FISHERY MANAGEMENT INVESTIGATIONS

IDAHO DEPARTMENT OF FISH AND GAME
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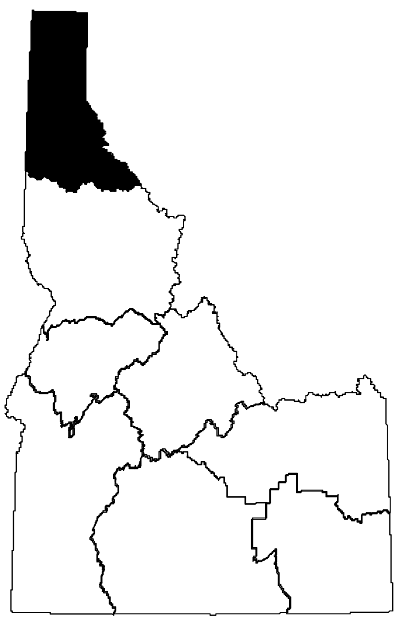
Ed Schriever, Director



Panhandle Region
2017

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LAKE TROUT MANAGEMENT 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 2017, gill nets were used to remove 1,871 Lake Trout during a two-week period from May 15 to May 26. Average daily catch rate from standard mesh sizes was 10 fish/box (± 2.7, 80% C.I.), which was similar to recent years. Lake Trout length ranged from 168 to 1,025 mm. Bull trout *Salvelinus confluentus* catch rate (0.12/box) was below average when compared to the previous nine year period. Trend data suggests Lake Trout population growth has been curbed and removal efforts to benefit native fishes in Upper Priest Lake should continue.

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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 severely depressed while the population in Priest Lake is considered functionally lost (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 1950's (Mauser et al. 1988). Westslope Cutthroat Trout harvest opportunities were closed in 1988, also 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 believed to be the primary cause of population-scale changes in native fish communities. Lake Trout, where introduced as a non-native sport fish, are often 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 1990's (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 native fish communities in Upper Priest Lake were at risk.

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 and reduce their abundance in the lake. These management efforts have removed between 150 and 5,000 Lake Trout annually from Upper Priest Lake (Fredericks et al. 2013). In 2017, we continued Lake Trout reduction efforts in Upper Priest Lake with the intent of benefiting native fish species.

OBJECTIVE

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

STUDY SITE

Upper Priest Lake is located approximately 21 kilometers (km) south of the Idaho-British Columbia boarder 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 ha, a maximum depth of approximately 31 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 Thoroughfare. The Thoroughfare 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 Thoroughfare outlet is < 0.15 m and prohibits most boat traffic.

METHODS

We completed the 2017 Upper Priest Lake Lake Trout removal effort between May 15 and May 26. Hickey Brothers Research, LLC was contracted to provide equipment and labor for completion of the netting project. An 11-m commercial gill net boat was used to complete sampling 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.

We used monofilament sinking gill nets to capture and remove Lake Trout from Upper Priest Lake. Individual gill net dimensions were 91 m by 2.7 m. 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) including 45, 51, 64 76, 89, 102, 114 and 127 mm (Table 1). 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 each day. The combined effort per day was 30 boxes of gill net. A total of 240 boxes of gill net were placed over ten days. Both morning and afternoon sets were made on each day, except the first and last days of each work week during which only one set was made on each date. The combined total effort for the first and last day of each work week 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 net was set throughout Upper Priest Lake over the course of the sampling period 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 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 2017 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 2017. 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 to 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 dispatched and returned to the lake.

Bycatch of non-target species associated with the removal effort was generally noted and fish were released if alive, though not all individuals were recorded. However, 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 2017. Variance around catch rate estimates was described using 80% confidence bounds. Confidence bounds were only estimated for years during with standardized gill net effort and mesh were used (i.e. 2014-2017). A 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.

RESULTS

We removed 1,871 Lake Trout during the ten-day gillnetting effort. Average daily catch rate from 51, 64, and 76 mm mesh sizes was 10 fish/box (± 2.7, 80% C.I.; Figure 1). Mesh-specific catch rates differed from those observed in 2016. Increased catch rates in 102 and 114 mm mesh sizes were the most dramatic changes observed in 2017 (Figure 2).

