveys of the Pend Oreille basin (Fredericks et al. 2013; Watkins et al. 2018; Ryan et al. 2020b). Significant changes in CPUE by species were described using a non-parametric Kruskal–Wallis test by ranks ($\alpha = 0.20$). The strength and direction of significant variation in CPUE was described as the correlation coefficient of CPUE by year. Statistical tests were completed using SYSTAT (Systat Software Inc.).

## RESULTS

We completed a FWIN survey of LPO and the POR from October 4 through October 9, 2020. Sampling effort included 48 gill-net nights fished among all sampled areas. A total of 119 Walleye were caught, comprising 7.7% of the total catch (Table 19). Walleye were caught at 35 of the 48 sampled sites at a mean CPUE of 2.5 fish/net (± 0.5, 80% CI; Figure 23). We captured Walleye throughout LPO and the POR (Figure 24). However, Walleye were not proportionally distributed by zone as was observed in prior FWIN surveys. For example, 61% of the Walleye caught came from net sets in the Pend Oreille River, but the Pend Oreille River represented approximately 32% of the total area sampled in our survey.

Walleye sampled in our survey represented a range of sizes. Mean total length (± 1 SD) was 433 (± 147) mm and varied from 187 to 758 mm (Figure 25). Sampled Walleye generally had robust condition. Mean (± 1 SD) VFI was 2.8 (± 2.2) and 4.1 (± 2.9) for male and female Walleye, respectively (Figure 26). Mean (± 1 SD) GSI was 2.1 (± 1.6) and 1.5 (± 1.6) for male and female Walleye, respectively (Figure 27). VFI values for male ($F = 0.85$, df = 3, $p = 0.47$) and female ($F = 0.92$, df = 3, $p = 0.43$) Walleye were not significantly different between years. Mean GSI values of male Walleye did not differ between years ($F = 1.42$, df = 3, $p = 0.24$). However, mean GSI values of female Walleye did vary significantly ($F = 4.20$, df = 3, $p < 0.01$), with mean GSI in 2014 being greater than 2011 ($q = 3.77$, $p = 0.04$) and 2017 ($q = 3.6$, $p = 0.01$). Female GSI values in 2020 were not significantly different from values described in any prior survey.

Eleven age classes were present in the collected samples, representing Walleye from age 0 to age 12 (Figure 28). Age-1 fish were the strongest year class detected. We found no age-9 or age-10 Walleye. RVI was 0.61 (Figure 28).

Walleye in the Pend Oreille system grew rapidly (Figure 29). Mean length of age-2 fish was 374 and 432 mm for male and female Walleye, respectively. Growth rates of sampled Walleye varied by sex. Maximum length of male and female Walleye were 697 and 758 mm. We found growth rates were comparable to previous surveys (Figure 30).

The sex ratio of Walleye caught in our survey was approximately equal, with 48% males and 52% females. Age-at-50%-maturity was 1.6 and 3 years for male and female Walleye, respectively (Figure 31). Mature Walleye observed in our sample were assigned to multiple year classes. The female diversity index value was 0.64.

We collected 19 species as bycatch associated with the FWIN survey (Table 19). Yellow Perch *Perca flavescens* (19.9 %) and Peamouth *Mylocheilus caurinus* (14.8%) were the most commonly encountered species (Table 19). Significant variation in CPUE was detected for Northern Pikeminnow, Peamouth, Smallmouth Bass *Micropterus dolomieu*, Tench *Tinca tinca*, and Yellow Perch among FWIN surveys (df = 3, *p* ≤ 0.2; Figure 33). Catch rates of Smallmouth Bass demonstrated a significant increase across surveys (*r* = 0.98). In contrast, declining relative abundance was evident in catch rates of Northern Pikeminnow (*r* = -1.00), Tench (*r* = -1.00), Peamouth ( *r* = -0.42), and Yellow Perch (*r* = -0.81).

We found Northern Pike catch was not widely distributed throughout the surveyed area. Northern Pike were caught primarily in the Clark Fork Delta and shallow bays along the northern shore of Lake Pend Oreille (Oden Bay and Kootenai Bay; Figure 32). A single Northern Pike was caught in the Pend Oreille River. Total length of Northern Pike varied from 287 to 1,100 mm.

## DISCUSSION

The Walleye catch rate in our survey declined from 4.3 fish/net in 2017 to 2.5 fish/net in 2020 (Ryan et al. 2020b), suggesting abundance also declined in the Pend Oreille basin. Prior FWIN surveys of the Pend Oreille Basin suggested the Walleye population was growing exponentially (Ryan et al. 2021). While we detected a decline in indexed abundance, representation across a spectrum of age classes remained robust. However, age-2 Walleye represented a considerably smaller proportion of the catch than was observed in prior surveys. Age-2 Walleye represented the most abundant age class in all prior FWIN surveys (Fredericks et al. 2013; Watkins et al. 2018; Ryan et al. 2020b).

The decline in Walleye abundance observed was likely influenced by multiple factors. For example, Walleye recruitment is known to be highly variable and may be influenced by both biotic and abiotic factors (Hansen et al. 1998). The RVI value of the Pend Oreille basin Walleye population decreased from 2017 to 2020 (Ryan et al. 2020b), suggesting recruitment became more variable during this time frame. Management actions also may have influenced abundance. An experimental Walleye suppression effort occurred annually since 2018 on Lake Pend Oreille with the intent of evaluating the effectiveness of mechanical removal for reducing Walleye abundance (Rust et al. 2020). This effort used gill nets to remove Walleye at identified spring pre-spawn and spawning concentrations. In addition, angler harvest of Walleye in the Pend Oreille basin was incentivized to encourage harvest. While exploitation of Walleye by anglers remained relatively low despite incentives (i.e., ~16%; Rust et al. 2020), the combined influence of management actions appears to have affected abundance at a measurable scale. It is too soon to determine if the existing suppression model will be a successful long-term management strategy; however, the observed population decline suggests it is having the intended impact. Thus, we recommend Walleye suppression continue at the existing level of effort and that effectiveness of suppression strategies continues to be evaluated through periodic FWIN surveys.

Walleye growth, condition, and age-at-maturity observed across FWIN surveys of the Pend Oreille basin continued to suggest resources were not limiting Walleye production. Ryan et al. (2021) suggested Pend Oreille basin Walleye grew fast and were physically robust relative to other Walleye populations in the region and across North America. They argued these characteristics were positively linked to population growth. Dynamic rates observed in our survey were consistent with prior surveys of this population (Fredericks et al. 2013; Watkins et al. 2018; Ryan et al. 2020b). As such, we conclude that the population continues to exhibit the potential rapid growth.

Walleye expansion in the Pend Oreille basin continued to be a concern relative to their potential to negatively impact both existing native fishes and sport fisheries. While our survey effort was focused on Walleye, observations of bycatch from our survey also informed the relative status of the broader fish community. We observed variable relative abundance trends for non-target species encountered during our Walleye survey. For example, the catch rate of Smallmouth Bass continued an increasing trend described in 2017 (Ryan et al. 2020b). In contrast, significantly lower catch rates were observed for Northern Pikeminnow and Yellow Perch, both relatively abundant species in this and prior FWIN surveys. For most species with significant deviations in catch rate among years, we did not conclude a trend existed and assumed differences among years represented annual variation and or a limitation in the sampling method rather than the influence of a newly established predator. However, we recommend a continued focus on trends in fish community composition as shifts in species, such as Northern Pikeminnow and Yellow Perch may reflect the influence of Walleye and overall predation on these prey species.

The catch rate of Northern Pike in our survey suggested abundance did not continue the positive trend identified in prior FWIN surveys. We found catch rate declined from 0.6 ± 0.3 fish/net (± 80% C.I.; Ryan et al. 2020b) in 2017 to 0.3 ± 0.1 fish/net. While Northern Pike abundance appeared to decline in the basin, we found their distribution was wider than observed in prior FWIN surveys. For example, we caught a Northern Pike in the Pend Oreille River, but had not previously detected them in any Department survey downstream of the Long Bridge at Sandpoint. Northern Pike have been present in the Pend Oreille basin for many years. However, little is understood about the mechanisms influencing recent fluctuations in abundance and distribution. A more directed study of Northern Pike movements in the Pend Oreille basin was recently initiated and is anticipated to improve the understanding of the species in the basin (Personal communication; Pete Rust; Idaho Department of Fish and Game). In addition, FWIN surveys continued to provide valuable information about other species, including Northern Pike. As such, we recommend a continued focus on monitoring relative abundance trends of Northern Pike and other species in association with future FWIN surveys.

## MANAGEMENT RECOMMENDATIONS

1. Maintain standardized FWIN surveys on a three-year rotation to evaluate changes in relative abundance, distribution, and population characteristics of Walleye and non-target species.

2. Continue spring-targeted Walleye removal efforts and incentivized angling as a management strategy for controlling Walleye abundance.

Table 19. Catch summary of species sampled during a fall Walleye index netting survey of Lake Pend Oreille and the Pend Oreille River, Idaho in 2020. Summary statistics included catch (*n*), catch rate (fish/net; CPUE) ± 80% confidence intervals (80% CI), percent catch by species (% Catch), mean total length (TL, mm), and minimum and maximum TL (mm).

| Species | *n* | CPUE±80% CI | % Catch | Mean TL | Min-max TL |
|---|---|---|---|---|---|
| Black Crappie | 39 | 0.8±0.4 | 2.5% | 179 | 68-370 |
| Bull Trout | 2 | 0.0±0.0 | 0.1% | 697 | 657-736 |
| Brown Bullhead | 51 | 1.0±0.8 | 3.3% | 274 | 180-375 |
| Brown Trout | 5 | 0.1±0.0 | 0.3% | 385 | 242-486 |
| Kokanee | 1 | 0.0±0.0 | 0.1% | 288 | 288 |
| Largemouth Bass | 10 | 0.2±0.2 | 0.6% | 124 | 90-146 |
| Longnose Sucker | 32 | 0.6±0.2 | 2.1% | 334 | 76-481 |
| Largescale Sucker | 96 | 2.0±0.5 | 6.2% | 460 | 111-573 |
| Lake Whitefish | 211 | 4.3±1.1 | 13.7% | 348 | 132-483 |
| Mountain Whitefish | 16 | 0.3±0.1 | 1.0% | 321 | 145-396 |
| Northern Pike | 15 | 0.3±0.1 | 1.0% | 675 | 287-1100 |
| Northern Pikeminnow | 135 | 2.8±0.6 | 8.7% | 362 | 130-615 |
| Peamouth | 229 | 4.7±1.3 | 14.8% | 295 | 135-382 |
| Pumpkinseed | 11 | 0.2±0.1 | 0.7% | 123 | 96-144 |
| Rainbow Trout | 10 | 0.2±0.1 | 0.6% | 398 | 305-546 |
| Smallmouth Bass | 199 | 4.1±0.8 | 12.9% | 340 | 88-534 |
| Tench | 49 | 1.0±0.3 | 3.2% | 416 | 122-526 |
| Walleye | 119 | 2.4±0.5 | 7.7% | 434 | 187-758 |
| Westslope Cutthroat Trout | 7 | 0.1±0.0 | 0.5% | 394 | 218-470 |
| Yellow Perch | 308 | 6.4±2.3 | 19.9% | 142 | 87-331 |

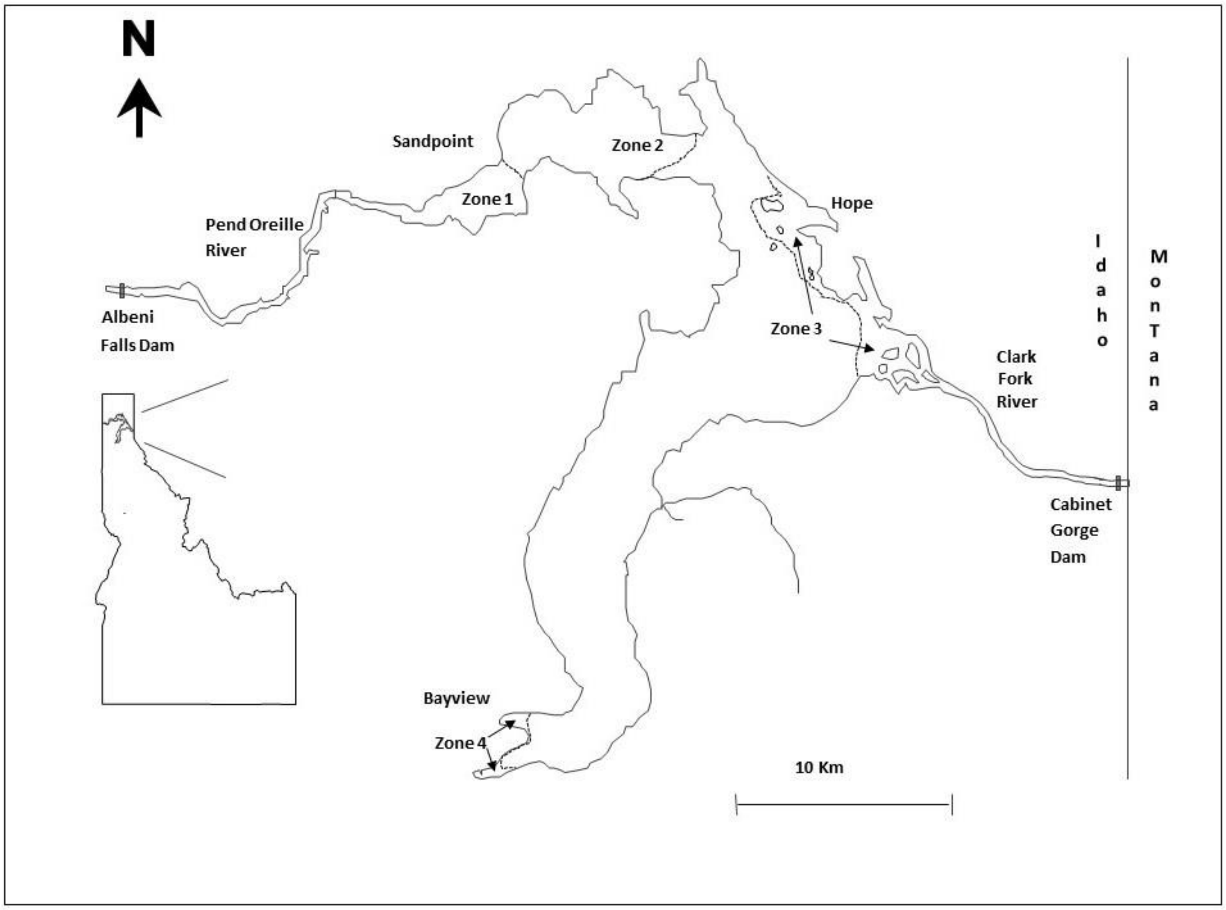

Figure 22. Map of Lake Pend Oreille, Idaho including the main inflow (Clark Fork River) and outflow (Pend Oreille River) and Cabinet Gorge and Albeni Falls dams. Depicted are the fall Walleye index netting survey zones within the Pend Oreille basin of Idaho, sampled in 2020.

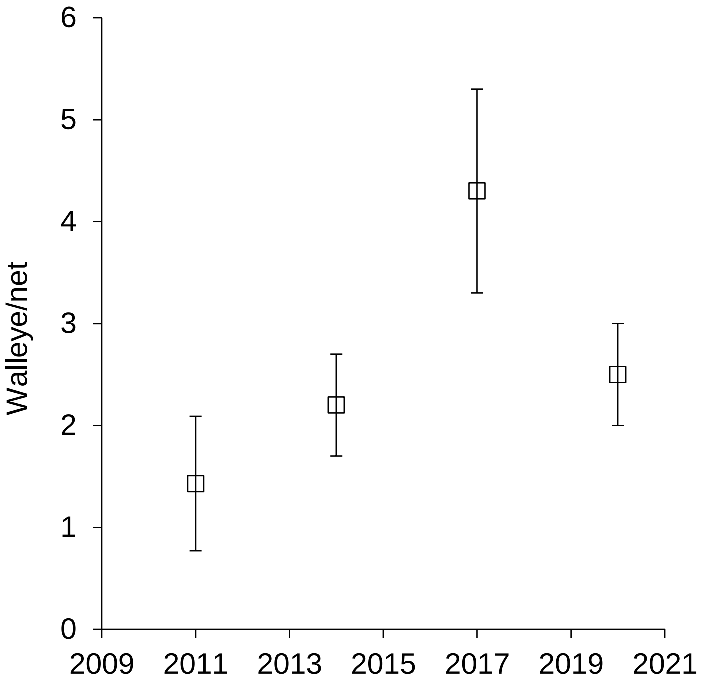

Figure 23. Walleye catch rates from fall Walleye index netting surveys of Lake Pend Oreille and the Pend Oreille River from 2011 through 2020. Error bounds represent 80% confidence intervals about mean catch rates.

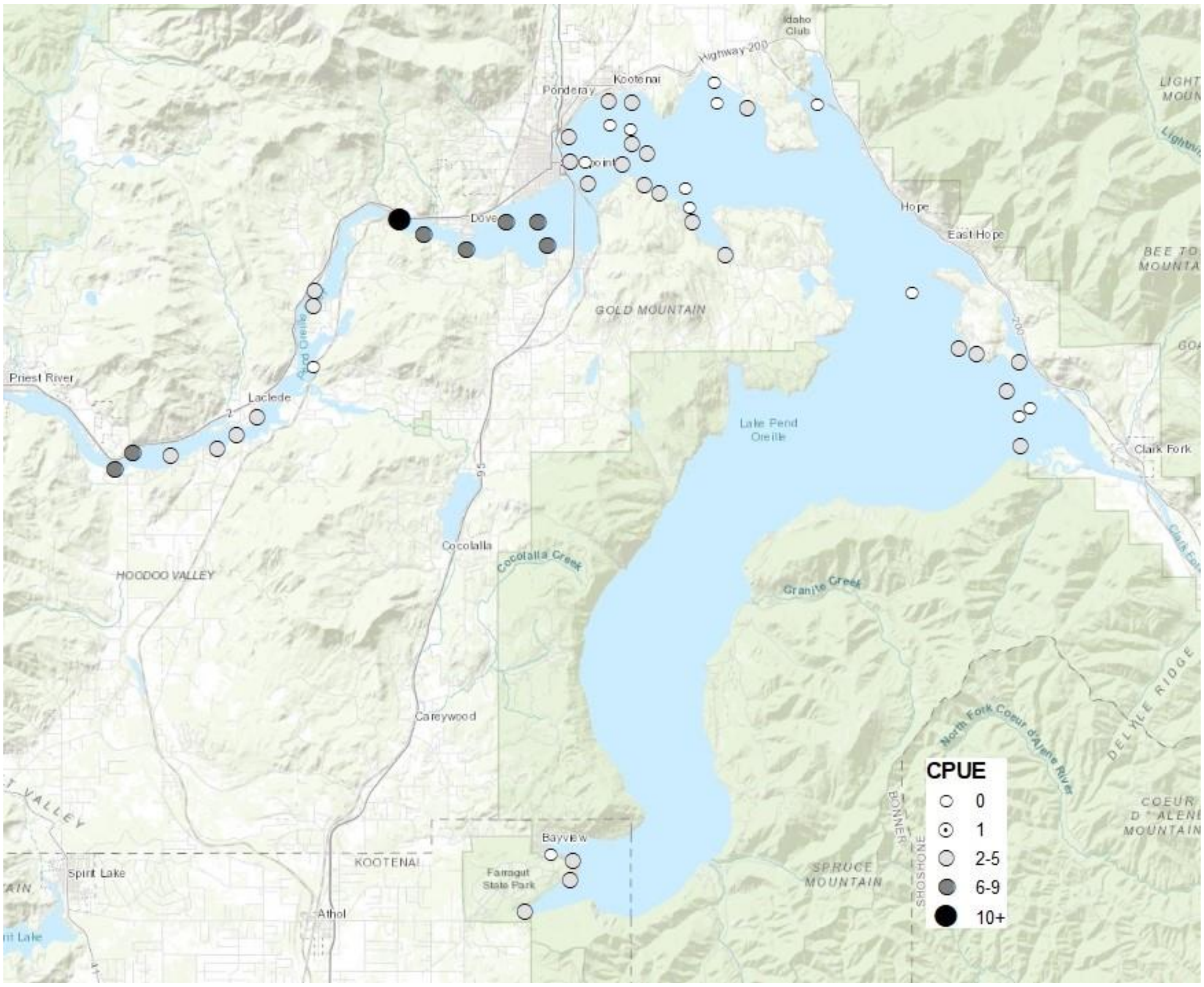

Figure 24. Fall Walleye index netting sampling locations in the Pend Oreille basin, Idaho during 2020. Sampling sites are displayed with corresponding Walleye CPUE (fish/net).

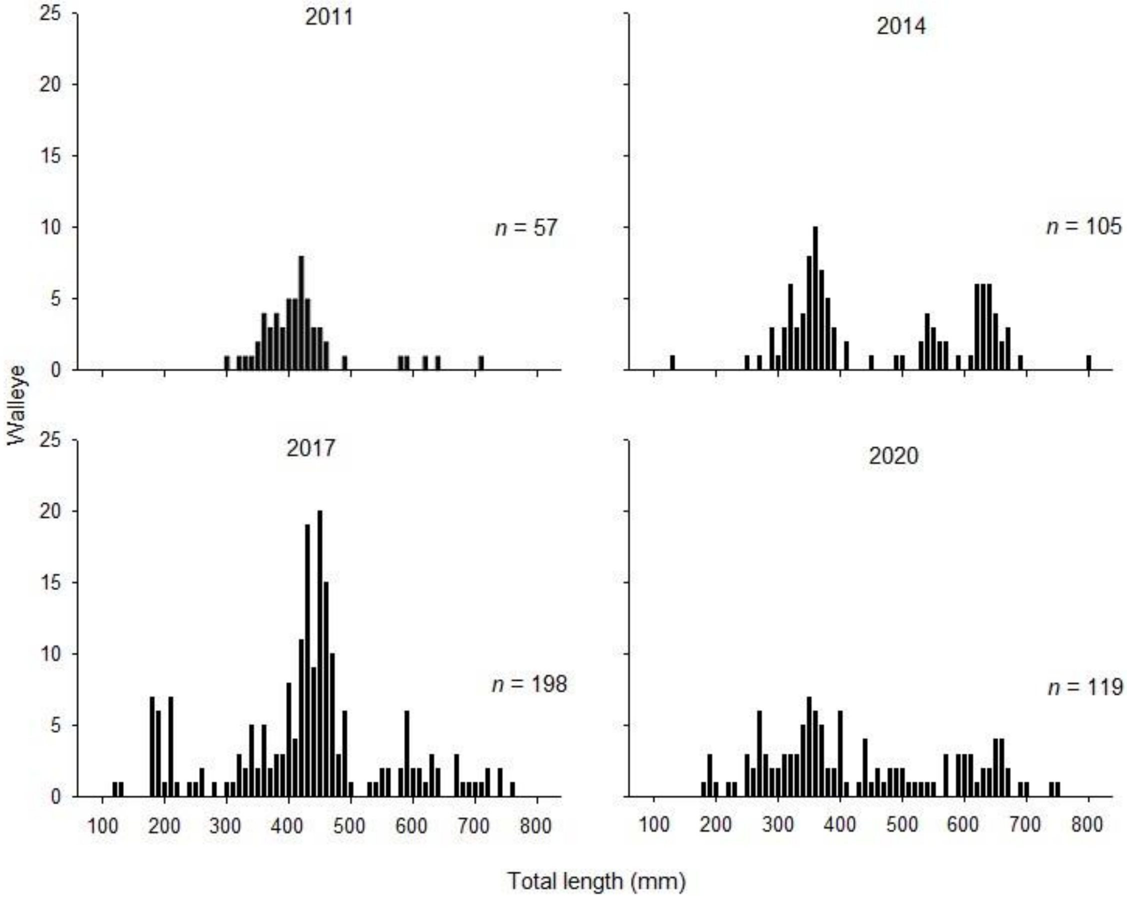

Figure 25. Length-frequency of sampled Walleye by total length from fall Walleye index netting surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, 2017, and 2020.