Total length of Lake Trout averaged 408 mm (± 4 mm, 80% C.I.) and varied from 168–1,025 mm (Table 1). In general, fish length increased with increased gill net mesh size. Small mesh sizes (45, 51, and 64 mm) had the highest catch rates and accounted for 69% of the total catch. These mesh sizes also represented 60% 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*, and Peamouth *Mylocheilus caurinus*. We caught 30 Bull Trout among all netting efforts, representing an average daily catch rate of 0.12 Bull Trout per box of net. Observed catch rate was below the average rate observed over the previous nine years (0.17 Bull Trout per box, Figure 4). Mean TL of Bull Trout was 440 mm (± 49 mm, 80% C.I.), and varied from 212 to 787 mm.

DISCUSSION

Lake Trout catch rate trends suggest our Upper Priest Lake management program aimed at controlling Lake Trout abundance to benefit native fish species was successful. Catch rates were generally believed to reflect relative abundance in the Lake Trout population. We observed stable to decreasing daily catch rates over the period from 2010 to 2017, suggesting abundance in Upper Priest Lake followed a similar pattern. Daily Lake Trout catch rates observed in our gillnetting were lowest from 2015 to 2017. Since 2015, daily catch rate estimates have appeared to be significantly lower than estimates prior to 2015, as indicated by non-overlapping confidence intervals (Figure 1). Collectively, these results suggest Lake Trout abundance was managed at a lower level than would be expected if no control actions were taken.

Mesh-specific catch rates suggested relative abundance of large Lake Trout in Upper Priest Lake was greater in 2017 than in other recent years. Generally, catch rates within larger mesh sizes have been stable. However, we observed average catch rates in 102 and 114 mm gill net mesh sizes that were the highest observed since 2014. Confidence intervals around

those catch rate estimates did not overlap with prior years, suggesting observed increases may have reflected a significant increase in relative abundance. In addition, the size structure of our catch also indicated an increase in large Lake Trout relative to past years. A trend in size structure was not evident in prior annual removal efforts to suggest a strong size class of fish was present or expected to grow into a vulnerable size range for 102 or 114 mm gill net mesh sizes (Watkins et al., 2018, Ryan et al., 2018, Ryan et al, 2020). As such, it is probable that the segment of the population caught in large gill net meshes represented immigrants from Priest Lake. Movement of Lake Trout between Priest Lake and Upper Priest Lake has been previously demonstrated (Fredericks and Venard 2001) and has been assumed to be a factor contributing to the stability of Lake Trout abundance in Upper Priest Lake. Although we believe catch rate of large Lake Trout increased, the magnitude of catch rates in larger mesh sizes was small relative to smaller gill net mesh sizes and was not significant within the context of overall catch rate observed in this effort.

Bull Trout catch rate was low and below the ten-year average. A number of factors may influence Bull Trout abundance in this system. Landscape-scale factors potentially influencing abundance include stream and/or lake habitat conditions. To our knowledge, no landscape-scale changes in stream habitat in the Upper Priest Lake drainage were known to have recently occurred. Lake Trout are believed to be the primary limiting factor for Bull Trout in Upper Priest Lake. As noted previously, Lake Trout relative abundance was observed to be stable to decreasing in Priest Lake over the trend period. Other factors potentially influencing annual catch rate estimates would likely be less predictable, such as expected variance associated with the catch rate estimate or annual variability in environmental conditions influencing habitat conditions in spawning tributaries. Irrespective of annual variation in observed Bull Trout catch rates, Lake Trout presence in Upper Priest Lake is the primary concern relative to the conservation of native species. Currently, our data suggest that Lake Trout population has been reduced, and the threat to native species remains, but at a lower level. As such, we recommend continuation of Lake Trout removal efforts in Upper Priest Lake as a tool for conserving native fishes.

RECOMMENDATIONS

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

Table 1. Gill net effort and Lake Trout (LKT) catch by gill net mesh size in Upper Priest Lake, Idaho during 2017. Total length (mm) ranges of Lake Trout caught were reported by associated gill net mesh sizes.