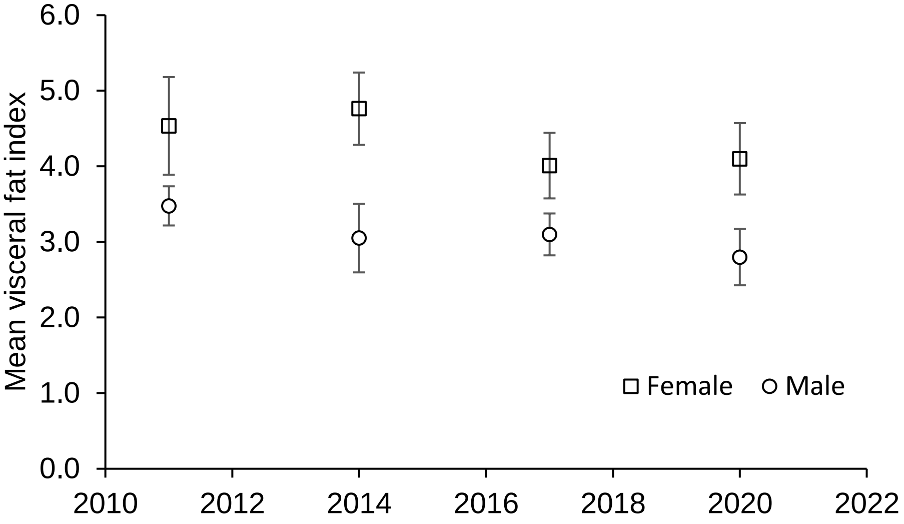

Figure 26. Mean Walleye visceral fat index (VFI) values (± 80% C.I.) by sex and year from Walleye caught in fall Walleye index netting surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, 2017, and 2020.

Figure 27. Mean Walleye gonadal somatic index (GSI) values (± 80% C.I.) by sex and year from Walleye caught in fall Walleye index netting surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, 2017, and 2020.

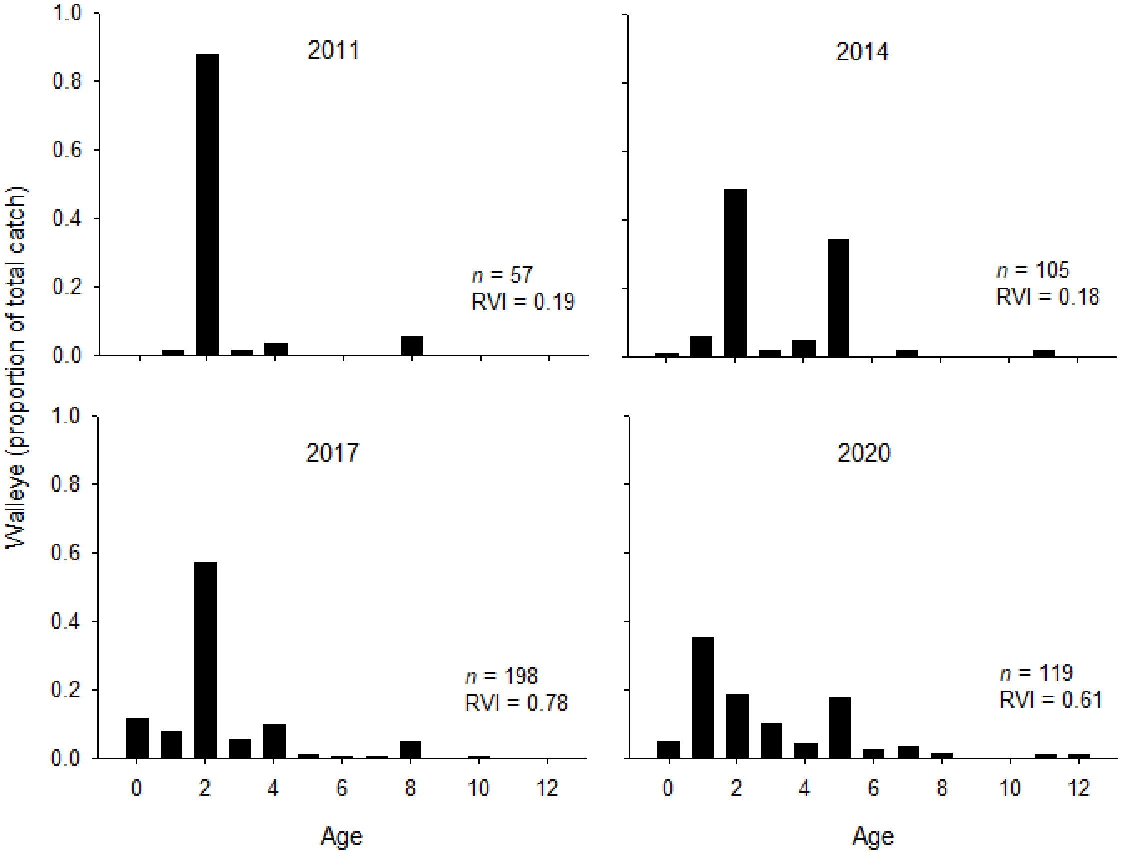

Figure 28. Age-frequency distributions of sampled Walleye in fall Walleye index netting surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, 2017, and 2020. Total catch (*n*) and recruitment variability index (RVI) values were included for each year.

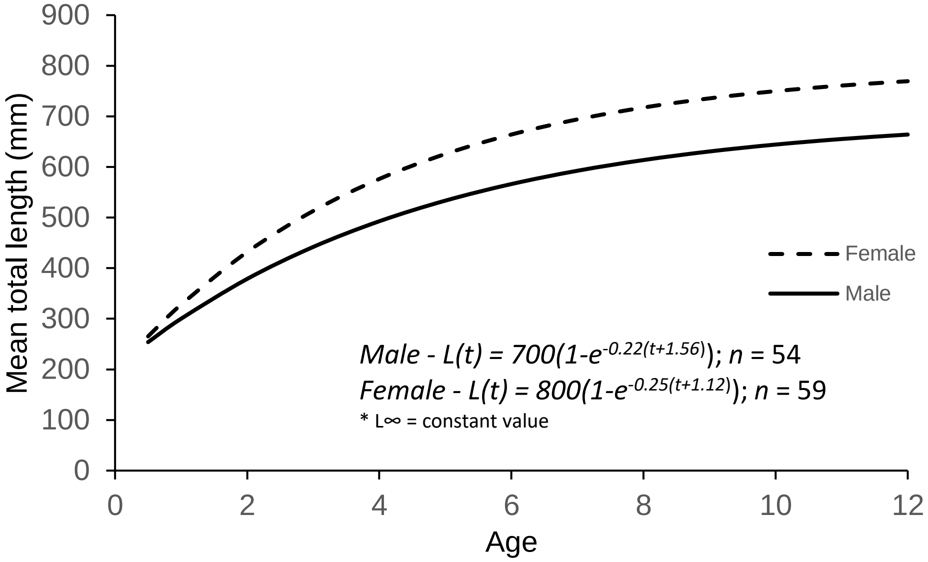

Figure 29. Mean total length-at-age of male and female Walleye collected in a fall Walleye index netting survey of Lake Pend Oreille and the Pend Oreille River, Idaho during 2020.

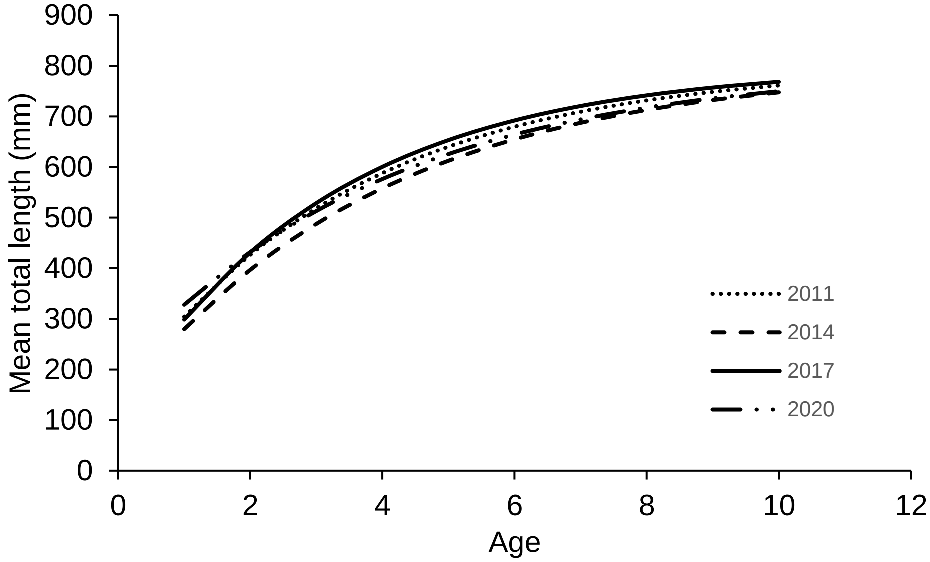

Figure 30. Comparison of growth curves of female Walleye collected in fall Walleye index netting surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, 2017, and 2020.

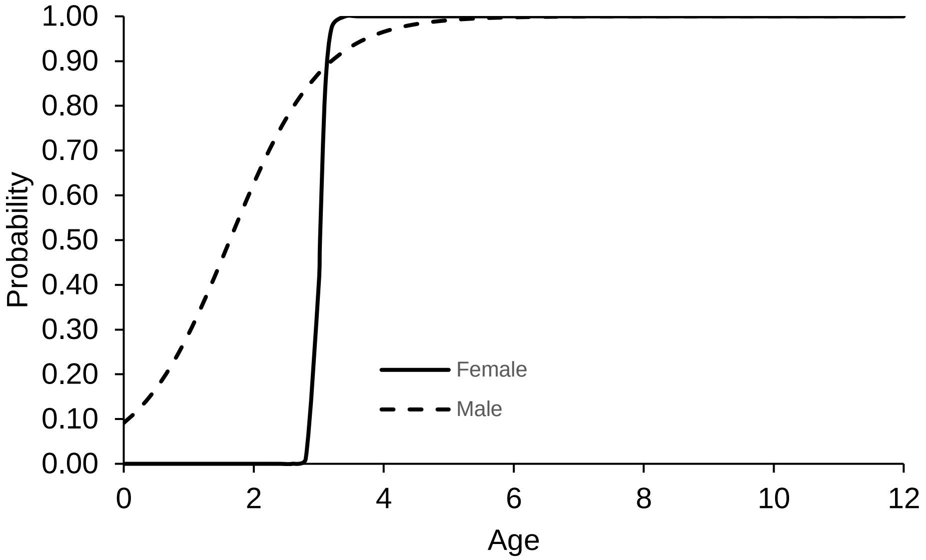

Figure 31. Probability of maturity by age for female and male Walleye collected in a fall Walleye index netting survey of Lake Pend Oreille and the Pend Oreille River, Idaho in 2020.

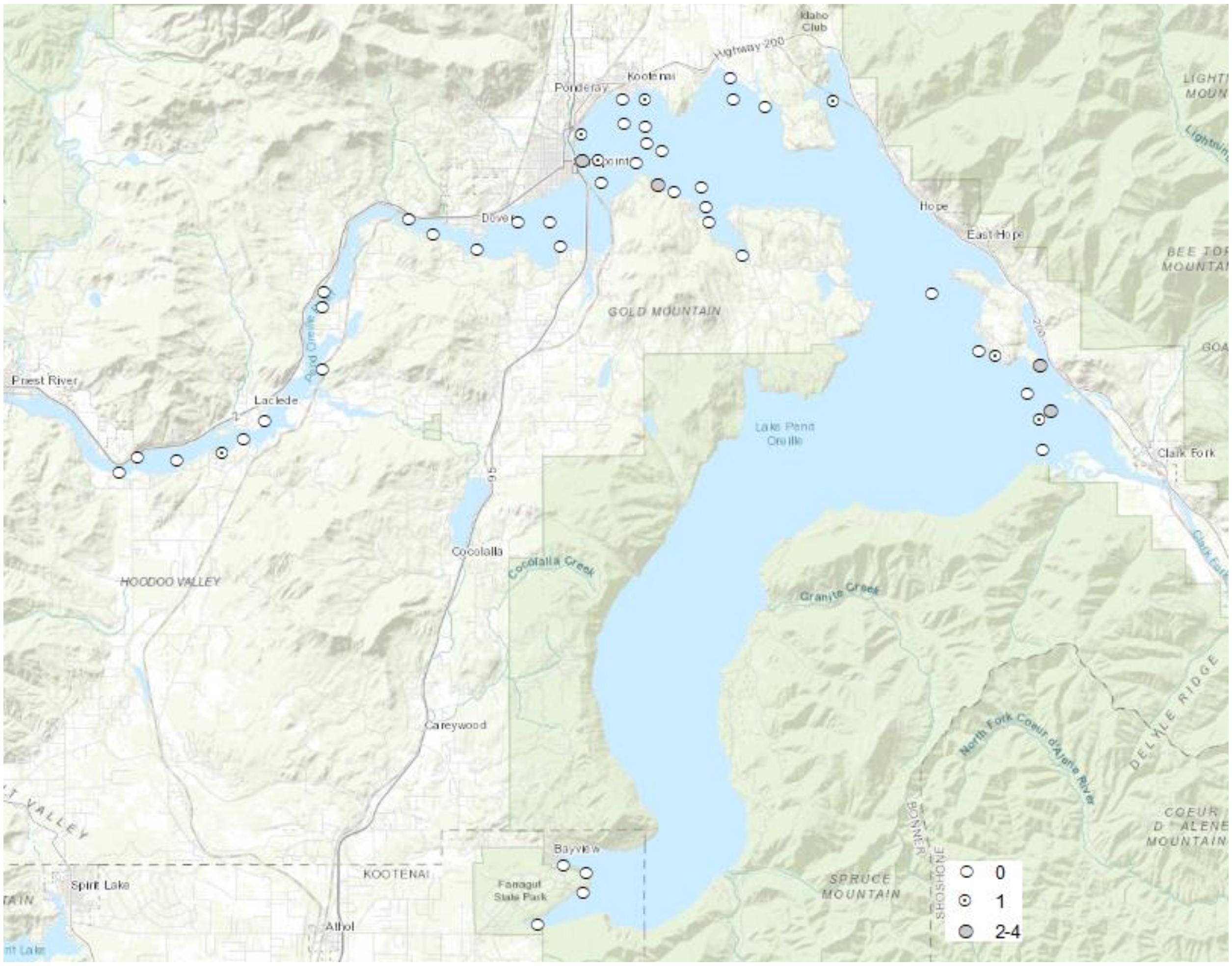

Figure 32. Fall Walleye index netting sampling locations in the Pend Oreille basin, Idaho during 2020. Sampling sites are displayed with corresponding Northern Pike CPUE (fish/net night).

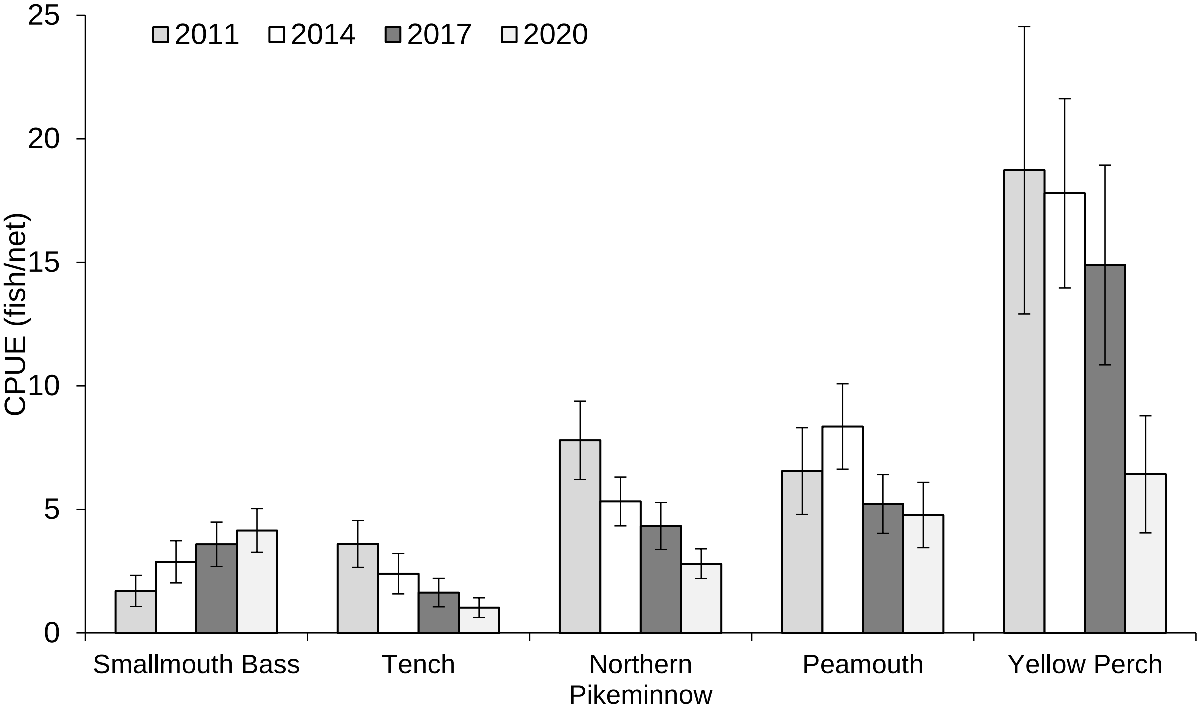

Figure 33. Mean catch rate (CPUE; fish/net) by survey year for common by-catch in Fall Walleye Index Netting surveys of Lake Pend Oreille and the Pend Oreille River, Idaho. Bounds around mean CPUE values represented 80% confidence intervals.

# HAYDEN LAKE INVESTIGATIONS

## ABSTRACT

In 2020, we completed multiple investigations of the Hayden Lake fish community including assessments of Pygmy Whitefish C*oregonus coulteri* abundance, kokanee *Oncorhynchus nerka* origin (hatchery vs wild), and mysid *Mysis diluviana* density. We caught a single Pygmy Whitefish among multiple bottom-trawl transects. Based on catch in our survey, we concluded Pygmy Whitefish were present, but exhibited limited distribution and abundance. A majority of kokanee collected (88.2%) were thermally marked, suggesting wild production remained low. We detected only a single late-strain kokanee from a 2018 stocking event, suggesting late kokanee exhibited poor survival in the lake. Mean density of combined immature and adult mysids was 107 mysids/m$^2$, representing moderate abundance and a stable population trend.

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## Introduction

Hayden Lake, located northeast of Hayden, Idaho in the Panhandle Region, provides fishing opportunity for multiple fish species and is a popular destination for anglers. A mix of warmwater species, including Largemouth Bass *Micropterus salmoides*, Black Crappie *Pomoxis nigromaculatus*, and Yellow Perch *Perca flavescens* were introduced in the early 1900s and are the primary focus of anglers (Maiolie et al 2011). More recent sportfish introductions in Hayden Lake also provide popular fishing opportunities. Smallmouth Bass *Micropterus dolomieu*, legally introduced, and Northern Pike *Esox lucius*, illegally introduced, added to the popular littoral fishery (Maiolie et al. 2011). Kokanee *Oncorhynchus nerka*, stocked since 2011, have noticeably increased angling effort in the pelagic areas of the lake. Historically, Hayden Lake provided a popular fishery for native Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, but stocking was discontinued and cutthroat abundance declined, leading to poor angler catch rates (Mauser 1978, Maiolie et al. 2011). Rainbow Trout were stocked in Hayden Lake since the early 1900s and angler reports suggested stocking historically provided a quality fishery. However, Rainbow Trout catch rates were poor (≤ 0.15 fish/hr) throughout the history of formal angler surveys on the lake (Ellis 1983, Davis et al. 2000, Maiolie et al. 2011). General observations of the fishery in recent years suggested Rainbow Trout represented only a small portion of the targeted effort and catch.

Improvement of the Hayden Lake trout fishery has been an ongoing focus of fisheries managers. Multiple management actions were attempted to increase trout survival and abundance. Management actions included introduction of mysid shrimp *Mysis diluviana* (mysids) an alternative food source (Heimer 1970), stocking rate manipulations, and experimentation with stocked strains and stocking locations. Despite these efforts, angler catch rates on trout continued to be low (Maiolie et al. 2011).

Kokanee have been stocked at low density (62-93 fish/ha) in Hayden Lake since 2011 to provide a pelagic sport fishery component (IDFG, unpublished data). Low density stocking was intended to provide a balance in size and abundance. Early-strain kokanee were stocked in most years (except 2018) and have performed well with average total length of age-2 fish in the spring varying from 289 to 388 (IDFG unpublished data). Although observed kokanee growth was desirable, some concern existed over maintenance of desired growth rates. This concern existed in part because mature kokanee have strayed to lake tributaries to spawn since introduction, but survival and associated production to the lake is not known. Production from wild-spawning kokanee may influence abundance and subsequent growth rates, making it difficult to maintain a quality kokanee fishery.

Pygmy Whitefish C*oregonus Coulteri* are an Idaho native species with distribution limited to several large lakes in the Panhandle region of the state (Wallace and Zaroban 2013). While Pygmy Whitefish were known to exist in the Panhandle, few investigations have described their distribution or abundance. Fredericks et al. (2013) conducted one of the few targeted investigations of the species in the region. They described the abundance of Pygmy Whitefish in Spirit and Priest lakes. In that work they indicated Pygmy Whitefish were relatively abundant in both lakes. Pygmy Whitefish occurrence was also described in Upper Priest Lake and Lake Pend Oreille in the Panhandle region (Wallace and Zaroban 2013).

In 2019, a single Pygmy Whitefish was caught during a gill net survey of kokanee in Hayden Lake. We found no reference indicating Pygmy Whitefish had previously been observed in this water body. While no prior observations from Hayden Lake were found, habitat characteristics of Hayden Lake are similar to other regional water bodies where Pygmy Whitefish are known to occur. For example, Hayden Lake is deep, oligotrophic, and connected hydraulically to the Upper Columbia River watershed (i.e., via the Rathdrum aquifer). While the observation of a Pygmy Whitefish in Hayden Lake provided evidence of their occurrence, a more formal documentation of presence and relative abundance was desired to inform the description of the species' distribution in the region.