Mesh	Mesh	Effort (m)	% of Effort	LKT caught	LKT/box	Min TL (mm)	Max TL (mm)
1.75	45 mm	13,167	20%	543	11.3	196	595
2	51 mm	13,167	20%	615	12.8	185	753
2.5	64 mm	13,167	20%	380	7.9	208	755
3	76 mm	4,389	7%	82	5.1	297	888
3.5	89 mm	4,389	7%	85	5.3	420	895
4	102 mm	8,778	13%	124	3.9	371	885
4.5	114 mm	4,389	7%	37	2.3	494	801
5	127 mm	4,389	7%	28	1.8	260	1,010

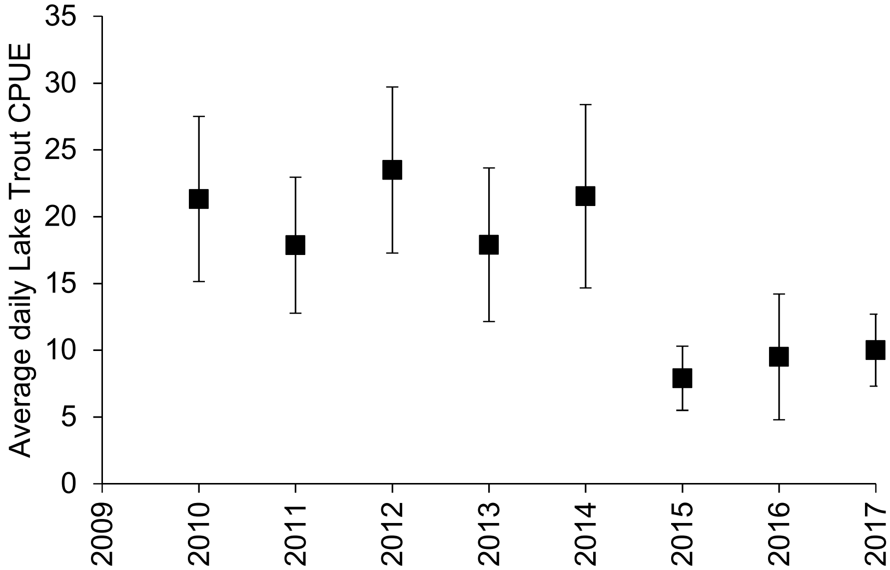

Figure 1. Average daily Lake Trout catch rates and 80% confidence intervals by year from combined standard gill net mesh sizes (51, 64, and 76 mm) fished in Upper Priest Lake, Idaho between 2010 and 2017.

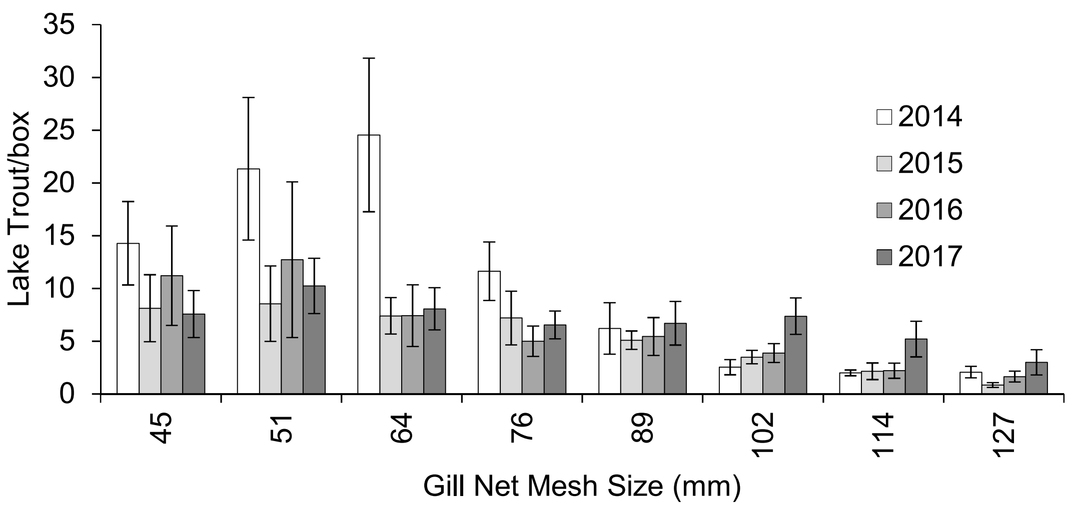

Figure 2. Average daily Lake Trout catch rate (Lake Trout/net box) and 80% confidence intervals by mesh size from all standardized gill nets fished in Upper Priest Lake, Idaho from 2014 to 2017.