In 2020, we conducted a bottom trawl survey of Hayden Lake to confirm the presence and describe the relative abundance of Pygmy Whitefish. In addition, we continued monitoring efforts initiated in prior years to describe kokanee origin (hatchery vs wild) and mysid density in the lake. Our description of kokanee origin was used to quantify wild production and its potential to influence abundance and growth. Estimated mysid density added to our understanding of abundance trends and the potential influence of mysids on the fish community.

## METHODS

### Pygmy Whitefish Status

We sampled Pygmy Whitefish in Hayden Lake using a bottom trawl on July 27, 2020. The trawl net was 6.5 m long with a mouth opening 2.5 m wide by 0.6 m high. Net mesh was 2.5 cm in the front section of the trawl with a 2.0 mm woven stretched mesh in the cod end. Five transects were completed at night (Table 20; Figure 35). Trawl depths varied from 24 to 55 m. The net was towed at approximately 4.2 km/h with the engine running at 1,000 rpm. Trawl length was variable. We used trawl catch to confirm species presence and describe relative abundance.

### Kokanee Monitoring

A sample of kokanee was collected from Hayden Lake on July 8 and 9, 2020 using suspended gill nets as described by Klein et al. (2019). Gill nets were 48.8 m long and 6.0 m in depth with 16 panels that were each 3.0 m long. Each net was configured with eight mesh sizes, including 12.7-, 19.0-, 25.4-, 38.1-, 50.8-, 63.5-, 76.2-, and 101.6- mm stretch measure. Two sample locations were non-randomly selected based on prior knowledge of kokanee distribution in the lake. Multiple nets were suspended at each location at varying depths to cover the vertical distribution of kokanee in the water column. All nets were fished overnight. Captured fish were identified, measured to total length (mm), and otoliths were removed.

Kokanee otoliths were inspected for thermal marks to identify hatchery- and wild-origin fish. Thermal marks were applied at the IDFG Cabinet Gorge Fish Hatchery during early hatchery rearing by manipulating water temperature in a designated pattern. Thermal mark patterns were unique to each year class. Identification of marks was completed by mounting otoliths, sulcus side up, to glass slides with Crystalbond 509 (Electron Microscopy Products, Hatfield, PA). Otoliths were then sanded until clearly viewable near the origin and viewed under 100x to 200x magnification to identify whether a mark was present. We assigned age to individual hatchery-origin kokanee using thermal marks.

### Mysid Monitoring

Mysids were sampled in Hayden Lake on May 27, 2020 to estimate population density. Sampling occurred at night during the dark phase of the moon. Twelve random sites were sampled. We attempted to select sites *a priori* from a depth zone equal or greater than 46 m. Vertical net tows were made from a depth of 46 m to the surface. If in the field a selected site was not actually 46 m deep, we looked for the desired depth range in close proximity to the site or made a tow from the maximum depth available if no deeper zone was present. A 1-m hoop net with 1,000-micron mesh net and a 500-micron bucket was used for all tows. Area of the net mouth was 0.8 m$^2$. Each mysid collected was counted and classified as either young-of-the-year (YOY), immature, or adult based on relative size and physical characteristics. We calculated density as mysids per square meter based on the area of the net mouth. We reported arithmetic mean density and 80% confidence intervals around each estimate.

## RESULTS

### Pygmy Whitefish Status

A single Pygmy Whitefish was caught among all trawl transects (Table 20). Total length and weight of this fish was 136 mm and 21 g. Slimy Sculpin *Cottus cognatus* were also caught in transects two, four, and five at varying rates. No fish were caught in transect one and a lack of debris caught in transect one suggested the net may have not contacted the bottom, potentially influencing observed catch. Debris caught in most transects consisted of rock, sticks, and miscellaneous detritus. In contrast, transect three collected a large amount of fine silt which filled the net and stalled the boats progress prior to completing the full transect. Transect three was also the location where a Pygmy Whitefish was caught.

### Kokanee Monitoring

We caught 57 kokanee among all gill net sets. Catch rate was 9.6 fish/net (± 8.8, 1 SD). Thermal marks were found on otoliths from 45 fish and represented kokanee from age-0 to age-3 (Table 21). Total length of age-2 kokanee was 337 mm. However, only a single marked age-2 kokanee was collected. No thermal mark was detected on otoliths of six fish. No otolith was recovered from additional six fish.

### Mysid Monitoring

Density of combined immature and adult mysids in Hayden Lake varied among sampled locations from 54 to 184 mysids/m$^2$ with a mean (± 80% C.I.) density of 107 mysids/m$^2$ (± 15; Table 22; Figure 35). YOY densities varied from 60 to 360 mysids/m$^2$.

## DISCUSSION

Our investigation confirmed Pygmy Whitefish occur in Hayden Lake. However, our catch of a single fish suggested abundance was low and distribution was limited. We noted catch rate in our survey was different than that described in other regional waters. For example, Fredericks et al. (2013) caught 105 Pygmy Whitefish from Spirit Lake in a comparable effort. We noted the location of catch in this survey (i.e., northern arm) was in the same portion of the lake where a Pygmy Whitefish was first detected in 2019. In our trawl survey, we found substrate in this area was unique relative to other transects. Although substrate type may influence distribution, limited catch in this survey precluded true evaluation of this factor.

Use of a bottom trawl in our survey of Pygmy Whitefish may have biased our understanding of abundance in Hayden Lake. Fredericks et al. (2013) noted vertical distribution of Pygmy Whitefish likely extended well above bottom trawl gear used in their surveys, potentially biasing density estimates. We used the same bottom trawl in our sample to facilitate comparability with other existing descriptions of Pygmy Whitefish catch. We also encountered challenges associated with fishing a bottom trawl over silty substrate, which may have influenced our catch. Fredericks et al. (2013) suggested small-mesh gill net may be a more suitable gear to effectively sample Pygmy Whitefish. We hypothesize gill nets may also have been more effective at sampling over a variety of substrate types, such as the silt dominant substrate we encountered in our survey. As such, we recommend future sampling of Pygmy Whitefish in Hayden Lake incorporate small-mesh gill nets to test the effectiveness of this sampling method.

A relatively small proportion (11.8%) of kokanee collected from Hayden Lake were unmarked, suggesting wild production remains low. Our observations were consistent with similar investigations completed in prior years (Ryan et al. 2023*;* Camacho et al. 2021). Kokanee length at age 2 was also comparable to prior years. Although we only sampled oneage-2 kokanee, its observed length might suggest wild production did not dramatically influence growth. While it does not appear wild recruitment is currently an issue impacting kokanee growth in Hayden Lake, inference from only one fish is limited. Nonetheless, we recommend periodic monitoring of wild production to better understand how wild production may vary over time.

Triploid late-spawning (late) kokanee were stocked in Hayden Lake in 2018 due to limited statewide supply of early-spawning (early) kokanee in that year (IDFG, unpublished data). Early kokanee were stocked in Hayden Lake in prior and subsequent years since 2011. We caught only a single marked late kokanee (age-2) in our sample, suggesting survival of the 2018 cohort was poor. Anecdotal angler reported catch rates of kokanee were also low in 2020. Gill net catch of the same age class in the prior year was greater, suggesting survival was poor from age-1 to age-2 (Ryan et al. 2023). Mechanisms influencing survival at the strain level were not clear. Regardless, we recommend early kokanee be prioritized when stocking Hayden Lake as they have consistently performed well since their introduction.

Mysid density estimates from Hayden Lake continued to represent a moderate population level. The population trend was stable relative to our recent sampling history. We recommend continued monitoring on a periodic basis to better understand long-term patterns in abundance, both in Hayden Lake and regionally.

## MANAGEMENT RECOMMENDATIONS

1. Conduct periodic surveys of Pygmy Whitefish relative abundance to assess status of isolated Idaho populations.

2. Test the effectiveness of small-mesh gillnets as a method to collect Pygmy Whitefish.

3. Periodically monitor wild kokanee production in Hayden Lake.

4. Prioritize stocking of early over late kokanee in Hayden Lake.

5. Periodically estimate mysid density in Hayden Lake.

Table 20. Depth (m), location, and catch from bottom trawl transects completed on Hayden Lake, Idaho on the night of July 27, 2020.

| Transect | Depth (m) | Start latitude | Start longitude | End latitude | End longitude | Species | Catch |
|---|---|---|---|---|---|---|---|
| 1 | 53-55 | 47.77907 | -116.69365 | 47.76850 | -116.70513 | -- | -- |
| 2 | 55 | 47.77183 | -116.70513 | 47.77907 | -116.69365 | Slimy Sculpin | 2 |
| 3 | 24-34 | 47.78625 | -116.69648 | 47.77988 | -116.69858 | Pygmy Whitefish | 1 |
| 4 | 55 | 47.75318 | -116.71243 | 47.76467 | -116.73667 | Slimy Sculpin | 24 |
| 5 | 37-52 | 47.76455 | -116.75160 | 47.75862 | -116.73532 | Slimy Sculpin | 7 |

Table 21. Kokanee catch (n) by age from suspended gill nets fished in July 2020 on Hayden Lake, Idaho. Mean total length (TL), length range, and kokanee strain (early vs late) were categorized by age. Age and strain were determined from thermal marks on kokanee otoliths.

| Age | *n* | Mean TL | Min-max TL | Strain |
|---|---|---|---|---|
| 0 | 17 | 97 | 92-103 | Early |
| 1 | 25 | 234 | 221-259 | Early |
| 2 | 1 | 337 | 337 | Late |
| 3 | 2 | 374 | 372-375 | Early |
| Unknown/wild | 12 | 183 | 93-348 | -- |

Table 22. Mysid density by sample site and life stage from May 2020 samples of Hayden Lake, Idaho. Life stages included young-of-the-year (YOY).

| Sample site | Latitude | Longitude | YOY/m$^2$ | Immature and adult/m$^2$ | All ages/m$^2$ |
|---|---|---|---|---|---|
| 1 | 48.69992 | -116.84776 | 1.2 | 107.7 | 108.9 |
| 2 | 48.68216 | -116.87552 | 0.0 | 100.4 | 100.4 |
| 3 | 48.66442 | -116.85066 | 1.2 | 53.8 | 55.1 |
| 4 | 48.63652 | -116.85791 | 1.2 | 75.9 | 77.1 |
| 5 | 48.61052 | -116.87714 | 3.7 | 86.9 | 90.6 |
| 6 | 48.58261 | -116.85108 | 2.4 | 105.3 | 107.7 |
| 7 | 48.56513 | -116.9079 | 7.3 | 99.1 | 106.5 |
| 8 | 48.55167 | -116.87752 | 4.9 | 106.5 | 111.4 |
| 9 | 48.55634 | -116.85088 | 4.9 | 104.0 | 108.9 |
| 10 | 48.51097 | -116.85129 | 6.1 | 192.1 | 198.3 |
| 11 | 48.50232 | -116.87905 | 8.6 | 64.9 | 73.4 |
| 12 | 48.59182 | -116.83867 | 13.5 | 183.6 | 197.0 |

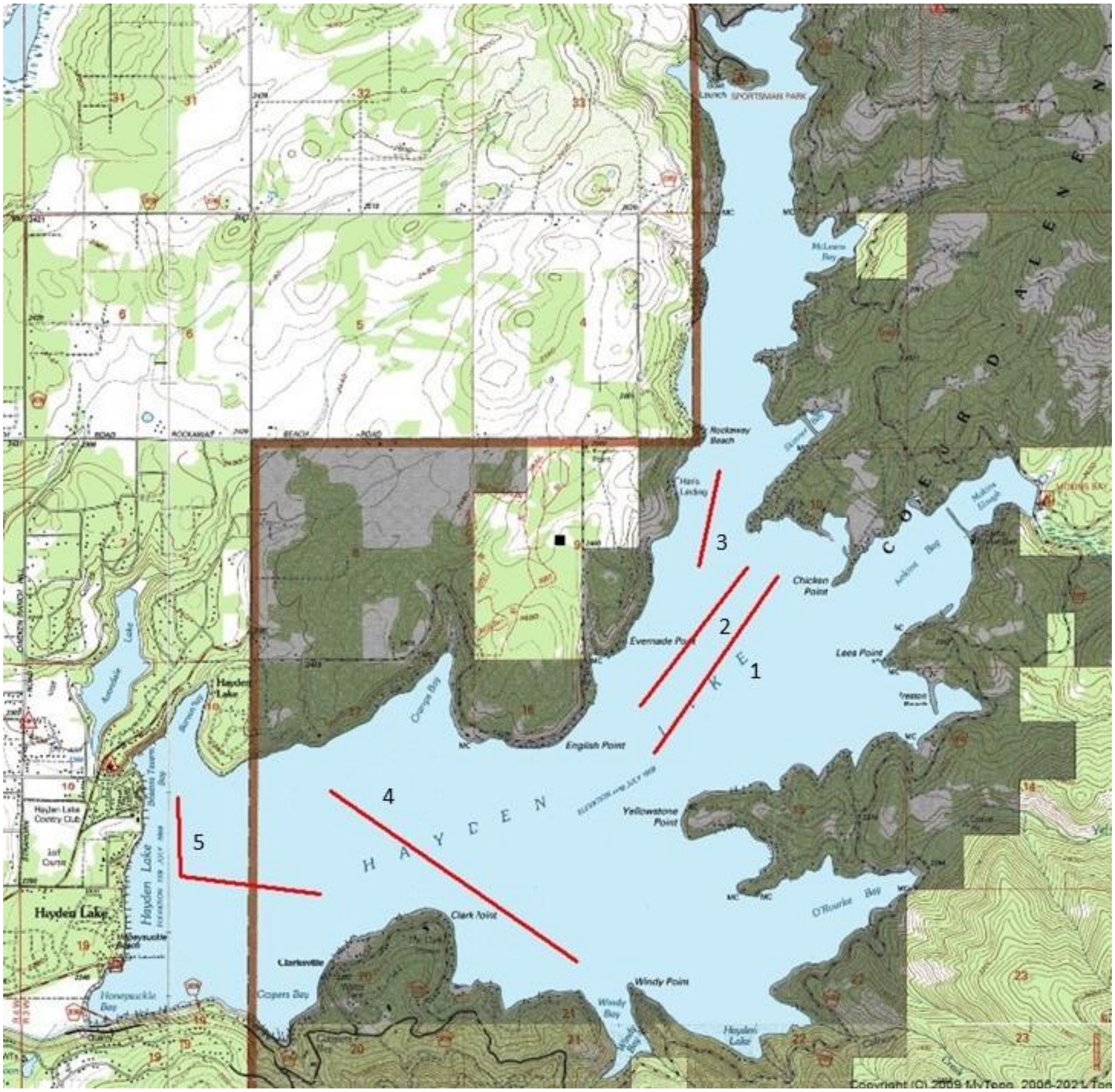

Figure 34. Location of bottom trawl transects on Hayden Lake, Idaho completed on July 27, 2020 and used to describe relative abundance and distribution of Pygmy Whitefish.

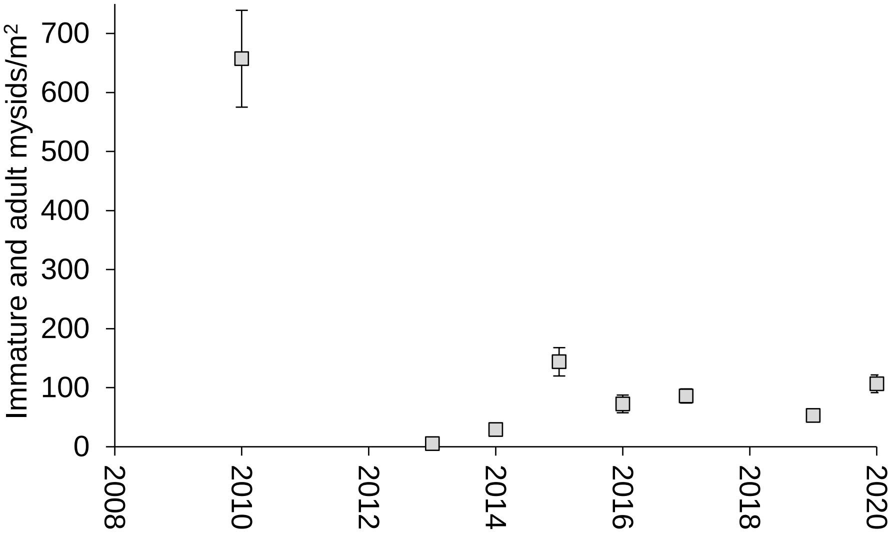

Figure 35. Mean density of immature and adult mysids in Hayden Lake, Idaho by year from 2010 through 2019. Error bars represent 80% confidence intervals

# LAKE COEUR D'ALENE AND SPIRIT LAKE KOKANEE EVALUATIONS

## ABSTRACT

We estimated age-specific abundance, density, and population characteristics of kokanee *Oncorhynchus nerka* in Lake Coeur d'Alene and Spirit Lake to monitor population trends. A modified midwater trawl was used to sample kokanee during July 22–24, 2020. We estimated a total abundance of 16.1 million and 340,192 kokanee in Lake Coeur d'Alene and Spirit Lake, respectively. The Lake Coeur d'Alene kokanee population had below average abundance of adult fish during 2020, but high abundance of age-0, age-1, and age-2 fish. Low adult densities resulted in large-sized adults (mean TL = 392 mm) that exceeded the longstanding management objective for Lake Coeur d'Alene. The Spirit Lake kokanee population also had a low abundance of adult fish, but a moderate abundance of age-0 fish. The largest kokanee caught in Spirit Lake was a 225 mm age-2 fish indicating size structure of kokanee in Spirit Lake may be improving. Poor recruitment in 2018 and high annual mortality of the 2017 year-class suggests that the trends in adult size structure may continue to increase for another year. Recruitment for the 2019 and 2020 year-classes was moderate and survival of the 2019 year-class to age-1 appears to be better than the previous few years. We recommend continued monitoring of both kokanee populations to assess trends in age-specific abundance and growth. Monitoring should focus on assessing the fishery-level effects in both lakes from recent weak year-classes.

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# INTRODUCTION

Kokanee *Oncorhynchus nerka* are a popular sport fish across much of the western U.S. because of their high catchability and table value. Kokanee angling is especially popular among local anglers because it is family-oriented, entertaining, and doesn't require complex gear. Kokanee comprise much of the fishing effort in northern Idaho lakes, making them an important focus for management. The Idaho Department of Fish and Game's (IDFG) current goal is to manage for adult kokanee abundances that support high annual harvest yields and provide prey for predators. Current and continued evaluations of kokanee populations in Lake Coeur d'Alene and Spirit Lake will provide information necessary to manage these fisheries for this goal.

Kokanee were introduced to Lake Coeur d'Alene in 1937 by IDFG to establish a harvest-oriented fishery (Goodnight and Mauser 1978; Hassemer and Rieman 1981; Maiolie et al. 2013). Initial introductions were made from a late-spawning shoreline stock from Lake Pend Oreille (originally Lake Whatcom, WA stock). During the early-1970s, attempts were made to introduce kokanee into Lake Coeur d'Alene from an early-spawning stock (Meadow Creek, British Columbia); however, early-spawning kokanee failed to establish a wild population and had dwindled by 1981 (Goodnight and Mauser 1980; Mauser and Horner 1982). Despite unsuccessful attempts to establish early-spawners, the kokanee fishery peaked in the mid-1970s and the wild, late-run stock was producing annual yields between 250,000–578,000 fish during that time (Goodnight and Mauser 1977; Goodnight and Mauser 1980; Rieman and LaBolle 1980). By the early 1980s, fishery managers had documented density-dependent effects on adult size structure of kokanee which prompted an increase in the daily bag limit from 25 to 50 fish per day and the introduction of Chinook Salmon *O. tshawytscha* as a biomanipulation tool to reduce kokanee abundance (Mauser and Horner 1982). Chinook Salmon naturalized in the system and are now an important component of the Lake Coeur d'Alene fishery. In recent history, evidence suggests the kokanee population has largely been influenced by environmental conditions, particularly high runoff events, and very little by the abundance of predators.

Kokanee populations are often greatly influenced by environmental conditions. For example, stochastic natural events can alter dynamic rate functions and have long-lasting effects on a population (Hassemer 1984). Poor recruitment commonly results from adverse environmental conditions and can be problematic from a fisheries management standpoint because kokanee are semelparous, and thus it may take several generations for recruitment to return to adequate levels. This dynamic was shown in Lake Coeur d'Alene where high runoff events (i.e., 1996 flooding), resulted in weak year-classes. The weak 1996 year-class resulted in low recruitment during subsequent years and translated into low abundance of harvestable age-3 and age-4 kokanee during 1998–2003. Lake Coeur d'Alene supports several predator species which prey upon kokanee at various life stages. As such, poor environmental conditions coupled with high predator abundance can have cumulative negative effects on kokanee dynamic rate functions, and thus abundance.

Late-spawning kokanee were also transplanted from Lake Pend Oreille to Spirit Lake in the late-1930s (Maiolie et al. 2013), and this stock has comprised the wild component of the fishery. According toyers (1990), Spirit Lake historically produced some of the highest relative annual yields of kokanee throughout the western U.S. and Canada. Attempts have been made to establish early-spawning kokanee to diversify the fishery, the last being in 2008 (Maiolie et al. 2013). However, it has been thought that beaver dams and limited spawning habitat precluded them from naturalizing and significantly contributing to the fishery. Population assessments in the 2000s showed high abundances of wild late-spawning adults, so stocking of early-spawning kokanee was discontinued in 2010. Recent kokanee assessments have shown fish are exhibiting slow growth relative to other systems, likely due to density-dependent effects. IDFG maintains long-term data on kokanee population dynamics and abundance in Lake Coeur d'Alene and Spirit Lake to continually evaluate population-level changes resulting from environmental factors and fishery management. In addition, annual assessment of the kokanee population provides IDFG with valuable information that can be shared with anglers.

## OBJECTIVES

1. Continue long-term monitoring to provide information related to kokanee and predator management in Lake Coeur d'Alene and Spirit Lake.

2. Estimate abundance and describe population characteristics of kokanee in Lake Coeur d'Alene and Spirit Lake.

## STUDY AREA

### Lake Coeur d'Alene

Lake Coeur d'Alene is a mesotrophic natural lake located in the Panhandle of northern Idaho (Figure 36). Lake Coeur d'Alene lies within Kootenai and Benewah counties, and it is the second largest natural lake in Idaho with a surface area of 12,742 ha, mean depth of 24 m, and maximum depth of 61 m (Rich 1992). The Coeur d'Alene and St. Joe rivers are the major tributaries to Lake Coeur d'Alene; however, many smaller tributaries also exist. The outlet to Lake Coeur d'Alene is the Spokane River, a major tributary to the Columbia River. Water resource development in the lake includes Post Falls Dam, which was constructed on the Spokane River in 1906 and raised the summer lake level by approximately 2.5 m. In addition to creating more littoral habitat and shallow-water areas, the increased water level created more pelagic habitat for salmonids (e.g., kokanee, Chinook Salmon).

The fishery in Lake Coeur d'Alene can be broadly characterized as belonging to one of three components—kokanee, Chinook Salmon, or warmwater species; all of which are popular among anglers. The fish assemblage has become increasingly complex over time, particularly during the past 30 years. Increased fish assemblage complexity has undoubtedly resulted in increased biological interactions, but also diversified angler opportunity. Because of its proximity to several major cities (i.e., Coeur d'Alene, Spokane), Lake Coeur d'Alene generates high angling effort that contributes considerably to state and local economies.

### Spirit Lake

Spirit Lake is in Kootenai County near the town of Spirit Lake, Idaho (Figure 37). The lake has a surface area of 596 ha, a mean depth of 11.4 m, and a maximum depth of 30.0 m. Brickel Creek is the largest tributary to the lake and drains a forested interstate watershed extending into eastern Washington. Brickel Creek originates on the eastern slope of Mount Spokane at approximately 744 m in elevation and flows in an easterly direction before forming Spirit Lake. Spirit Lake discharges into Spirit Creek, an intermittent outlet located at the northeastern end of the lake. Spirit Creek flows into the Rathdrum Prairie where it typically becomes subterraneous and contributes to the Rathdrum Aquifer.

Spirit Lake is a popular fishery with three main components—kokanee, Westslope Cutthroat Trout (stocked as fingerlings), and warmwater species (Camacho et al. 2021). Angler effort for kokanee typically peaks in early summer when water levels are higher and boating access is best. A second peak in angler effort for kokanee occurs during late-winter when sufficient ice forms for safe ice fishing. Historically, high densities of small kokanee have been immensely popular with ice anglers along with a 25 fish daily bag limit. However, after several years of low densities the bag limit was reduced to 15 fish per day in 2000. Densities increased and the bag limit was once again increased to 25 fish per day in 2016.

Unlike other large northern Idaho lakes with kokanee (i.e., Lake Pend Oreille, Lake Coeur d'Alene, Priest Lake), Spirit Lake did not have any pelagic predators until 2016 when Fall Chinook Salmon were introduced (See Chinook Monitoring Chapter within this report).

## METHODS

During 2020, kokanee were surveyed in Lake Coeur d'Alene and Spirit Lake on July 22–24 and July 21, respectively. Kokanee were sampled using a modified midwater trawl (hereafter referred to as the trawl) towed by a 9.2 m boat at a speed of 1.55 m/s. The trawl is a gear that has been successfully employed in large lentic systems for sampling kokanee (Rieman and Meyers 1991). The trawl consisted of a fixed frame (3.2 m × 2.0 m) and a single-chamber mesh net (6.0-mm delta-style No. 7 multifilament nylon twine, knotless mesh). The trawl assembly consists of two winch-bound cable towlines which are each passed through a single pulley block. The pulley blocks are vertically attached to a 2.4 m-tall frame mounted to the stern of the boat allowing the trawl to be easily deployed and retrieved during sampling. Additional information on the trawl can be found in Bowler et al. (1979), Rieman (1992), and Maiolie et al. (2004).

Trawling was conducted at 18 and five predetermined transects throughout Lake Coeur d'Alene and Spirit Lake, respectively (Figure 36; Figure 37). Transects were originally assigned using a systematic sampling design within three arbitrary strata (i.e., Sections 1, 2, and 3) and have remained the same to standardize annual abundance estimates (Ryan et al. 2014). During fish sampling, the bottom and top of the kokanee layer was identified using the onboard sonar unit, and the trawl was towed in a stepwise pattern (2.4-m increments; three minutes per step) to capture the entire fish layer at each transect (Rieman and Meyers 1991). Upon retrieval of the trawl, kokanee were measured for total length (TL; mm) and saggital otoliths were collected from 10 individuals per 1-cm length group if available. Otoliths were removed following the procedure outlined by Schneidervin and Hubert (1986). Whole otoliths were viewed by a single reader using a dissecting microscope with reflected light to estimate age.

Kokanee spawner length and age structure were estimated to evaluate growth objectives for Lake Coeur d'Alene. At this time, these data are not collected in Spirit Lake each year due to difficulties accessing fish in the early-Winter months. Mature adults were sampled on November 18, 2020 using a sinking experimental gill net (46.0 m × 1.8 m with panels of 50-, 64-, 76-, 88-, and 100-mm stretch-measure mesh) in the vicinity of Higgens Point in Wolf Lodge Bay where spawning kokanee are easily accessible and index netting has historically occurred. Sampled fishes were sexed and measured for TL (mm). In addition, otoliths were removed from 10 individuals per 1-cm length group immediately after sampling. Whole otoliths were viewed by a single reader using a dissecting microscope with reflected light to estimate age.

Age structure from trawl catch of both populations was estimated using an age-length key (Isermann and Knight 2005; Quist et al. 2012). Age data was then used to generate estimates of age-specific abundance. Total population abundance estimates have traditionally been used to index the kokanee populations in both Spirit and Coeur d'Alene lakes. Therefore, we calculated total age-specific abundance (*N*) which could be compared to prior surveys. Length-frequency information from trawling and spawner index netting was analyzed to provide insight on size structure and length-at-age.

## RESULTS

### Lake Coeur d'Alene

We sampled a total of 1,533 kokanee by trawling in Lake Coeur d'Alene. We estimated a total population abundance of 16.1 million kokanee at a density of 1,670 kokanee/ha. Age-specific abundance estimates were approximately 4.6 million age-0, 6.5 million age-1, 5.0 million age-2, and 20,369 age-3/4 kokanee based on trawling (Table 23). The highest densities of kokanee fry (age-0) were observed in the northern portion of the lake (Section 1; Figure 36), particularly near Wolf Lodge Bay. Section 2 contained the highest densities of age-1 kokanee. However, age-1 densities were almost as high in Section 3. Age-2 kokanee densities were highest in Section 3. Adults were only caught in Section 2. Kokanee sampled by trawling varied in length from 35 to 363 mm TL (Figure 38) and varied in age from 0 to 4 years old (Figure 39).

Spawning kokanee varied in length from 250 to 464 mm TL and all were estimated to be either three or four years old. Similar to past years, female kokanee represented a smaller proportion of the sample (Figure 40). Mean TL was 392 mm (SD = 48.7) for male and 375 mm (SD = 11.6) for female kokanee. Overall mean TL was 391 mm (SD = 47.7). Mean TL of kokanee spawners in 2020 was larger than in 2019, and all sampled fish met or exceeded the adult length objective (Figure 41).

### Spirit Lake

We sampled a total of 150 kokanee by trawling in Spirit Lake. We estimated a total abundance of 340,192 kokanee. Age specific abundances were estimated as 208,014 age-0, 129,675 age-1, 2,504 age-2, and 0 age-3 kokanee based on trawling (Table 24). Total density was estimated as 582 kokanee/ha and a density of 0 age-3 kokanee/ha. Age-0 and age-1 Kokanee tended to be distributed more towards the west end of the lake. Age-2 fish were only found in the middle portion of the lake in trawl transect 3. A weak 2017 year-class was confirmed by the lack of any age-3 fish captured in the trawl. An even weaker 2018 year-class produced the lowest abundance of age-2 kokanee on record. Kokanee sampled during trawling varied in length from 40 to 225 mm TL (Figure 42) and varied in age from 0 to 2 years old (Figure 43).

# DISCUSSION

## Lake Coeur d'Alene

The kokanee population in Lake Coeur d'Alene has supported a productive harvest fishery over the past several years. Angling was reportedly good again during 2020 and produced above average sized fish to the delight of many anglers. This is the second consecutive year of above average sized adults and was the lowest adult abundance on record. Adult spawner size exceeded the desired range and was well-above the most recent 10-year average. Average adult size from spawner sampling was the third largest for males (392 mm; SD = 49) and second largest for females (275 mm; SD = 12) on record. Despite a low adult abundance, overall kokanee abundance was at a record high. Abundance of young-of-year kokanee was the seventh highest on record and was 2.5-fold higher than the previous 10-year mean. Age-1 kokanee abundance was the highest and age-2 kokanee abundance was the second highest on record dating back to 1979. High abundances of younger year-classes suggest anglers should expect mean size of adult kokanee to decrease for the next few years from those observed in 2020.

When adult abundance was low in the past, reduced bag limits or emergency rule closures were implemented in some years to protect spawners (DuPont et al. 2011, Fredericks et al. 2009). In 2006 and 2008, the kokanee fishery was closed in the fall to protect congregating spawners in the Wolf Lodge Bay area because kokanee were thought to be more susceptible to angling as size increases (Fredericks et al. 2009, Rieman and Maiolie 1995). However, newer research has contested that angler catchability increases as kokanee size increases (Klein et al. 2020). In addition, midwater trawling techniques are known to be ineffective at sampling kokanee >300 mm and produce estimates that are biased low for larger kokanee (Rieman and Meyers 1991, Klein et al. 2019). In 2020, 93% of spawners during index netting were >300 mm and were not susceptible to midwater trawl sampling, thus resulting in a low adult abundance estimate.

An emergency rule change to restrict kokanee harvest was not implemented in 2020, much like occurred in 2001. The kokanee population in 2001 had a record low abundance of adults, but also had a high number of younger fish, similar to 2020 (Liter et al. 2007). Managers did not alter the fishery in 2001 and observed an average abundance of young-of-the-year kokanee in 2002. This scenario provided evidence that a small number of adults could sustain adequate recruitment. By not implementing an emergency rule change, an opportunity was created that historically may not have occurred for anglers to enjoy some of the largest kokanee ever produced in Lake Coeur d'Alene. Furthermore, we observed a low number of adults can provide an outstanding fishery albeit with lower catch rates. Nonetheless, fry production in 2021 should be evaluated to determine if recruitment was poor in response to low adult abundance and angler harvest. While potential management options for influencing the kokanee fishery are limited, continued population monitoring is important for understanding kokanee ecology and for providing public information.

## Spirit Lake

Spirit Lake has historically been one of Idaho's top kokanee fishing waters (Maiolie et al. 2013). The lake supports a summer troll fishery and winter ice fishery, making it an important regional resource. The kokanee population has a long history of being highly variable in terms of recruitment and growth, and this has continued over the last 15 years (Maiolie et al. 2013). The fishery has tended to follow suit whereby angling effort tracks adult abundance and size structure; however, the fishery can also be variable due to winter ice conditions (Camacho et al. 2021).

Overall kokanee abundance was lower in 2020 and substantially lower compared to surveys in the past 10 years. Age-2 and age-3 abundance was the lowest observed since 1981. Since no age-3 fish were sampled, it is possible these fish were larger and not susceptible to sampling using the midwater trawl. Relative year-class strength and survival of kokanee among years appears to trend similarly to Coeur d'Alene Lake. Similarities in year-class strength, annual mortality, and relative adult size between Spirit Lake and Coeur d'Alene Lake may be attributed to regional environmental conditions.

The kokanee population often exhibited strong density-dependent growth, thus depressing size structure and at times leading to decreased interest among anglers. The introduction of a predator has the potential to reduce kokanee abundance and subsequently increase kokanee size structure and angler interest. It is too early to determine if the initial Chinook stockings have had a meaningful impact on the kokanee population. Few Chinook have been observed or caught by anglers since the initial stocking and no spawning adults have been observed to date.

In addition to the introduction of Chinook into Spirit Lake, the daily bag limit regulation for kokanee changed in 2016 from 15 fish to 25 fish. The change reverted to pre-2000 regulation bag limits in an effort to increase angler interest and harvest after several years of high kokanee abundance. However, angler effort and harvest can be highly variable depending on seasonal climate conditions. Some summer harvest occurs via troll fishing, but boat access becomes limited when lake water levels drop reducing angler effort on kokanee. When sufficient ice formation occurs, angler effort and harvest on kokanee can increase (Camacho et al. 2021). A yearlong creel survey of Spirit Lake initiated in April 2018 suggested the increase in the daily bag limit to pre-2000 regulations did not result in increased kokanee harvest to pre-2000 levels, despite more adult kokanee estimated in the lake during the most recent creel survey. Further assessment is needed to better understand long-term trends in kokanee population abundance and size structure in relation to environmental conditions, regulation changes, and predation impacts.

## MANAGEMENT RECOMMENDATIONS

1. Continue annual kokanee population monitoring on Lake Coeur d'Alene and Spirit Lake, including assessing fry production from the weak spawner abundance in 2020.

2. Evaluate the effects of Chinook Salmon on kokanee age-specific abundance in Spirit Lake.

Table 23. Estimated average abundance of kokanee made by midwater trawl in Lake Coeur d'Alene, Idaho, from 1979–2019, 2010-2019, and 2020.

| | Estimated Abundance by Age | | | | |
|---|---|---|---|---|---|
| Year | Age-0 | Age-1 | Age-2 | Age-3/4 | Total |
| 1979-2019 | 3,285,877 | 1,760,514 | 1,691,191 | 662,021 | 7,260,336 |
| 2010-2019 | 1,851,100 | 2,129,462 | 2,335,661 | 537,078 | 6,606,624 |
| 2020 | 4,641,725 | 6,494,731 | 4,959,556 | 20,369 | 16,116,380 |

**Surveys not conducted in 2005 and 2012.*

Table 24. Estimated abundance of kokanee made by midwater trawl in Spirit Lake, Idaho, from 1981–2020.

| | Estimated Abundance by Age | | | | |
|---|---|---|---|---|---|
| Year | Age-0 | Age-1 | Age-2 | Age-3/4 | Total |
| 1981-2019 | 230,352 | 166,733 | 198,165 | 67,923 | 663,698 |
| 2010-2019 | 267,543 | 196,222 | 452,313 | 109,334 | 1,025,579 |
| 2020 | 208,014 | 129,675 | 2,504 | 0 | 340,192 |

**Surveys not conducted in 1992, 1996, 2001-2004, 2006, 2012, and 2013.*

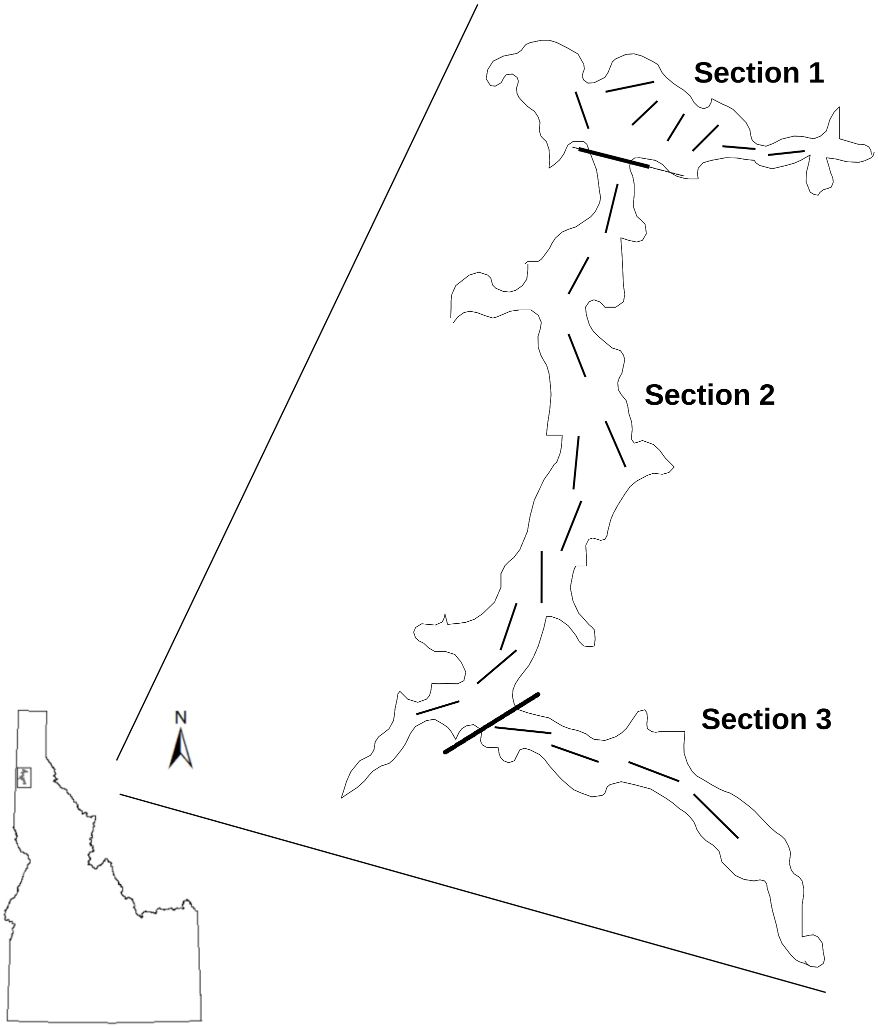

Figure 36. The approximate location of historical trawling transects used to estimate abundance of kokanee in Lake Coeur d'Alene, Idaho.

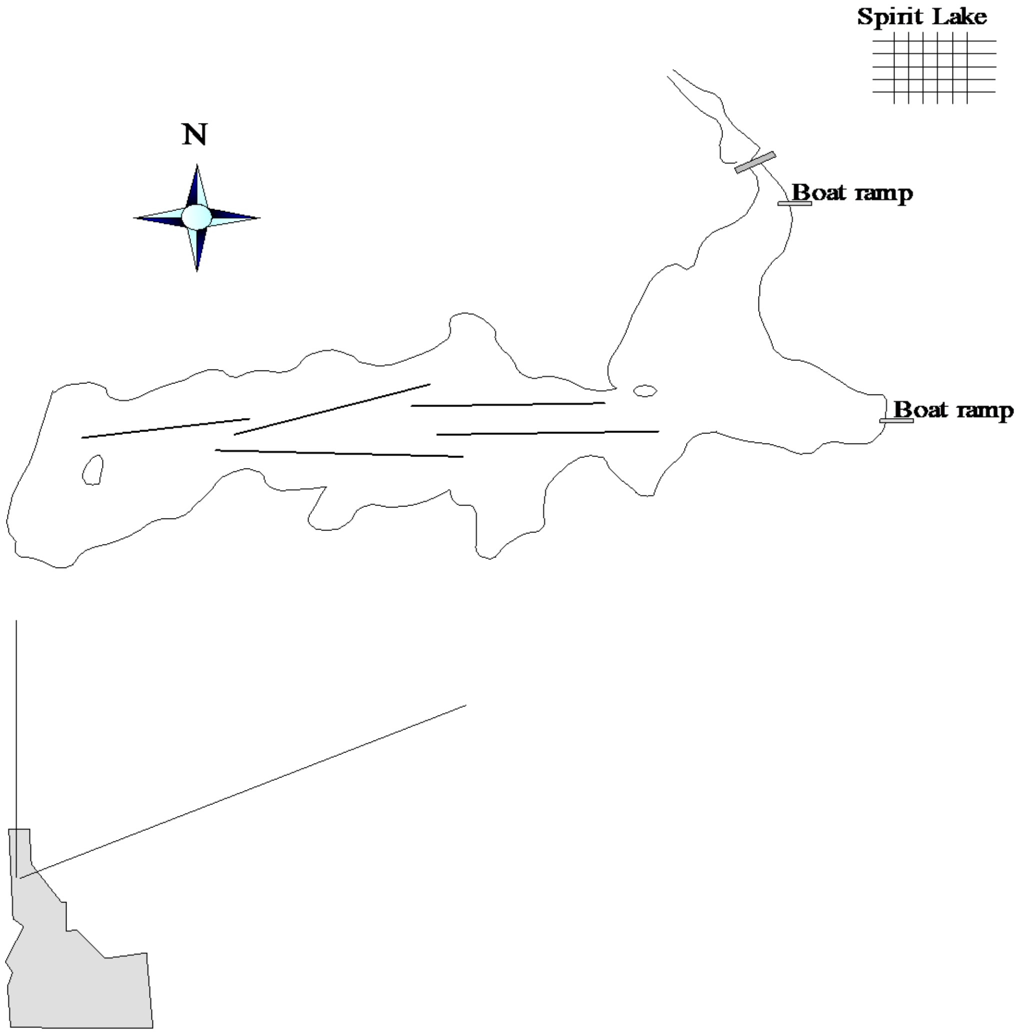

Figure 37. The approximate location of historical trawling transects used to estimate abundance of kokanee in Spirit Lake, Idaho.

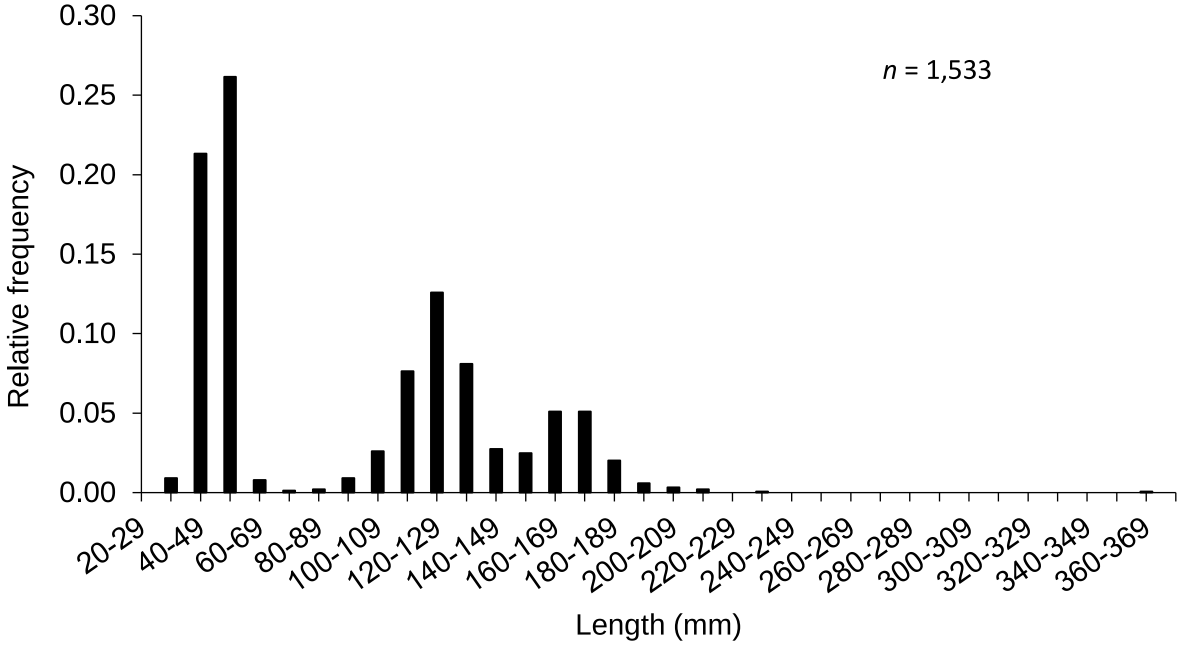

Figure 38. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (July 22–24, 2020).