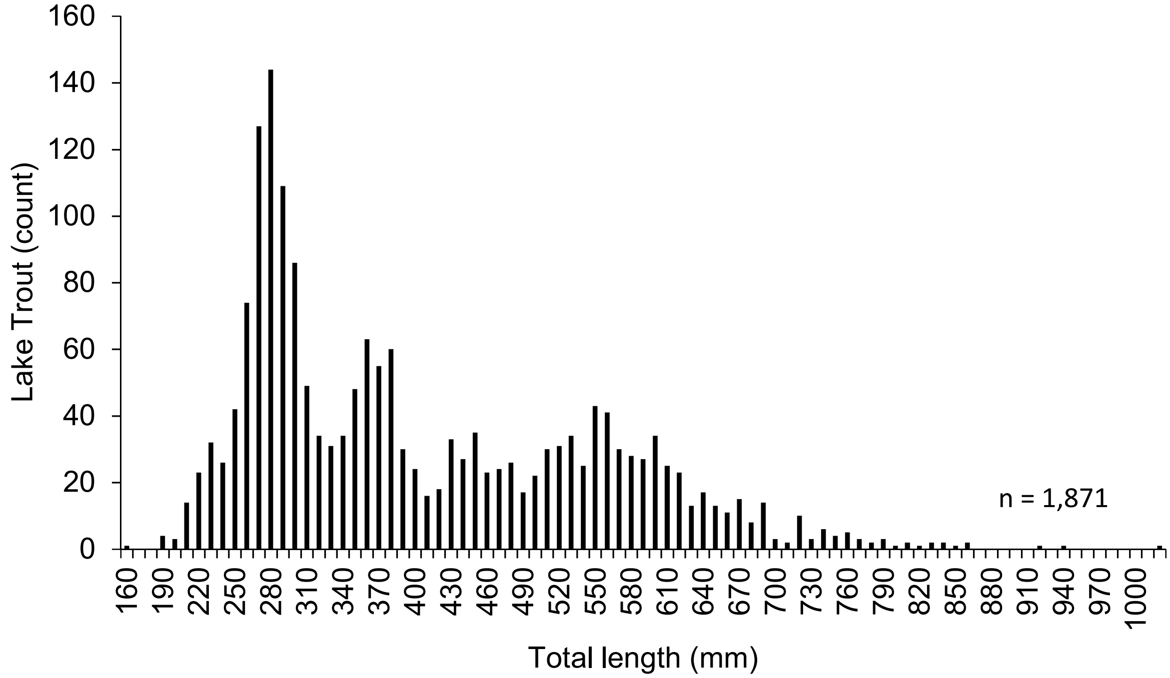

Figure 3. Length-frequency histogram of Lake Trout sampled in Upper Priest Lake, Idaho during 2017.

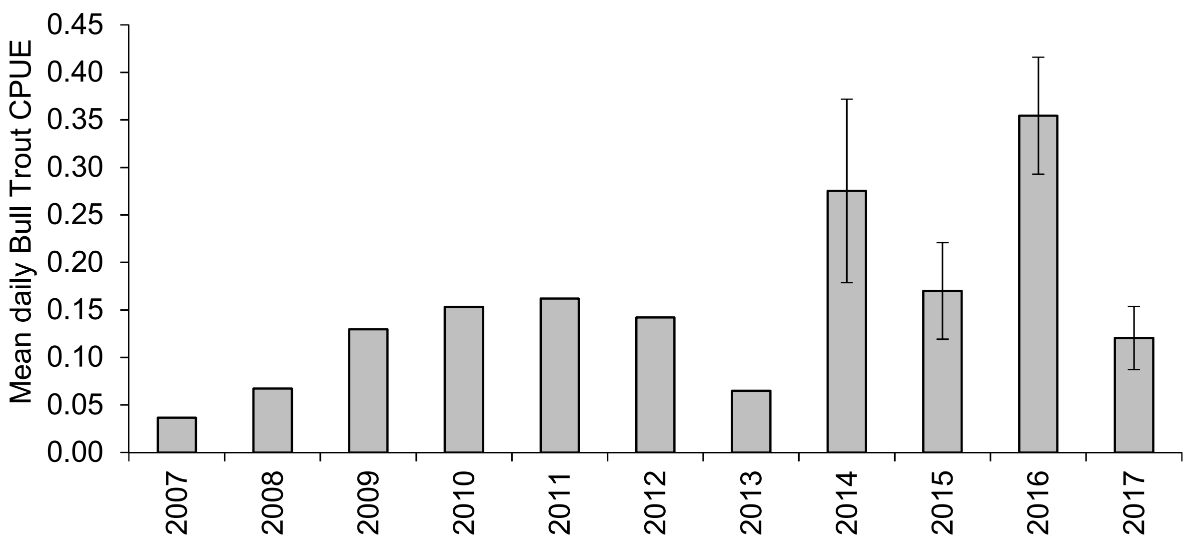

Figure 4. Mean daily Bull Trout catch rate (Bull Trout/box) and 80% confidence intervals from all mesh sizes fished in Upper Priest Lake, Idaho from 2007 to 2017. Confidence intervals were only estimated for years in which gill net mesh and effort were standardized.