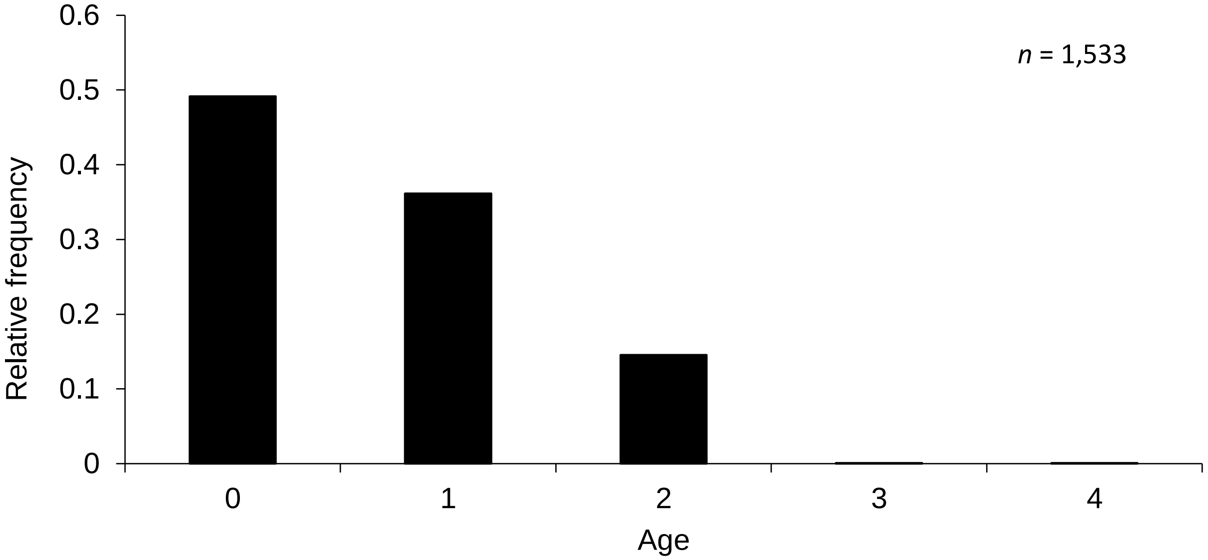

Figure 39. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (July 22–24, 2020).

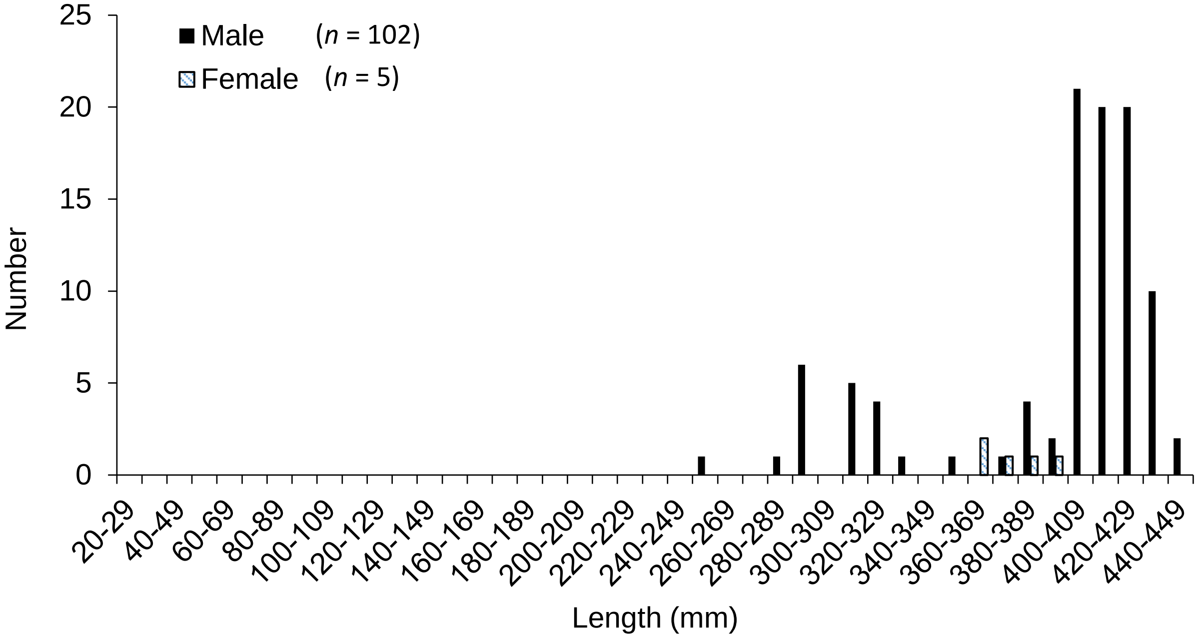

Figure 40. Length-frequency distribution for male and female spawning kokanee sampled from Lake Coeur d'Alene, Idaho (December 1, 2020).

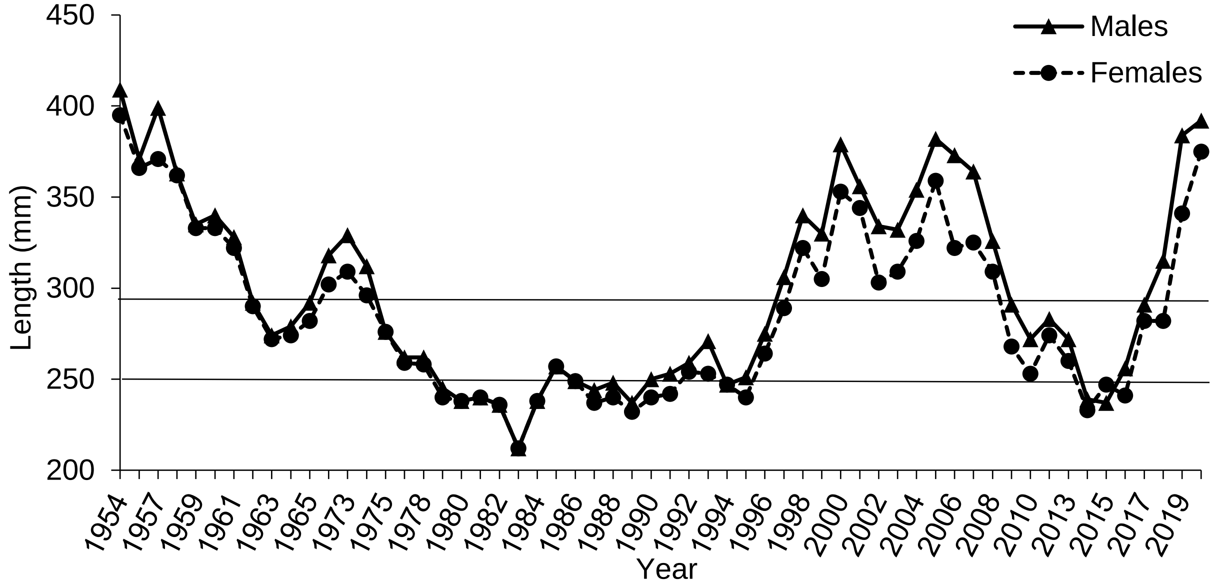

Figure 41. Mean total length of mature male and female kokanee sampled near Higgens Point in Lake Coeur d'Alene, Idaho (1954–2020). Horizontal lines indicate the upper and lower limit of the adult length management objective (250–280 mm).

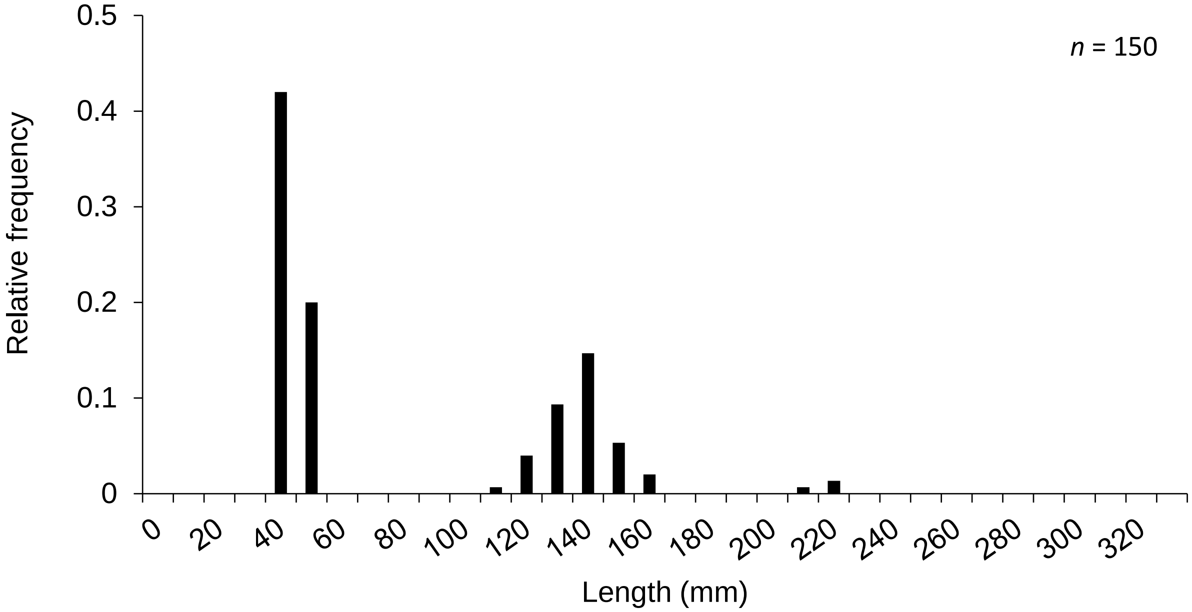

Figure 42. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (July 21, 2020).

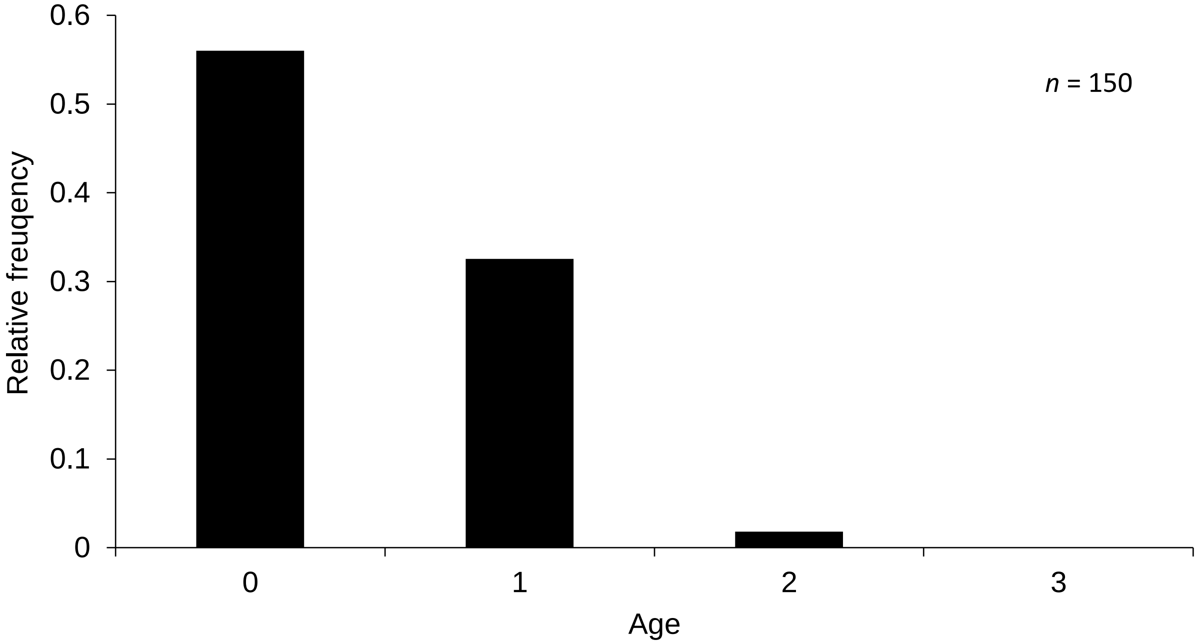

Figure 43. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (July 21, 2020).

# LAKE COEUR D'ALENE AND SPIRIT LAKE CHINOOK SALMON EVALUATIONS

## ABSTRACT

We evaluated escapement of Fall Chinook Salmon *Oncorhynchus tshawytscha* to assess trends in adult abundance by enumerating redds at standard index reaches for the Lake Coeur d'Alene and Spirit Lake populations. In 2020, a total of 249 redds were observed in all index reaches combined for Lake Coeur d'Alene. All but nine redds were found in the Coeur d'Alene River basin. The nine other redds were found in the St. Joe River index reach and were the first redds observed since 2015. Combined redd abundance from all index reaches was more than quadruple the number of redds in 2019. A total of 34 carcasses were collected from the Coeur d'Alene River index reaches and averaged 714 mm in total length. Females were slightly smaller than males on average and comprised 47% of the carcasses collected. All fish were 3 or 4 years old, except one 5-year-old male. The first redd survey for Sprit Lake was completed in 2020. No Chinook Salmon redds, carcasses, or live fish were observed. Hatchery outplants were adipose fin clipped to evaluate if fish recruit to the fisheries. No hatchery fish were recovered during carcass recoveries on the spawning grounds. Future assessments should include annual monitoring of adult escapement and spawner age structure so that changes in abundance, age-at-maturity, and growth can be identified. Information related to population characteristics can be used to assess population-level changes and facilitate better management of the Lake Coeur d'Alene and Spirit Lake fisheries.

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# INTRODUCTION

Chinook Salmon *Oncorhynchus tshawytscha* is an anadromous Pacific salmon species historically found throughout the Columbia River Basin (Wallace and Zaroban 2013). While anadromy is the natural life history form of Chinook Salmon, adfluvial life histories exist where the species has been successfully stocked into lentic systems outside of their native distribution. For example, both Chinook Salmon and Coho Salmon *O. kisutch* have been stocked into large lakes and reservoirs in the northern United States where they have naturalized and provide important angling opportunities (Diefenbach and Claramunt 2013; MFWP 2013). With adequate fluvial spawning habitat, many landlocked Pacific salmon populations are able to adopt adfluvial life history strategies and naturalize in lentic systems, persisting well outside of their native distribution.

In addition to providing angling opportunities, Chinook Salmon have been stocked as a biomanipulation tool to reduce kokanee *O. nerka* abundance (Mauser and Horner 1982). Kokanee are a pelagic-oriented species that exhibit density-dependent growth, and increases in population abundance commonly reduce length-at-age. In some instances, high kokanee abundance can reduce the size structure below angler satisfaction and interest. In an absence of fishing mortality, predators, such as Chinook Salmon, can be used to reduce kokanee abundance. The semelparous life history, short life span (≤ 5 years), overlapping use of pelagic habitat with kokanee, and limited spawning habitat availability make Chinook Salmon a desirable predator that can be manipulated through stocking in response to kokanee abundance and length-at-age fluctuations.

IDFG has stocked Chinook Salmon into Lake Coeur d'Alene since 1982 and Spirit Lake since 2017. The primary purpose of Chinook Salmon in Lake Coeur d'Alene is to maintain a fishable population that does not depress the kokanee population yet helps to achieve kokanee size structure objectives. Spirit Lake was stocked with Chinook Salmon primarily as a research project assessing survival, growth and return to creel of different ploidy strains and secondarily as a predator to reduce consistently overabundant and small-bodied kokanee. Despite low and varied recruitment into the fishery for both waterbodies, Chinook Salmon remain popular with anglers because they often grow to trophy sizes and have very palatable flesh. Prior to the introduction of Chinook Salmon, nearly all (~99%) of the angling effort in Lake Coeur d'Alene had been targeted at kokanee (Rieman and LaBolle 1980); however, more recent studies have shown that most effort (~42%) is now targeting Chinook Salmon (Hardy et al. 2010). The IDFG's objective is to manage for a high yield kokanee fishery (15 and 25 fish daily bag limit for Lake Coeur d'Alene and Spirit Lake, respectively) and trophy Chinook Salmon fishery (2 fish daily bag; none under 508 mm). As such, monitoring Chinook Salmon populations and understanding factors that regulate each population is critical for providing quality angling opportunities.

# OBJECTIVES

1. Monitor trends in Chinook Salmon redd abundance as an index of adult abundance.

2. Evaluate stocks and stocking strategies for hatchery Chinook Salmon to improve return-to-creel of supplemental fish.

# STUDY AREA

## Lake Coeur d'Alene

Lake Coeur d'Alene is a natural mesotrophic water body located in the Panhandle of northern Idaho (Figure 44). Lake Coeur d'Alene lies within Kootenai and Benewah counties, and it is the second largest natural lake in Idaho with a surface area of 12,742 ha, mean depth of 24 m, and maximum depth of 61 m (Rich 1992). The Coeur d'Alene and St. Joe rivers are the major tributaries to Lake Coeur d'Alene; however, many smaller second and third order tributaries also exist. The outlet to Lake Coeur d'Alene is the Spokane River, a major tributary to the Columbia River. Water resource development in the watershed includes Post Falls Dam, which was constructed on the Spokane River in 1906, and raised the summer lake level approximately 2.5 m.

The fish assemblage in Lake Coeur d'Alene is composed of three native sport fish species, five native nongame species, 16 introduced sport fish species, and one introduced nongame species. The fishery in the lake, however, can be broadly summarized as belonging to one of three components—kokanee, Chinook Salmon, or littoral species; all these components are popular among anglers. Increased fish assemblage complexity has undoubtedly resulted in increased biological interactions, but also diversified angler opportunity. Because of its proximity to several major cities (i.e., Coeur d'Alene, Spokane), Lake Coeur d'Alene generates high angling effort, contributing considerably to both state and local economies.

Fall Chinook Salmon were first stocked into Lake Coeur d'Alene in 1982 as a biomanipulation tool to reduce kokanee abundance. Kokanee exhibit density-dependent growth and increases in population abundance commonly reduce length-at-age. This relationship has been evident in Lake Coeur d'Alene. Fishery managers noted declines in size structure of kokanee during the late-1970s and concluded that fishing mortality could not sufficiently influence abundance. Goodnight and Mauser (1980) recommended an increase in the daily bag limit of kokanee from 25 to 50 fish following the 1979 season. The following year, Mauser and Horner (1982) noted that "the population size still exceeded the capacity of the system to produce fish of a desirable size to anglers" and recommended that predators be used to reduce abundance. Although kokanee harvest had reached an all-time high of ~578,000 fish in 1979, managers were convinced that improvements in size structure were needed to maintain angler interest. The semelparous life history and short life span of Chinook Salmon made it a desirable predator, and it was thought that their abundance could be regulated by stocking alone. An added benefit of Chinook Salmon was the creation of an additional fishery in the system. Previous managers had no expectation of naturalization and wild reproduction from Chinook Salmon introduced into Lake Coeur d'Alene; however, Chinook Salmon were observed spawning in Wolf Lodge Creek as early as 1984 and wild fish had become common in the fishery by 1986. Wild Chinook Salmon redds were observed in the Coeur d'Alene River and St. Joe River around 1988, and by then wild fish dominated the angler catch (Horner et al. 1989; Fredericks and Horner 1999).

Through the 2000s IDFG was actively utilizing Chinook Salmon as a tool for managing the kokanee population in Lake Coeur d'Alene. In response to fluctuations in kokanee abundance and size, managers regulated Chinook Salmon abundance through stocking (or lack thereof), excavation of wild redds (Davis et al. 2000), and blocking tributaries with weirs to prevent adults from reaching spawning areas (Horner and Rieman 1985, Davis et al. 1996a). Estimates of wild production were obtained by coupling redd survey information with known out of basin egg-fry survival rates. Historically, Chinook Salmon redd objectives have been between 60 and 100 total redds among both the Coeur d'Alene and St. Joe rivers (Nelson et al. 1996, DuPont et al. 2009).

During years when the objective was exceeded, redds were excavated, and supplemental stocking was used during years when wild redd abundance was below objective. However, the effectiveness of managing adult Chinook Salmon densities using supplemental stocking and redd excavation has been unsubstantiated. In addition, the kokanee population appears to be influenced more by environmental conditions rather than predator abundance. As such, IDFG has not excavated Chinook Salmon redds since 2009, but monitors trends in redd abundance.

One factor that has influenced the IDFG's ability to manage Chinook Salmon abundance in Lake Coeur d'Alene is related to performance and retention of hatchery fish. Although approximately 20,000 individuals are stocked annually, return-to-creel of hatchery fish is very low. Creel surveys conducted at angling tournaments and anecdotal evidence from avid Chinook Salmon anglers suggest that recruitment of hatchery fish to the fishery is close to zero. Ryan et al. (2014) evaluated performance of hatchery Chinook Salmon among rearing hatcheries and between spring and fall stocking seasons. The authors reported that hatchery fish performance may be lower among cohorts that were raised at Nampa Fish Hatchery and released in spring stocking groups. These results have influenced current management, and the IDFG now rears supplemental Chinook Salmon for Lake Coeur d'Alene at Cabinet Gorge Hatchery in Clark Fork, Idaho. In addition, stocking has been moved to early fall (i.e., late-September or early-October) when fish are larger and post-smoltification. Anglers have reported that hatchery sub-adult Chinook Salmon (identified by a clipped adipose fin and size <500 mm) were more commonly encountered during 2013–2014. However, time is needed to evaluate if these fish will recruit to the fishery as adults at rates desirable for managers.

## Spirit Lake

Spirit Lake is a natural, mesotrophic water body located near the town of Spirit Lake in the Panhandle of northern Idaho (Figure 45). Spirit Lake lies within Kootenai county and has a surface area of 596 ha, a mean depth of 11.4 m, and a maximum depth of 30.0 m. Brickel Creek is the largest surface water tributary and main inlet to Spirit Lake. Brickel Creek originates on the eastern slope of Mount Spokane at approximately 744.0 m in elevation and flows in an easterly direction before entering Spirit Lake. Spirit Lake discharges into Spirit Creek, a small, intermittent outlet located at the northeastern end of the lake. Spirit Creek flows into the Rathdrum Prairie where flow typically becomes subterraneous and contributes to the Rathdrum Aquifer.

The fishery in Spirit Lake has three main components: kokanee, Westslope Cutthroat Trout *O. clarki lewisi*, and littoral species. Much like Lake Coeur d'Alene, kokanee abundance and size structure has varied widely over the years. During good years and when conditions allow, the lake supports a very popular ice fishery targeting kokanee (Maiolie et al. 2011). However, in recent years size structure has been dominated by smaller-sized fish and anglers seem to have lost interest in the fishery. As part of a statewide, multi-year, multi-waterbody IDFG research project, Chinook Salmon were stocked into Spirit Lake to assess survival and growth of diploid and triploid Chinook Salmon. An added benefit to stocking Chinook Salmon was a potential reduction of abundant kokanee through predation leading to an increase in kokanee size structure and angler satisfaction. Stocking Chinook Salmon into Spirit Lake to reduce kokanee abundance was not a new concept. In 1983, mangers feared kokanee were approaching carrying capacity in Spirit Lake and recommended, but never implemented, stocking a predator such as Chinook Salmon on a limited basis to reduce kokanee abundance (Rieman and Horner 1984).

Fall Chinook Salmon (Tule stock) were stocked into Spirit Lake in 2016 through 2019 for the ploidy study. Each September when water temperatures cooled, approximately 5,000 young-of-the-year Chinook Salmon were planted at the Bronze Bay boat launch on the western end of the lake. Half of the stocked fish were triploid and the other half were diploid. Triploid salmonids are sterile and do not pose the same risks of becoming a naturally reproducing population, such as occurred with diploid Chinook Salmon stocked in Lake Coeur d'Alene. However, triploid salmonids have had lower survival than their diploid counterparts in other studies (Brock et al. 1994, Rutz and Baer 1996, Koenig et al. 2011). Fin clips from angler-caught Chinook Salmon are collected to assess the survival and return to creel of each ploidy group. Anglers turn in fin clips to collection stations at the Sportsman's Access and Kootenai County boat launches on the east end of the lake. Supplemental fin clips and biological metrics collected from incidental catches during other regional management surveys are also used. If acceptable survival and growth can be attained, triploid Chinook Salmon could provide a useful alternative with reduced risks of natural reproduction and allow managers to more closely regulate predator/prey relationships between Chinook Salmon and kokanee. Stocking for the ploidy study ended after the 2019 stocking. The collection of fin clips is still ongoing, but will cease after the fall of 2023 when the 2019 stocking group completes their life cycle as a 5-year-old spawning adult.

Until conclusions regarding the ploidy study are made, it was decided to continue stocking 5,000 young-of-the-year Chinook Salmon each fall with a few modifications. All fish stocked were to be diploid and be of the same stock used in Lake Coeur d'Alene. The stocking location was moved from a direct release into the lake at Bronze Bay to the main inlet, Brickel Creek. This was done to induce homing back to Brickel Creek for easy collection of spawning adults for hatchery broodstock or manipulation of escapement.

## METHODS

### Lake Coeur d'Alene

Chinook Salmon escapement has been monitored using annual redd counts in the Coeur d'Alene and St. Joe rivers since 1990. Standardized index reaches (Table 25) have been sampled annually during late-September through early-October to estimate relative redd abundance. Early surveys were done via helicopter, but since 2012 surveys have been conducted by watercraft (Ryan et al. 2014). Two individuals floated the Coeur d'Alene River index reaches during October 7–8, 2020 and the St. Joe index reach during October 9, 2020. During sampling, all redds were enumerated and georeferenced with a global positioning system. Redd abundance was estimated as the total number of redds observed among all index reaches and were compared to previous annual surveys to provide insight on trends in abundance.

### Spirit Lake

In 2020, the first annual redd count in Brickel Creek was completed to monitor Fall Chinook Salmon escapement in Spirit Lake. Two experienced Chinook Salmon redd observers surveyed the lower 6.1 rkm from the mouth to the second vehicle bridge upstream of the mouth near Supper Creek. This reach encompassed a large majority of the spawning habitat available. All redds were enumerated and georeferenced with a global positioning system. Redd abundance was estimated as the total number of redds observed.

Fall Chinook Salmon carcasses were collected in all index reaches and measured for total length (mm), otoliths were removed, sex was determined, and gonads were categorized for spawning success (females only). Carcasses were retrieved by hand in shallow water or with a fishing pole outfitted with a large, weighted treble hook with flagging in deep pools. For each fish, the body cavity was opened to examine the gonads for sex identification. Female ovaries were further categorized as fully spawned, partially spawned, or pre-spawn based on the amount of eggs remaining in the body cavity. Fully spawned females had less than 100 eggs remaining in the body cavity. Pre-spawn females had a full body cavity of eggs. Partially spawned females were any female that did not meet the criteria of the other categories. Partially spawned females typically appeared to have about half as many eggs as a pre-spawn female. Otoliths from ten fish per 10 cm length group were removed, cleaned, and placed into 10 ml vials for ageing. Otoliths were viewed whole under a dissecting microscope and annuli were enumerated by one reader. Age was calculated as the number of otolith annuli plus one to account for the first winter in the hatchery. This ageing nomenclature makes parent to progeny productivity calculations easier for future assessments. Readers were not allowed to review biological information for each fish during the age estimation process to avoid bias.

Eggs from Fall Chinook Salmon were acquired from Fort Peck Fish Hatchery located near Fort Peck, Montana, and were hatched and reared at Cabinet Gorge Hatchery in Clark Fork, Idaho. The adipose fin was completely removed from all hatchery juvenile Fall Chinook Salmon (*n* = 22,800). Hatchery juveniles were stocked into Wolf Lodge Creek (Lake Coeur d'Alene, *n* = 19,800) on September 17, 2020 (Figure 44) and Brickel Creek (Spirit Lake, *n* = 3,000) on September 18, 2020 (Figure 45). The Wolf Lodge Creek stocking location was located at a large culvert approximately 7.6 km upstream of the mouth on South Meyers Hill Road adjacent to the intersection of South Meyers Hill Road and South Wolf Lodge Creek Road. The Brickel Creek stocking location was located approximately 3.9 km upstream of the mouth at a large automobile pull out next to Brickel Creek between Twin Bridge Creek and Blister Rust Creek. Hatchery Fall Chinook Salmon were stocked post-smoltification and in an upstream location to improve homing behavior and survival.

## RESULTS

### Lake Coeur d'Alene

We observed a total of 249 redds in index reaches of the Coeur d'Alene River basin (Figure 46). We observed 147 redds in the mainstem Coeur d'Alene River between Cataldo and the confluence of the South Fork Coeur d'Alene River, 66 redds in the North Fork Coeur d'Alene River between the confluence of the South Fork Coeur d'Alene River and the confluence of the Little North Fork Coeur d'Alene River, and 27 redds in the South Fork Coeur d'Alene River between the confluence with the North Fork Coeur d'Alene River and Theater Road bridge (Table 25). Nine redds were observed in the St. Joe River index reach between St. Joe City and the Calder Bridge (Table 25). Chinook Salmon redd abundance in 2020 more than quadrupled compared to 2019.

A total of 34 carcasses were collected in the Coeur d'Alene River system. One carcass was observed in the St. Joe River at Calder, but personnel were unable to retrieve it. Average length was 714 mm (range 540 – 830 mm). On average, females were 15 mm smaller than males (Table 26). Females comprised 47% of the carcasses collected. Females were classified as 75% fully spawned, 15% partially spawned, and 10% pre-spawn. Ageing structures were collected from 19 of the 34 carcasses. All aged fish were 3 or 4 years old, except one male was 5 years old. As expected, 3-year-old fish were the smallest in length on average, but the length range of 4 and 5 year old fish overlapped (Table 27).

### Spirit Lake

No Chinook Salmon redds, live fish, or carcasses were observed in Brickel Creek in 2020.

## DISCUSSION

### Lake Coeur d'Alene

The Chinook Salmon fishery in Lake Coeur d'Alene has improved substantially over the past decade, and 2020 produced some good angling by anecdotal assessment. The combination of relatively stable environmental conditions and abundant kokanee forage has likely allowed the population to rebound from the low abundances observed previosly. The fall 2020 redd survey was well above the previous 5-year average (mean = 115 redds).

The Chinook Salmon fishery in Lake Coeur d'Alene has historically been supported almost entirely by naturally produced individuals regardless of number of supplemental hatchery fish stocked. Despite ongoing efforts to identify factors influencing return-to-creel of hatchery produced Chinook Salmon, the post-release fate of those individuals remains unknown. Previous research has addressed factors that limit survival (Maiolie et al. 2013; Ryan et al. 2014), but no work has sought to understand retention of hatchery-origin Chinook Salmon and whether post-release emigration may be a limiting factor. Anglers catch adipose-removed Chinook Salmon in Lake Roosevelt reservoir which have presumably emigrated from Lake Coeur d'Alene and become entrained in the reservoir (William Baker, Washington Department of Fish and Wildlife, personal communication). These reports are not uncommon and are received from both anglers and Washington Department of Fish and Wildlife personnel. Post-release emigration has been documented in other lentic systems in Idaho where Fall Chinook Salmon are stocked. For instance, hatchery Chinook Salmon stocked into Deadwood Reservoir in the Southwest Region have been sampled in Black Canyon Reservoir on the Payette River (Arthur Butts, personal communication). Additionally, hatchery Chinook Salmon stocked into Anderson Ranch Reservoir have been reported in Arrowrock Reservoir and Lucky Peak Reservoir (Arthur Butts, personal communication). These reports raise concern about post-release retention of hatchery stocked fish and the resulting effect on return-to-creel.

Starting in 2017, IDFG changed the stock of hatchery fish used for supplementation from anadromous Tule Fall Chinook Salmon from Astoria, Oregon to a landlocked, adfluvial stock. It is likely that Chinook Salmon from anadromous stocks have a strong tendency to emigrate after release, particularly when stocked into waters within the Columbia River Basin. The maintenance of this life history may lead to a substantial portion of the hatchery fish attempting to emigrate after release. The newly selected hatchery stock is expected to improve retention, survival of hatchery fish, and subsequent return-to-creel; however, we will be unable to fully-quantify the effect of this management action until 2017 outplants recruit to the fishery. Anecdotal evidence from anglers suggests that age-2 adipose-clipped individuals have been more common in the fishery. Future work will focused on evaluating relative return-to-creel by comparing stocking strategies that are hypothesized to improve retention.

### Spirit Lake

This year was the first survey conducted for Chinook Salmon redds for Spirit Lake, and it was the first year with a full complement of age classes that could potentially produce adult spawners from fish stocked in 2016-2018. The lack of observed redds was not surprising. Anglers reported poor catch rates and few fin clips were returned to the collection boxes, suggesting few adult Chinook Salmon were in the lake.

Potential spawning habitat is limited for Chinook Salmon in Spirit Lake. The only perennial stream with potentially suitable spawning habitat is Brickel Creek. The section surveyed for redds was chosen to give the best possible indication of natural spawning. The section has adequate spawning habitat with cold (10 °C), clean water and appropriate spawning gravels, except for the lowermost 1.6 rkm. This was also evident due to the lack of Brook Trout spawning in the lowermost portion, which was abundant throughout the rest of the surveyed area. The lowermost 1.6 rkm portion of the creek flows through private ground currently being used as a cattle pasture and appears to have been mechanically straightened and deepened. The creek in this section is narrow with tall, steep banks and a silty sand substrate that is not suitable for spawning. Based on this assessment we recommend removing this lower portion from the redd survey in the future. Furthermore, the upstream end of the survey section should be extended beyond its current terminus at the vehicle bridge near Supper Creek to include all upstream suitable habitat available. Once the extent of habitat being used by Chinook Salmon is determined, a truncated section of the surveyed area could be used as a standardized index reach.

Despite not observing any live Chinook Salmon, carcasses, or redds in Brickel Creek, it is possible there were adults attempting to spawn elsewhere in the lake. Landowners near the intermittent outlet on the northeast part of the lake, reported seeing adult Chinook Salmon swimming in the shallow slough north of Spirit Lake Road during late-September. This could suggest there were adults actively looking for suitable spawning habitat, but they may have been unable to locate Brickel Creek. Furthermore, these returning adults were stocked directly into the lake after smolting as juveniles and did not have the opportunity imprint on Brickel Creek as a natal water. Imprinting is believed to be the mechanism that allows adults to successfully navigate to their natal waters to spawn (Dittman and Quinn 1996). However, the landowner reports were not confirmed by IDFG personnel. Future work will be aimed at determining if and where Chinook Salmon are naturally spawning and continuing to provide fin clip samples for the statewide ploidy study.

## MANAGEMENT RECOMMENDATIONS

1. Continue evaluation of hatchery Chinook Salmon performance; specifically, the efficacy of alternative stocks and stocking strategies.

2. Continue to enumerate Chinook Salmon redds at index reaches in the Coeur d’Alene River and St. Joe River for Lake Coeur d’Alene.

3. Continue to enumerate Chinook Salmon redds in Brickel Creek for Spirit Lake.

4. Alter the redd survey section on Brickel Creek to exclude the lower 1.6 rkm and include the suitable spawning habitat upstream of Supper Creek.

Table 25. Location, description of index reaches, and number of Chinook Salmon redds counted during surveys from the most recent five years. Surveys are conducted in the Coeur d'Alene and St. Joe rivers for Lake Coeur d'Alene and Brickel Creek for Spirit Lake.

| | | Year | | | | |
|---|---|---|---|---|---|---|
| Reach | Description | 2020 | 2019 | 2018 | 2017 | 2016 |
| | Coeur d'Alene River | | | | | |
| CDA 1 | Cataldo to S.F. Coeur d'Alene River confluence | 147 | 38 | 27 | 61 | 76 |
| CDA 2 | S.F. to L.N.F Coeur d'Alene River confluence | 66 | 9 | 1 | 18 | 29 |
| CDA 3 | S.F. Coeur d'Alene River | 27 | 14 | -- | -- | -- |
| | St. Joe River | | | | | |
| SJR 1 | St. Joe City to Calder bridge | 9 | 0 | 0 | 0 | 0 |
| | Brickel Creek | | | | | |
| BC1 | Mouth to vehicle bridge at Supper Creek | 0 | -- | -- | -- | -- |

Table 26. Sex, number, sex ratio, total length (mm; Mean, Minimum–Maximum [Min–Max]) for all Chinook Salmon carcasses collected from the Coeur d'Alene River index reaches during the 2020 redd surveys.

|  |  |  | Total Length |  |
|---|---|---|---|---|
| Sex | *n* | % | Mean | Min-Max |
| Female | 20 | 47 | 708 | 600 - 780 |
| Male | 14 | 53 | 723 | 540 - 830 |

Table 27. Age (years), number, age composition, total length (mm; Mean, Minimum–Maximum [Min–Max]) for aged Chinook Salmon carcasses collected from the Coeur d'Alene River index reaches during the 2020 redd surveys.

|  |  |  | Total Length |  |
|---|---|---|---|---|
| Age | *n* | % | Mean | Min-Max |
| 3 | 10 | 53 | 656 | 540 - 780 |
| 4 | 8 | 42 | 734 | 630 - 830 |
| 5 | 1 | 5 | 720 | 720 |

Figure 44. Location of Lake Coeur d’Alene, Idaho. The black triangle represents the location where juvenile hatchery Chinook Salmon were released in Wolf Lodge Creek.

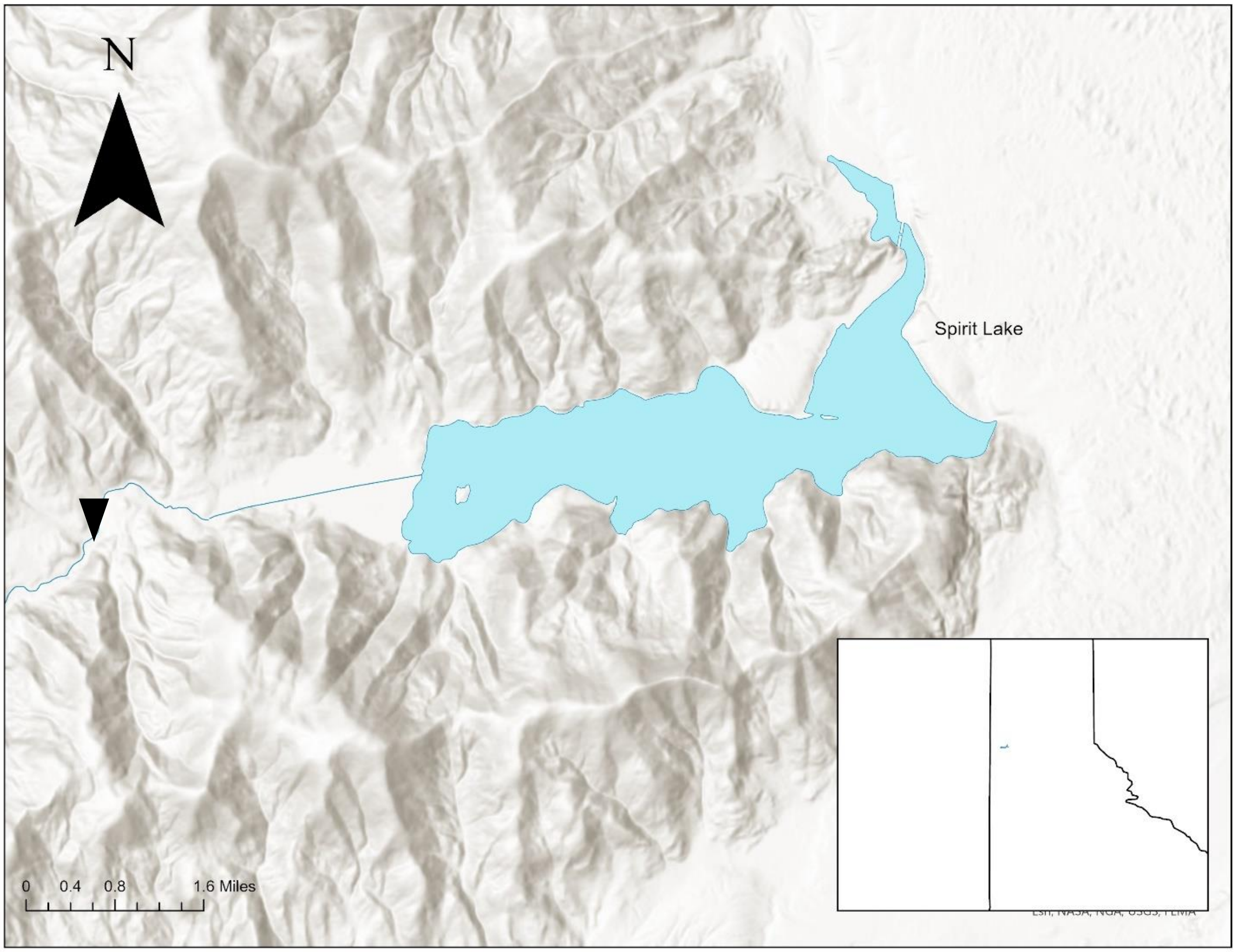

Figure 45. Location of Spirit Lake, Idaho. The black triangle represents the location where juvenile hatchery Chinook Salmon were released in Brickel Creek.

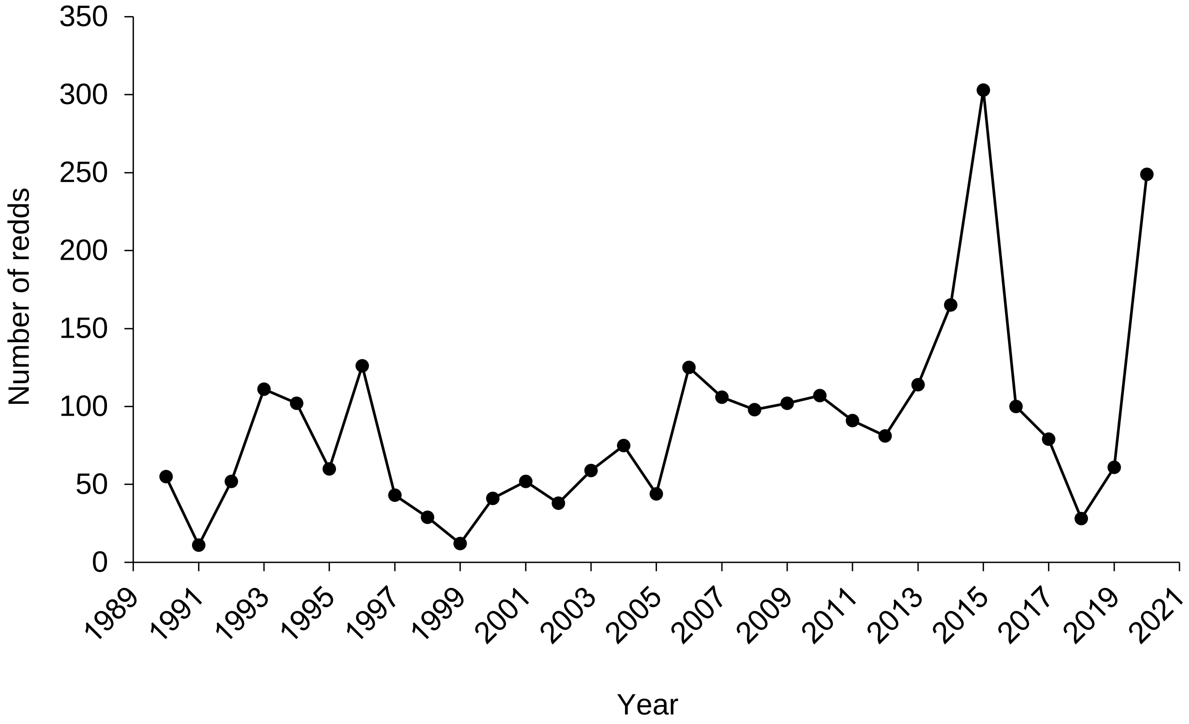

Figure 46. Number of Chinook Salmon redds counted during sampling of index reaches in the Coeur d’Alene River and St. Joe River from 1990 to 2020.

# SPOKANE BASIN WILD TROUT MONITORING

## ABSTRACT

Long-term data obtained from historical snorkeling surveys have been critical for informing management of wild salmonids in the upper Spokane River Basin over the past several decades. In the Coeur d'Alene and St. Joe rivers, maintenance of long-term datasets has allowed the Idaho Department of Fish and Game to document responses of Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* to environmental conditions, habitat rehabilitation, and angling regulations. During July 28–August 6, 2020, we used daytime snorkeling to observe fishes at historical sampling transects in the Coeur d'Alene River ($n$ = 43) and St. Joe River ($n$ = 35) basins. We estimated total Westslope Cutthroat Trout densities of 0.46 fish/100 $m^2$ in the Coeur d'Alene River basin and 0.58 fish/100 $m^2$ in the St. Joe River. Size structure of Westslope Cutthroat Trout was better in the St. Joe River compared to the Coeur d'Alene River basin. For Westslope Cutthroat Trout ≥ 305 mm in total length, we estimated densities of 0.05 fish/100 $m^2$ in the North Fork Coeur d'Alene River basin and 0.20 fish/100 $m^2$ in the St. Joe River. Densities of Rainbow Trout *O. mykiss* remained relatively low in both drainages, with estimates being similar to the past 15–20 years. Overall, trends in abundance in the upper Spokane River Basin continue to be variable but are down from the 10-year averages for the last two consecutive years. Future monitoring should continue to better inform management of Westslope Cutthroat Trout and to demonstrate progress toward conservation objectives.

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# INTRODUCTION

Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* is one of 14 subspecies of Cutthroat Trout *O. clarki* native to North America. The native distribution of Westslope Cutthroat Trout is the most widespread of the 14 subspecies spanning both sides of the Continental Divide (Behnke 1992; Behnke 2002). Their native distribution west of the Continental Divide includes the Salmon River and its tributaries, as well as all major drainages throughout the Idaho Panhandle. Despite their widespread distribution, declines in occurrence and abundance of Westslope Cutthroat Trout have been documented throughout their native range (Shepard et al. 2005). In Idaho, Westslope Cutthroat Trout still occupy 85% of their historical range (Wallace and Zaroban 2013). However, many populations of Westslope Cutthroat Trout have been negatively influenced by a variety of factors. Extensive land and water development activities, which have reduced available instream habitat and altered flows and thermal regimes, have negatively affected Westslope Cutthroat Trout (Peterson et al. 2010). Another important factor related to range and abundance reductions has been interaction with non-native salmonids (i.e., Rainbow Trout *O. mykiss*, Brook Trout *Salvelinus fontinalis*), which often leads to competition and hybridization (Rainbow Trout only; Marnell 1988; Allendorf et al. 2004; Shepard et al. 2005; Muhlfeld et al. 2009).