PRIEST LAKE FISHERY INVESTIGATIONS

ABSTRACT

In 2017, we investigated Priest Lake kokanee *Oncorhynchus nerka* abundance in an effort to describe population trends. We conducted a lake-wide mobile acoustic survey to estimate kokanee abundance. In addition, we monitored kokanee spawner abundance in Priest Lake by counting mature spawning adults at five standard areas. We also conducted surveys of Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* abundance in Priest and Upper Priest lakes to improve understanding of these populations. Estimated density of Priest Lake kokanee in August was 24 fish/ha and 5 fish/ha for fry and age-1 to age-4, respectively. A total of 2,679 kokanee adults were observed along five shoreline areas of Priest Lake in November. The combined survey results suggested kokanee densities were low. Surveys of Westslope Cutthroat Trout abundance resulted in observed catch rates of 1.1 fish/net in Priest Lake and 3.5 fish/net in Upper Priest Lake. In Priest Lake, catch rate declined, growth rate increased, and annual mortality increased relative to 2014 survey. Catch rate of Westslope Cutthroat Trout in Upper Priest Lake was similar to that observed in 2014. In both lakes, Westslope Cutthroat Trout were well distributed, but we observed fewer small (< 250 mm TL) fish than in 2014.

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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, but have been regulated under a "no harvest" scenario since the late 1980s due to perceived declines in abundance. 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 quickly gained considerable interest among anglers (Fredericks et al. 2013). Lake Trout, once less common in the catch, provided a trophy opportunity prior to the kokanee collapse. 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. Mysis shrimp *Mysis diluviana* were introduced to Priest Lake in the 1960s and have positively influenced Lake Trout by providing readily available forage and negatively influenced other once–abundant fish species both directly through diet overlap and indirectly through their influence on Lake Trout abundance (i.e., kokanee, Bull Trout, Westslope Cutthroat Trout; IDFG 2013).

Current management of the Priest Lake fishery is focused on providing a mix of angling opportunities, primarily for Lake Trout, kokanee, and Westslope Cutthroat Trout. In 2017, we conducted surveys of kokanee abundance to describe current population trends. We also conducted surveys to assess the status of Westslope Cutthroat Trout in Priest and Upper Priest lakes.

METHODS

Acoustic Kokanee Survey

We conducted a lake-wide mobile acoustic survey on Priest Lake to estimate kokanee abundance on the night of August 16, 2017. We used a Simrad EK60 split-beam, scientific echosounder with a 120 Hz transducer to estimate kokanee abundance. Ping rate was set at 0.3 to 0.5 ping per second. 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 for use in calibration of signal speed and as a reference of the expected zone of occupancy for kokanee. Water temperatures were measured at one meter intervals for 15 m using a YSI 85-50 dissolved oxygen temperature meter (YSI Incorporated). Mean water temperature for water depths between zero and ten m was used in system calibration. We used Simrad ER60 software (Simrad Yachting) to determine and input the calibration settings.

We used standardized transects to complete the survey (Maiolie et al. 2013). We followed a uniformly spaced, zigzag pattern of 15 transects stretching from shoreline to shoreline (Figure 1). 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 software version 5.4 (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 echograms. 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. Then 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 and -45 dB) to estimate the density of kokanee fry. The percentage of large targets (-44 dB to -30 dB) was used to estimate age-specific kokanee density.

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

Shoreline Kokanee Count

We monitored kokanee spawner abundance in Priest Lake on November 6, 2017. Spawning kokanee were observed and counted at five standardized 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 to obtain size and sex information. One gill net was set for 15 minutes. The monofilament gill net was 46 m long with variable mesh panels including mesh sizes of 3.8, 5.1, 6.4, 7.6, 10.2, and 12.7 cm stretch-measure mesh. Sexes were determined by examining external characteristics and gonads of each individual.

Westslope Cutthroat Trout Monitoring

We used a systematic survey design to describe relative abundance, distribution, and population characteristics of Westslope Cutthroat Trout in Priest Lake and Upper Priest Lake. Survey locations were spaced at approximately two kilometer intervals around Priest Lake and 500-m intervals around Upper Priest Lake from random starting locations. Measurements used to space sampling locations were completed in Terrain Navigator Pro 9.21 (My Topo, Billings MT).

Sampling effort was conducted on the nights of June 5, 6, and 7, 2017. We sampled Westslope Cutthroat Trout using 45 x 1.8 m monofilament, experimental, floating gill nets. Gill nets were constructed with six panels and included mesh panels with 3.8, 5.1, 6.4, 7.6, 10.2, and 12.7 cm stretch-measure mesh. Nets were set perpendicular to the shoreline in nearshore areas. All nets were fished overnight with set times ranging from 12 to 19 hours. All fish collected were identified, measured (TL, mm), weighed (g), and fin rays from the leading edge of the pectoral fin was removed for ageing.

Relative abundance was described as average catch per unit effort (CPUE, fish/net). We described variability among net catches by calculating 80% confidence intervals for average CPUE estimates. Confidence intervals were calculated using methods for normally distributed data.

Fish collected in our survey were used to describe general population characteristics and dynamic rates for Westslope Cutthroat Trout. Pectoral fin rays were mounted in epoxy, sectioned near the proximal end on 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. Length-at-age was reported as an index of growth where applicable. Each ageing structure was viewed by two independent readers. Differences among readers were solved by committee. When agreement could not be reached, structures were removed from the sample. Growth rates were described using the von Bertalanffy growth model 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. The variability in age estimates was described by calculating a coefficient of variation for total length by assigned age.

Total annual mortality and survival were estimated from catch-at-age frequencies using a catch curve (Miranda and Bettoli 2007) generated in Fisheries Analysis and Modeling Simulator (FAMS; American Fisheries Society, Bethesda, MD). Although structures were collected from all fish for ageing, an age estimate was not confidently achieved for all samples. We used an age-length key to assign ages to fish for which age was not estimated.

Westslope Cutthroat Trout emigration potentially influenced our investigation of age and growth. Adfluvial Westslope Cutthroat Trout spawn and rear in Priest Lake tributaries. Emigration from rearing tributaries may occur following a varying period of rearing (Bjornn 1957). We assumed forage availability and subsequent growth potential might be impacted by where a fish resides and for what period of time. To better understand the influence emigration timing had on age and growth patterns, we estimated the age at emigration for Westslope Cutthroat Trout sampled. Incremental measures of growth were used to estimate the period in which a juvenile fish first emigrated from a stream to Priest Lake. Increments of growth were measured on individual otoliths from the trailing edge of an opaque band to the trailing edge of the next opaque band. We described the year of emigration as the period of greatest incremental growth. Our assessment of emigration was based on an assumption that initial growth after emigration was

fast due to a transition from a low productivity-limited space lotic environment to a higher productivity-unlimited space lentic environment.

Periodic Westslope Cutthroat Trout surveys on Priest and Upper Priest lakes were initiated in 2014 as a method of describing trends and better understanding the dynamics of these populations. As such, we compared catch rates, size structure, measures of growth, and estimates of annual mortality from this survey to observations from 2014.

RESULTS

Acoustic Kokanee Survey

Estimated density of Priest Lake kokanee in August 2017 was 24 fry/ha ± 10.8 (80% C.I.; Table 1) and 5 age-1 to age-4 kokanee/ha ± 1.5 (Table 1; Figure 2). Expanded densities represented a total abundance of 198,332 kokanee fry and 43,313 kokanee ages 1-4. A temperature profile measured prior to our survey suggested a thermocline occurred between nine and ten m below the surface of the lake (Figure 3).

Shoreline Spawner Count

We counted 2,679 kokanee along five shoreline areas of Priest Lake in 2017 (Table 2). Spawning adult kokanee collected near Hunt Creek varied in length from 363 to 500 mm and averaged 425 mm (n = 50) and 402 mm (n = 13), for males and females, respectively. Kokanee counts represented a decline from a peak observed in 2013 (Figure 4).