Concerns about the rangewide status of Westslope Cutthroat Trout have resulted in two petitions for listing under the U.S. Endangered Species Act (ESA 1973, as amended) in 1997 and 2001. Subsequent evaluations of extant populations determined that the relatively broad distribution and persistence of isolated populations in Oregon, Washington, and Canada did not warrant protection under the ESA (U.S. Federal Register 1998, 2003). However, the U.S. Forest Service and Bureau of Land Management regard Westslope Cutthroat Trout as a sensitive species, and the Idaho Department of Fish and Game (IDFG) has designated it as a Species of Greatest Conservation Need (IDFG 2006; IDFG 2013). Due to their importance as a recreational, cultural, and socioeconomic resource, the IDFG has intensely managed Westslope Cutthroat Trout populations for both general conservation and to provide quality angling opportunities.

The Spokane River Basin represents one of the most important areas for Westslope Cutthroat Trout conservation in Idaho and the Pacific Northwest; specifically, because major tributaries to the Spokane River (i.e., Coeur d'Alene River, St. Joe River) provide strongholds for this native species (DuPont et al. 2009; Stevens and DuPont 2011). In addition, Westslope Cutthroat Trout populations in the upper Spokane River Basin support important recreational fisheries. The proximity of the Coeur d'Alene and St. Joe rivers to large communities (i.e., Coeur d'Alene, Spokane) makes these waters popular destination trout fisheries, and angling effort has increased in recent times (Fredericks et al. 1997; DuPont et al. 2009).

Over the past century, Westslope Cutthroat Trout angling regulations have become increasingly conservative with a shift toward non-consumptive use (Hardy et al. 2009; Kennedy and Meyer 2015). For example, prior to 2008, the lower portions of the Coeur d'Alene River (Lake Coeur d'Alene to the confluence of Yellow Dog Creek) and St. Joe River (Lake Coeur d'Alene to the confluence of North Fork St. Joe River) were managed with a two fish daily bag and slot limit (none between 203 and406 mm; Hardy et al. 2009). However, the entire Spokane River Basin within Idaho is now managed under a catch-and-release regulation for Westslope Cutthroat Trout, except for the St. Maries River (seasonal two fish daily bag limit). The shift to catch-and-release rules led to improvements in these populations; although increased education, enforcement of regulations, and habitat rehabilitation have also positively contributed. Regardless of mechanism, Westslope Cutthroat Trout populations responded positively, and angler effort followed suit. Improvements in the quality of the fishery, combined with the adoption of year-round seasons, increased angler use in the Coeur d'Alene and St. Joe rivers (IDFG 2013). Long-term monitoring has proven critical for formulating effective management plans for conservation of Westslope Cutthroat Trout in Idaho. Standardized monitoring has allowed IDFG to evaluate population-level responses to environmental change and management activities (Copeland and Meyer 2011; Kennedy and Meyer 2015), and thus improve the quality of the fishery in the Spokane River Basin.

## OBJECTIVES

1. Monitor trends in abundance, distribution, and size structure of wild salmonids in the upper Spokane River Basin, with focus on Westslope Cutthroat Trout populations.

2. Monitor fish assemblage structure and species distribution to identify shifts that may occur for native and non-native fishes alike.

## STUDY AREA

The Coeur d'Alene and St. Joe rivers are the largest tributaries to Lake Coeur d'Alene and combined these drainages comprise ~50% of the greater Spokane River watershed. Both rivers originate in the Bitterroot Mountains along the Idaho-Montana border and are greatly influenced by snowmelt and spring runoff. Approximately 90% of the land area within the drainages is publicly owned and managed by the U.S. Forest Service (Strong and Webb 1970). Dominant land use practices in both drainages include hard rock and placer mining and extensive timber harvest (Strong and Webb 1970; Quigley 1996; DEQ 2001). While the combination of these activities has negatively influenced instream habitat and water quality, increased oversight and regulation of land use have improved environmental conditions for native fishes in both the Coeur d'Alene and St. Joe river drainages (DEQ 2001).

Historical sampling reaches were established on the Coeur d'Alene River in 1973 (*n* = 38; Figure 47; Bowler 1974) and St. Joe River in 1969 *(n* = 28; Figure 48; Rankel 1971; Davis et al. 1996b). Sampling was conducted periodically at first, but since 1990, sampling has been conducted annually. Sampling sites in the Coeur d'Alene River basin have evolved since inception. However, the sampling scheme currently used was created in 2003 and incorporates all the reaches from previous sampling scheme iterations. Unlike the Coeur d'Alene River basin, sites in the St. Joe River basin have been static except for the addition of seven reaches in the lower river between Avery and Calder in 1996 (Davis et al. 1996b). Sampling reaches in the St. Joe River drainage occur only in the mainstem St. Joe River (Figure 48), while reaches within the Coeur d'Alene River drainage also occur in tributaries, such as the North Fork Coeur d'Alene River, Little North Fork Coeur d'Alene River, and Teepee Creek (Figure 47).

## METHODS

Standard index reaches in the Coeur d'Alene River basin and St. Joe River were sampled using daytime snorkeling during July 28–30, 2020 and August 4-6, 2020, respectively (DuPont et al. 2009; Thurow 1994). One index reach was not sampled in 2020. In the North Fork of the Coeur d'Alene, NF01 (slough) was incorporated into site NF01 because the river channel moved, and the slough is now part of the main channel. One (wetted width ≤10 m wide) or two (wetted width >10 m wide) observers slowly snorkeled downstream identifying fishes to species and estimating total length (TL; inches) of all salmonid species. All snorkelers obtained training on observation techniques and protocol by an experienced individual prior to conducting the survey. Transects have been marked with a global positioning system (GPS) and digital photographs provided reference to the upper and lower terminus of each reach. Estimates of salmonid abundance was limited to age-1+ fish, as summer counts for young-of-year (YOY) Westslope Cutthroat Trout and Rainbow Trout are typically unreliable. After completion of each sampling reach, each species was enumerated and separated into 75-mm length groups. Nongame fish species (e.g., *Cottus* spp. and *Cyprinus* spp.) were enumerated, but lengths were not estimated.

Reach length and wetted width were measured at each sampling site with a laser rangefinder. Surface area ($m^2$) was estimated at each site to provide a measure of sampling effort. The habitat type (pool, riffle, run, glide, pocket water), maximum depth, dominant cover type and amount of cover (estimated as % of surface area) in the area sampled was measured to assess if changes in habitat may have contributed to any changes in fish abundance and assemblage structure. For each species, the total number of fish observed from all sites was divided by the total surface area sampled from all sites sampled in a year to provide a standardized annual density measure. In addition, a 10-year density average was calculated using the arithmetic mean from the 10 previous annual densities prior to 2020.

Size structure of Westslope Cutthroat Trout was also estimated for each river system. Relative size distribution (RSD) was used to summarize length-frequency distributions (Neumann et al. 2012) and describe size structure. Relative size distribution was calculated as

$$\text{RSD} = (a \,/\, b) \times 100,$$

where $a$ is the number of fish greater than or equal to the minimum quality length (i.e. ≥ 228 mm) and $b$ is the number of fish greater than or equal to 305 mm length (Neumann and Allen 2007; Neumann et al. 2012).

## RESULTS

### Coeur d'Alene River Basin

A total of 785 Westslope Cutthroat Trout, 6 Rainbow Trout, and 1,810 Mountain Whitefish was observed among the 43 sampling sites in the Coeur d'Alene River basin. In addition, we observed 605 Northern Pikeminnow *Ptychocheilus oregonsis*, 19 Largescale Sucker *Catostomous macrocheilus*, and 1 Brook Trout *Salvelinus fontinalis*. The total density of Westslope Cutthroat Trout was 0.46 fish/100 $m^2$ (Figure 49), and total density of Westslope Cutthroat Trout ≥305 mm was 0.05 fish/100 $m^2$ in the Coeur d'Alene River basin (Figure 50). For during 2020, Estimates of total density and density of Westslope Cutthroat Trout ≥305 mm observed in 2020 were lower than the 10-year averages (total Westslope Cutthroat Trout = 0.91 fish/100 $m^2$; Westslope Cutthroat Trout ≥ 300 mm = 0.21 fish/100 $m^2$). Total density of Rainbow Trout in 2020 was <0.01 fish/100 $m^2$, which was lower than the 10-year average of 0.13 fish/100 $m^2$ (Figure 51). Total density of Mountain Whitefish in 2020 was 1.06 fish/100 $m^2$ and was lower than the 10-year average of 2.62 fish/100 $m^2$ (Figure 52). We estimated an RSD-305 of 41 (Figure 53).

### St. Joe River

A total of 574 Westslope Cutthroat Trout, zero Rainbow Trout, and 650 Mountain Whitefish was observed among the 35 sampling sites in the St. Joe River. In addition, we observed 245 Largescale Sucker, 189 Northern Pikeminnow, and zero Bull Trout *S. confluentus* during 2020 sampling. Total density of Westslope Cutthroat Trout was 0.58 fish/100 $m^2$ and was lower than the 10-year average (1.09 fish/100 $m^2$; Figure 54). Total density of Westslope Cutthroat Trout ≥305 mm was 0.20 fish/100 $m^2$ and was lower than the 10-year average (0.40 fish/100 $m^2$; Figure 55). Total density of Rainbow Trout was zero fish/100 $m^2$ and was on par with the 10-year average (0.00 fish/100 $m^2$; Figure 56). Total density of Mountain Whitefish was 0.47 fish/100 $m^2$ and was lower than the 10-year average (1.30 fish/100 $m^2$; Figure 57). Size structure of Westslope Cutthroat Trout in the St. Joe River (RSD-305 = 42) was similar to the Coeur d'Alene River Basin (Figure 53).

## DISCUSSION

The upper Spokane River Basin represents one of Idaho's most important watersheds for conservation of Westslope Cutthroat Trout. Previous work on Westslope Cutthroat Trout showed that historical declines in abundance and size structure in both the Coeur d'Alene and St. Joe rivers were directly related to overfishing and habitat degradation (Rankel 1971; Lewynsky 1986; Mallet and Thurow 2022). However, in the Spokane River Basin and elsewhere in Idaho, Westslope Cutthroat Trout populations have positively responded to changes in angling regulations and habitat quality.

Westslope Cutthroat Trout densities increased from the beginning of this monitoring program and peaked during the 2010s. Current total densities are below 10-year averages for both rivers. Densities of all fish from 2020 were slightly lower and densities of fish >305 mm were nearly stable or increasing compared to 2019. We have documented a considerable amount of variability in annual density estimates since the regulation change to a catch-and-release fishery in 2008.

Mountain Whitefish densities continue to be higher in the Coeur d'Alene River than the St. Joe River. The Coeur d'Alene River is generally at a lower elevation and has a lower gradient than the St. Joe River which may provide better conditions for Mountain Whitefish (Roth et al. 2022). While considerable variation in annual densities has been observed in both rivers, densities have been below the 10-year average since 2016 in the Coeur d'Alene River while densities in the St. Joe River were below the 10-year average for the second consecutive year.

Rainbow Trout densities remain at extremely low abundance throughout the Coeur d'Alene and St. Joe rivers. Rainbow Trout are known to compete and hybridize with Westslope Cutthroat Trout. IDFG manages for low abundance of Rainbow Trout in the Spokane River Basin to reduce the potential for such interactions. At current densities, Rainbow Trout do not pose a major management concern.

In recent history, a concern among the angling public has been about the effect of summer conditions and its interaction with angling-induced fish mortality. In 2015, the Coeur d'Alene River and St. Joe River basins experienced moderate to extreme drought conditions characterized by unusually warm and dry climate (NOAA 2016). While densities for Westslope Cutthroat did decline in the following year after the drought, the decline was no greater in magnitude than observed declines that occurred before 2015 in better climate conditions. Furthermore, densities for all Westslope Cutthroat and those >305 mm returned to or near 10-year averages between the initial decline in 2016 and 2019 suggesting any immediate drought-induced mortality that occurred was negligible and did not have a prolonged impact on the fishery. Westslope Cutthroat are known to utilize cold water refugia when water exceeds 22ºC by moving to the mouths of or into cold water tributaries and to cold water upwellings in side channels (Dupont et al. 2008). Strategic movements to cold water refugia can negate impacts from sustained warm water periods.

Alternatively, overwintering conditions likely have more effect on mortality than summer conditions. Westslope Cutthroat Trout utilize slow, deep pools in larger rivers (Bjornn and Reiser 1991; Hunt 1992; Schmetterling 2001) connected to a wide floodplain (DuPont et al 2008). Deep pools provide refuge from faster water velocities during normal flows resulting in lower energetic costs to maintain position. Similarly, floodplain connectivity adjacent to deep pools provide refuge from faster velocities during winter/spring high flow events such as rain on snow, ice dam breakup, and spring runoff. During winters with decreased river levels, pool abundance and depth can be greatly reduced. The result is a reduction of an already limited habitat and an increase in competition stressors by congregated fish, especially larger fish (Cunjak and Power 1986). Mean winter base flows were as low or lower than the winter of 2015 in the Coeur d'Alene and St. Joe rivers for the second consecutive year. In the years following these low baseflows, Westslope Cutthroat Trout densities typically decrease from the previous year.

While 2015 presented severe drought conditions during the summer, we did not observe directly attributable and sustained shifts in the population. Annual density estimates have been variable among years and any immediate decline observed in 2016 may be a result of natural variation. However, winter conditions have been found to be a key factor effecting trout populations in other locations and generally seem to be more of a factor than summer conditions in the Coeur d'Alene and St. Joe rivers. Cumulative effects of poor conditions in adjacent seasons (summer and winter) and/or multiple years are not well understood. The long-term effects of sustained poor conditions on recruitment dynamics and somatic growth may be revealed through continued annual monitoring.

## MANAGEMENT RECOMMENDATIONS

1. Continue to monitor wild trout abundance and population characteristics in the upper Spokane River Basin.

2. Continue to monitor trends in fish assemblage characteristics.

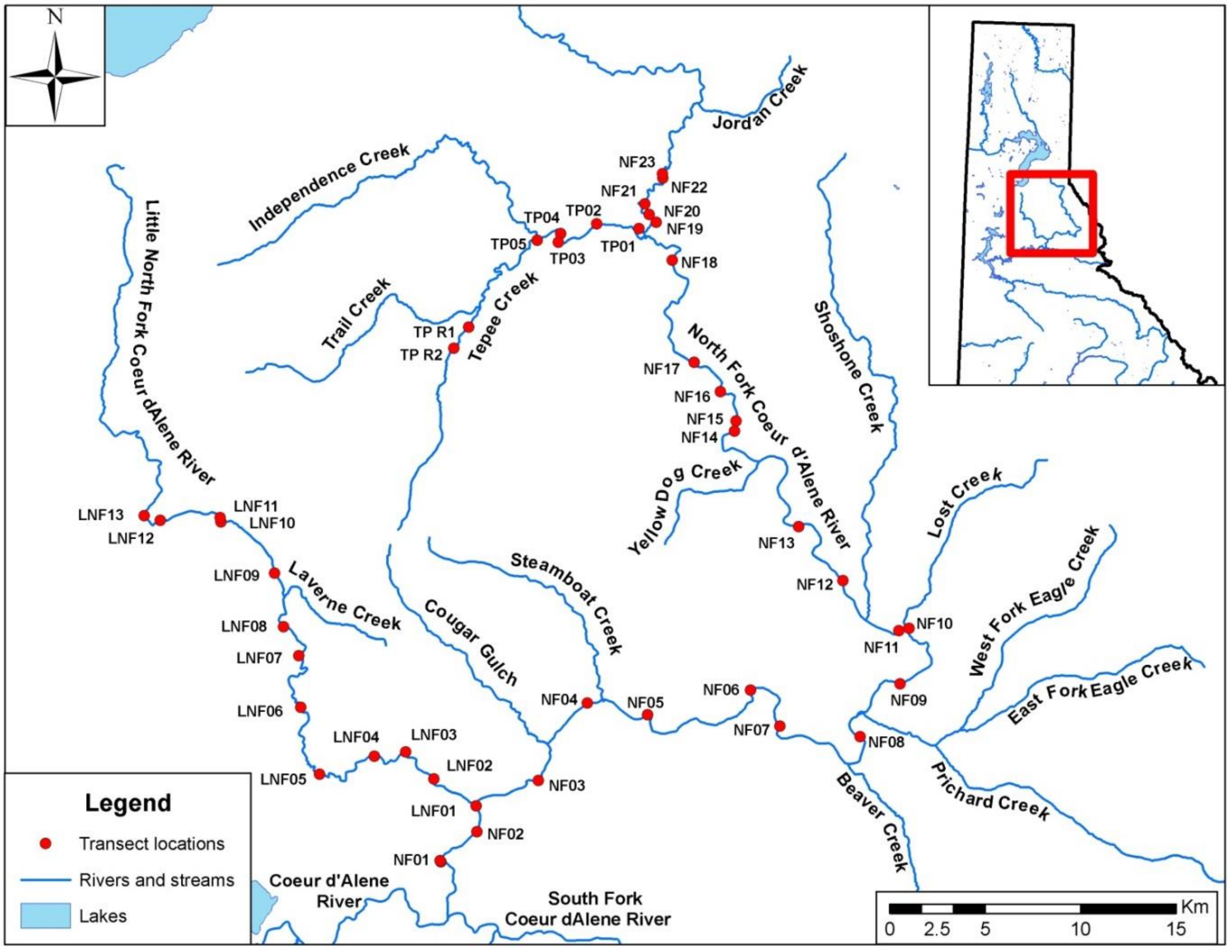

Figure 47. Location of 44 index reaches sampled using snorkeling in the Coeur d’Alene River, Idaho during July 28–30, 2020.

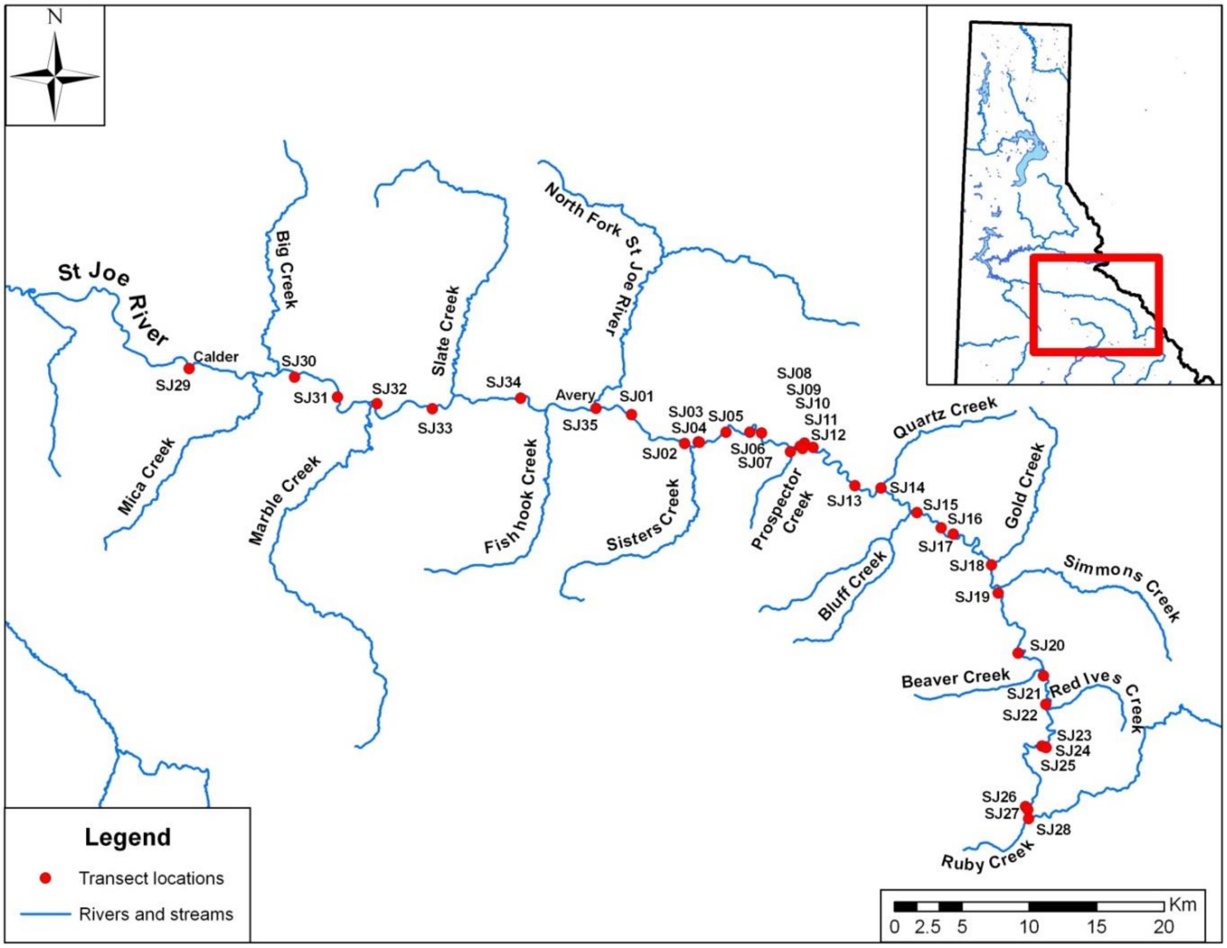

Figure 48. Location of 35 index reaches sampled using snorkeling in the St. Joe River, Idaho during August 4-6, 2020.

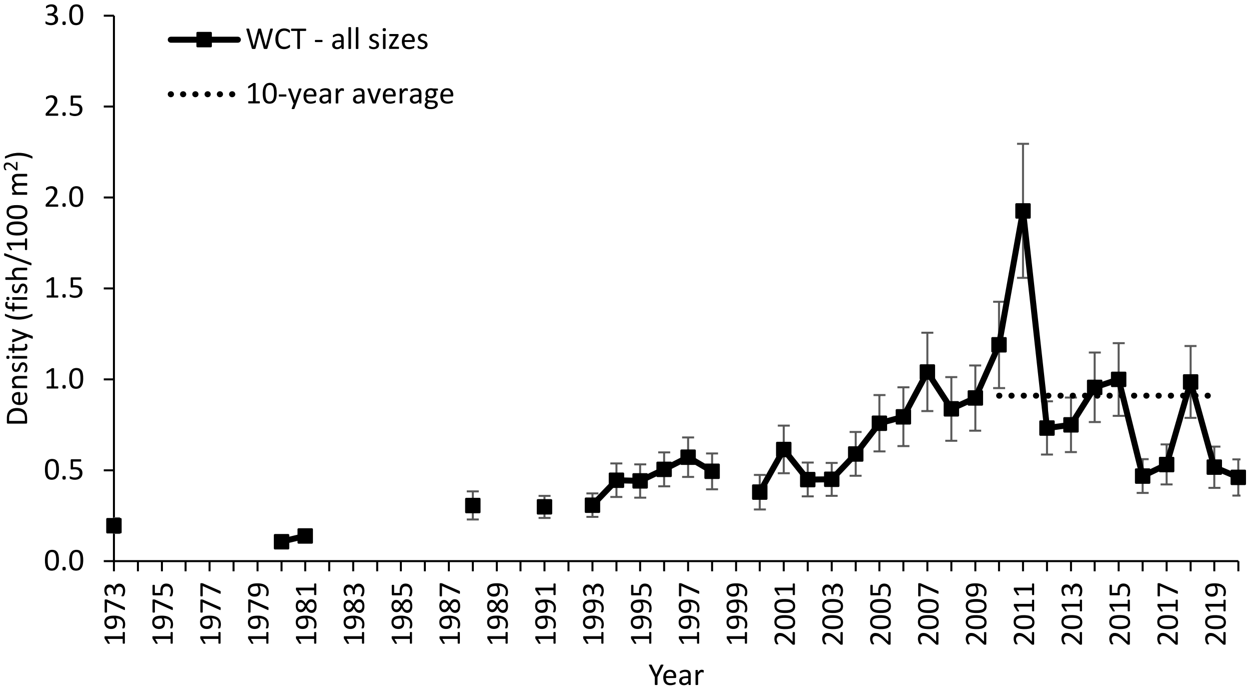

Figure 49. Density and 10-year average of Westslope Cutthroat Trout observed during snorkeling in the Coeur d’Alene River basin (1969–2020).

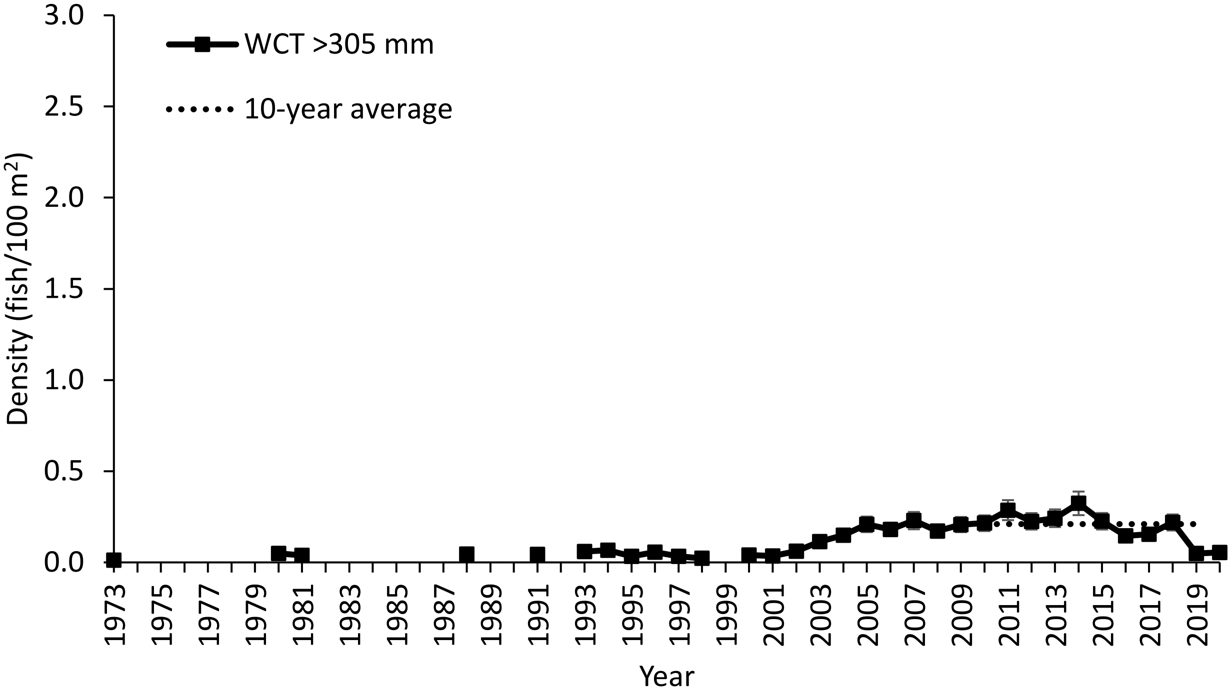

Figure 50. Density and 10-year average of Westslope Cutthroat Trout larger than 305 mm TL observed during snorkeling in the Coeur d'Alene River basin (1969–2020).

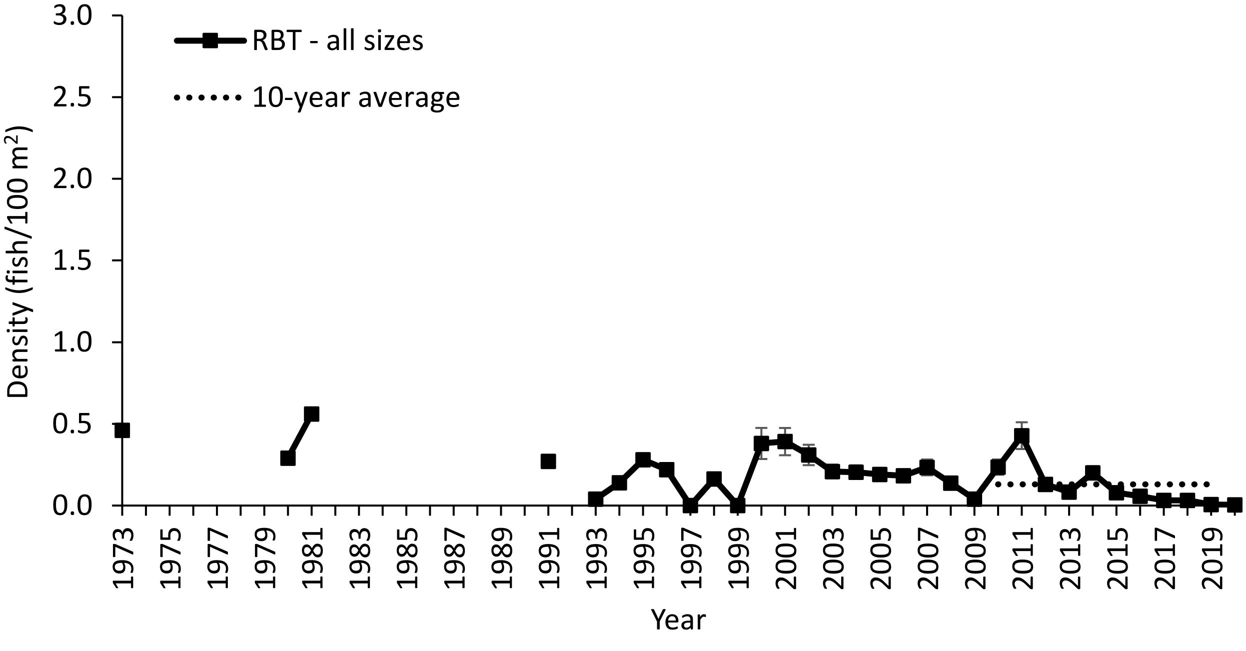

Figure 51. Density and 10-year average of Rainbow Trout observed during snorkeling in the Coeur d'Alene River basin (1969–2020).

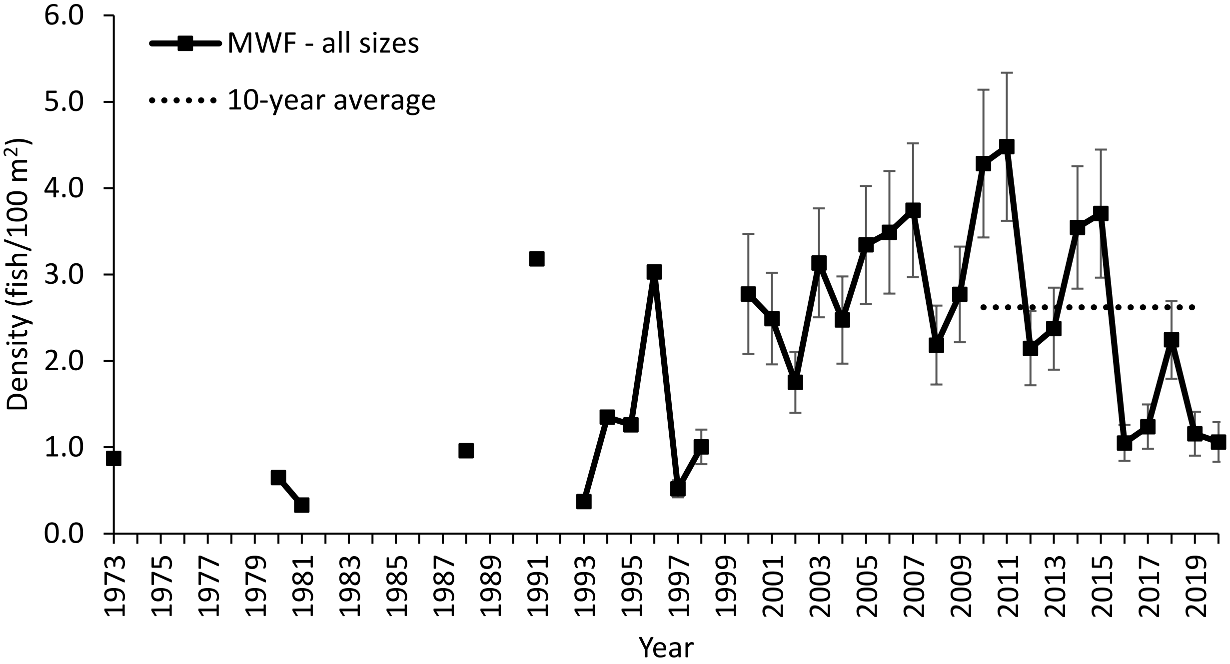

Figure 52. Density and 10-year average of Mountain Whitefish observed during snorkeling in the Coeur d'Alene River basin (1969–2020).

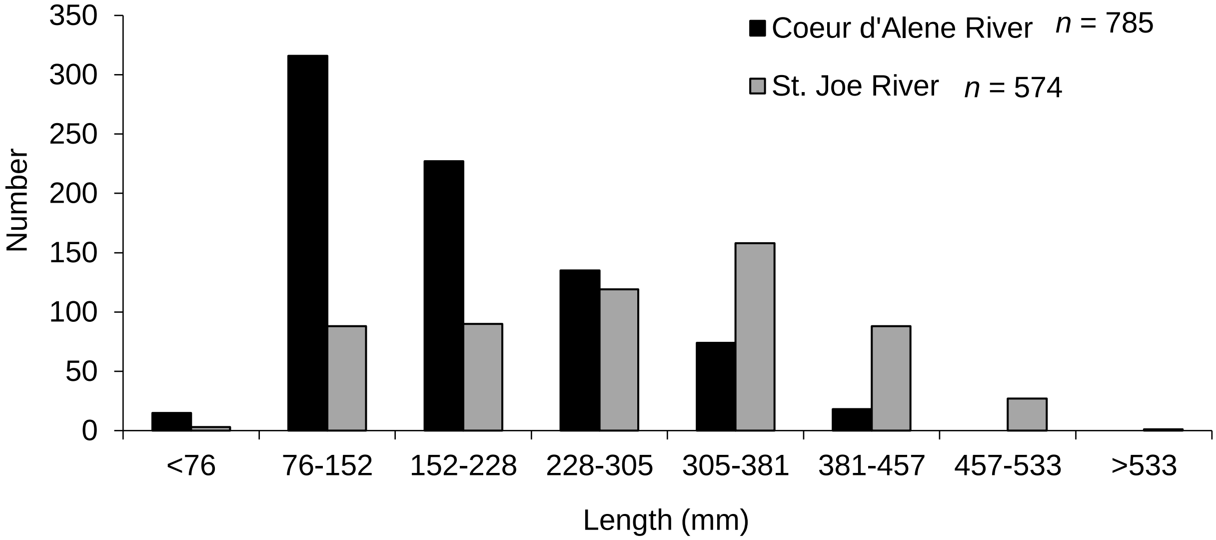

Figure 53. Length-frequency distributions of Westslope Cutthroat Trout observed during snorkeling in the Coeur d'Alene River basin and St. Joe River (2020).

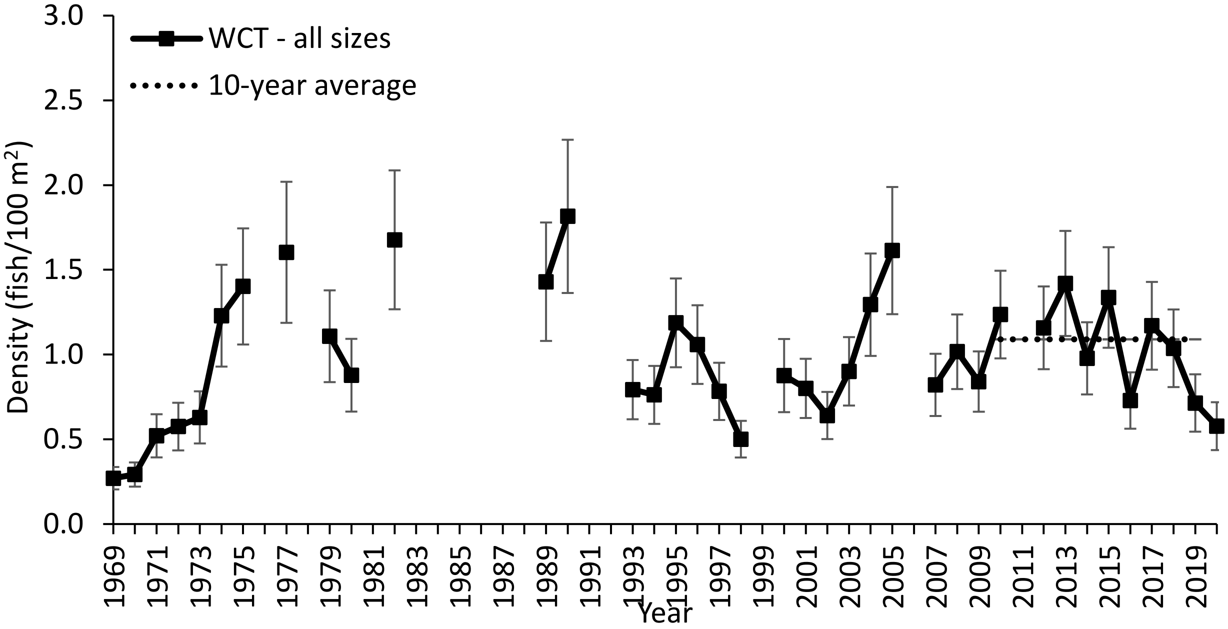

Figure 54. Density and 10-year average from the current year of Westslope Cutthroat Trout observed during snorkeling in the St. Joe River (1969–2020).

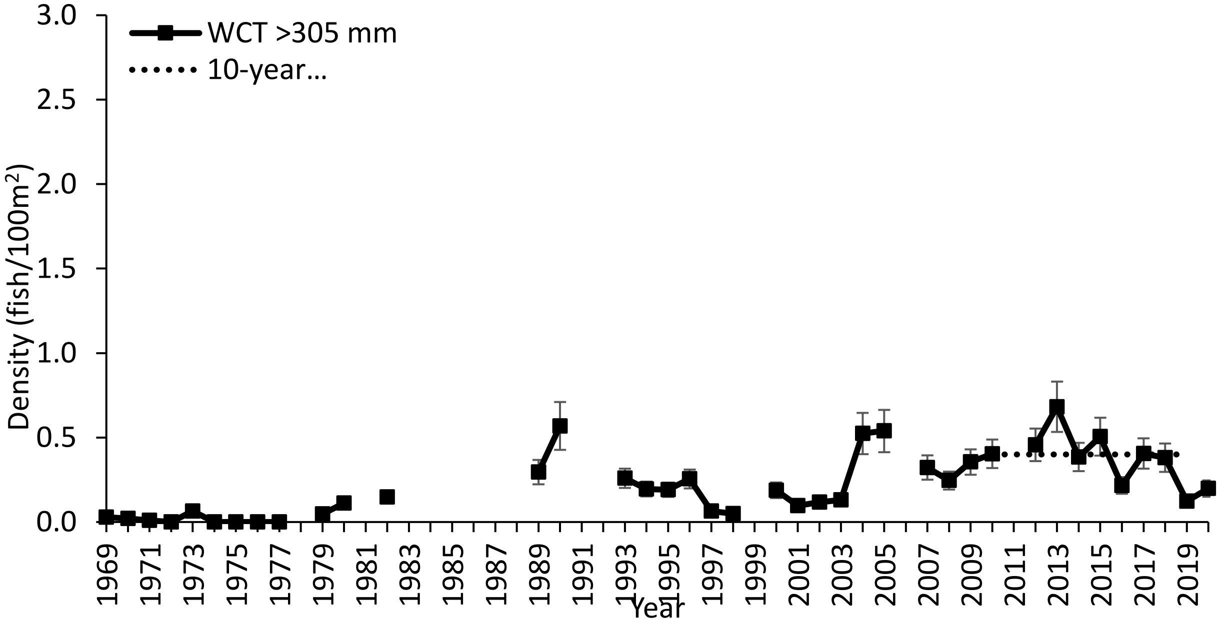

Figure 55. Density and 10-year average from current year of Westslope Cutthroat Trout larger than 305 mm TL observed during snorkeling in the St. Joe River (1969–2020).

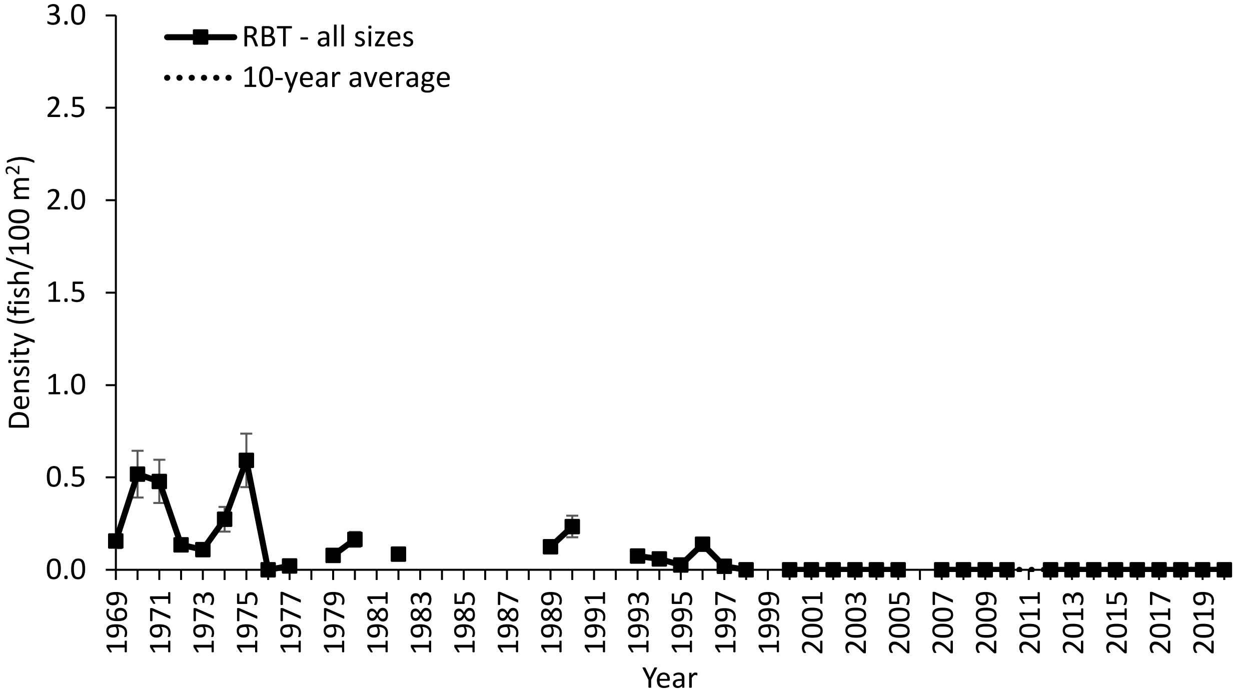

Figure 56. Density and 10-year average from current year of Rainbow Trout observed during snorkeling in the St. Joe River (1969–2020).

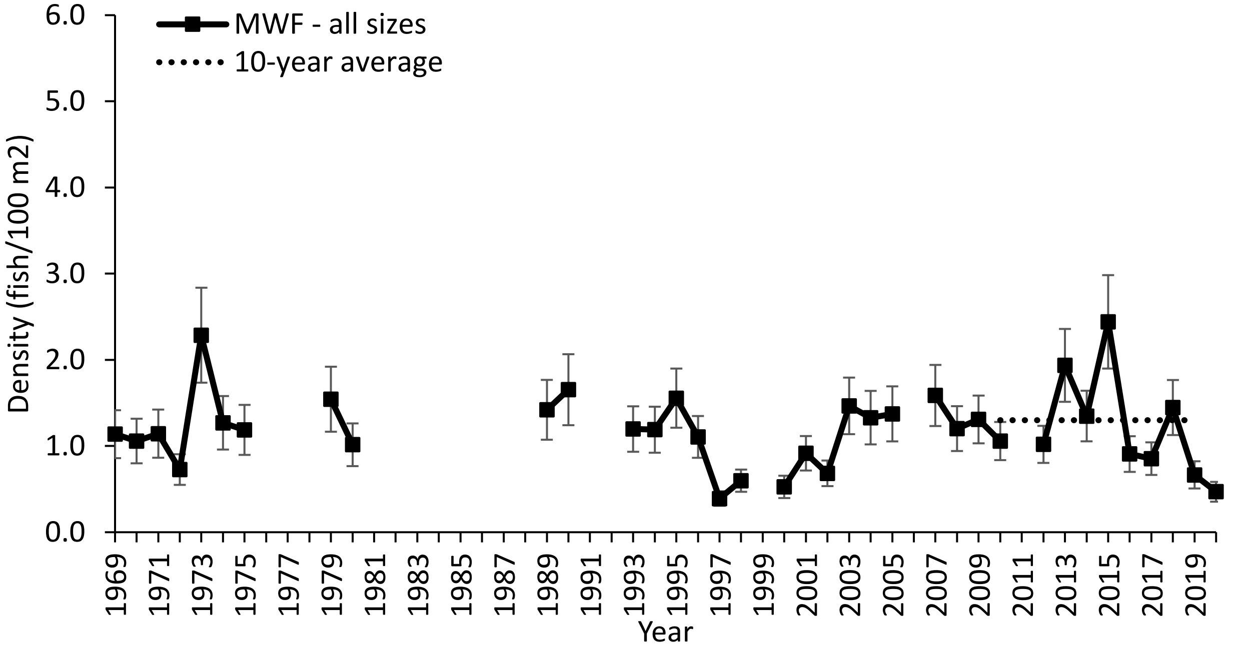

Figure 57. Density and 10-year average from current year of Mountain Whitefish observed during snorkeling in the St. Joe River (1969–2020).

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