Westslope Cutthroat Trout Monitoring

We sampled 46 Westslope Cutthroat Trout among 44 gill net sets in Priest Lake. Four net sets were dislodged or tampered with, which caused them to fish ineffectively. These nets were removed from our survey analysis. Mean Westslope Cutthroat Trout CPUE was 1.1 ± 0.2 fish/net (80% C.I.; Table 3). Westslope Cutthroat Trout were well-distributed across the lake, but catch was concentrated more heavily on the western shoreline (Figure 5). We sampled 13 other species (Table 3), with the most abundant species being Northern Pikeminnow *Ptychocheilus oregonensis* (CPUE; 11.3 ± 2.0) and Peamouth *Mylocheilus caurinus* (CPUE = 2.6 ± 2.0).

In Upper Priest Lake, we caught 28 Westslope Cutthroat Trout in gill net sets (CPUE = 3.5 ± 0.8). Catch of Westslope Cutthroat Trout was well-distributed around the lake (Figure 5). Bycatch represented a simpler fish community than Priest Lake with only six additional species caught (Table 4). Similar to Priest lake, Northern Pikeminnow were the most abundant species encountered (CPUE = 13.1 ± 5.2).

Mean total length of Westslope Cutthroat Trout collected from Priest Lake was 397 mm (± 12, 80% C.I.) and varied from 175 mm to 534 mm (n = 46; Figure 6). Corresponding age estimates varied from age-1 through age-6 (n = 36; Figure 7). Growth rates were greater in Priest Lake than Upper Priest Lake (Figure 7). For example, we estimated length-at-age-5 at 452 mm in Priest Lake and 399 mm in Upper Priest Lake. Variability in length-at-age estimates was generally low (CV = 5% - 14%). Incremental growth measures suggested juvenile emigration occurred at age-1 (89%) and age-2 (11%).

Size structure of Westslope Cutthroat Trout collected in Upper Priest Lake was similar to Priest Lake with a mean total length of 355 mm (± 12, 80% C.I.) varying from 281 to 449 mm (n = 27; Figure 6). Corresponding age estimates varied from age-2 through age-6 (Figure 7). The coefficient of variation in length–at-age estimates from Upper Priest Lake fish varied from 7% to 10%, thus demonstrating low variation in length-at-age estimates. Emigration from natal tributaries was estimated to occur at age-1 (74%) and age-2 (26%).

Total annual mortality of Westslope Cutthroat Trout was estimated to be higher in Priest Lake than Upper Priest Lake. Annual mortality in Priest Lake from ages four through six was 70% (n = 46; Figure 8). In contrast, annual mortality was estimated at 58% (n= 23; Figure 9) in Upper Priest Lake from ages three through six.

We observed variability in our comparison of several metrics described in both 2014 and 2017 surveys of Westslope Cutthroat Trout in Priest Lake and Upper Priest Lake. Specifically, we observed a decline in catch rate (Figure 10), an increase in growth rate (Figure 11), and an increase in annual mortality for Westslope Cutthroat Trout in Priest Lake (Table 5). In both lakes, we observed a less diverse distribution of fish lengths in the catch with a lower proportion of smaller and younger fish caught (Figure 6). Catch rate of Westslope Cutthroat Trout in Upper Priest Lake was similar to that observed in 2014 (Figure 10). Not all metrics were estimated for Upper Priest Lake in 2014 and therefore limited our ability to describe trends in that population.

DISCUSSION

Estimated abundance of Priest Lake kokanee and other metrics described in our surveys continued to reflect a low density kokanee population. As evidence, both our acoustic estimate of abundance and shoreline spawner counts were low. In addition, our acoustic estimate of abundance represented a decline from recent levels. However, observed variability of recent estimates limited our ability to conclude abundance changed significantly (Figure 3; Ryan et al. *In review*). Priest Lake kokanee spawner counts also declined relative to counts completed from 2011 through 2016 (Figure 4; Ryan et al. *In review*). Corresponding average length of kokanee spawners increased, a trend observed since 2013 that aligned with our expectations of declining abundance (Figure 4).

Westslope Cutthroat Trout catch rates in Priest and Upper Priest did not vary dramatically from 2014 to 2017. Although we observed an increase in catch rate in Upper Priest Lake, overlapping confidence bounds suggested differences were not likely significant. Greater variation in catch rate between survey years was observed in Priest Lake. However, a difference of 0.7 fish/net was not considered to be substantial. Westslope Cutthroat Trout catch rate in Priest Lake remained near one fish/net, suggesting a moderately abundant population still was present. In comparison, a harvestable population of Westslope Cutthroat Trout is present in Cocolalla Lake. Catch rate from a comparable survey of that hatchery supported fishery was similar to what we observed in Priest Lake (See Stocking Evaluations *in this report*).

Few small (< 250 mm) Westslope Cutthroat Trout were observed in the catch from both Priest and Upper Priest lakes in 2017, suggesting that segment of the populations was less abundant in the lakes than observed in our last survey. We speculate that fewer small fish in the lake segment of these populations may be the result of multiple factors, including poor recruitment, low juvenile survival in natal tributaries, low juvenile survival after emigration, or delayed emigration in recent years resulting from potentially good conditions in natal tributaries. Although all of these scenarios or some combination may be plausible, we did not have adequate

information to discern which, if any, may be true. It may be possible to better understand the dynamics of juvenile recruitment of Westslope Cutthroat Trout to the lake populations. For example, paired sampling events in tributary streams and the lakes may allow better understanding of how populations fluctuate in tributaries relative to the lakes. However, the scale of effort to effectively sample tributary populations is large and would likely not be feasible on a frequency necessary to describe patterns accurately. Alternatively, continued monitoring of the lake populations with focus on year-class strength may also allow some better understanding over time, but will require a time series of survey history. Continued monitoring of the in-lake populations of Westslope Cutthroat Trout is recommended as it is consistent with our current approach and is the most feasible option at this time.

Precisely describing growth and related metrics for the Westslope Cutthroat Trout populations in our survey waters has been challenging. Watkins et al. (2018), noted poor precision and lack of confidence in the 2014 estimates of length-at-age and other age related metrics. In the analysis of this survey, we used fin rays to estimate age rather than otoliths. In doing so, we found low variation in length-at-age estimates relative to previous estimates. This perceived increase in precision created both confidence in age estimates and uncertainty in other metrics describing the populations at-large. For example, our description of growth rate in Priest Lake suggested fish grew much faster than was described in our 2014 survey. Although, variability in growth rate may occur, we are uncertain how dramatically this may occur in Priest Lake and how much growth was influenced by our method rather than large-scale environmental changes. We also observed little variation in incremental measures of growth between years for many fish in our sample using fin rays. Because our approach for describing age-at-emigration relied on strong difference in growth between years, low variability in incremental growth measures may limit our ability to accurately define emigration patterns. Our resulting age-at-emigration estimates represented a narrower time frame than previously described (Watkins et al. 2018). Although uncertainties did exist between surveys due to differences in ageing methods, the increased confidence in assessment of age based on length provided rationale for maintaining the use of fin rays for future survey work involving Westslope Cutthroat Trout. Therefore, we recommend fin rays continue to be used to estimate age of Westslope Cutthroat Trout in this system and that this method remains standard to limit uncertainty.

Our ability to accurately estimate annual mortality of Westslope Cutthroat Trout in Priest Lake and Upper Priest Lake continued to be influenced by low recruitment of younger age classes to our gear. Resulting annual mortality estimates were influenced by low catch of young trout, and the few older age classes in our catch curve estimates. Similar to the 2014 survey of Priest Lake (Watkins et al. 2018), patterns of juvenile emigration from natal tributaries may have influenced our estimator. With low trout densities, the mortality estimates are heavily influenced by small sample sizes of young fish. We continue to suggest caution be used when interpreting estimates of mortality for these populations because of the uncertainties in our estimators.

RECOMMENDATIONS

1. Continue utilizing acoustic surveys and shoreline spawner counts as tools for monitoring Priest Lake kokanee abundance in low density conditions.

2. Continue monitoring Westslope Cutthroat Trout in Priest and Upper Priest lakes to improve understanding of these populations and monitor trends over time. Complete surveys on a three year rotation.

3. Use fin rays to estimate age of Westslope Cutthroat Trout in this system as a standard method to improve understanding of dynamics in age-related metrics.

4. Cautiously interpret estimates of mortality from Priest and Upper Priest Westslope Cutthroat Trout populations due to data limitations.

Table 2. Acoustic survey results for kokanee in Priest Lake, Idaho conducted on August 16, 2017.

Transect	Single targets	NASC	Mean TS	Total density (fish/ha)	% fry	Fry density	% ages 1-4	Age 1-4 density
1	6	0.9	-49.6	20	1.00	20	0.00	0
2	21	1.0	-49.6	21	0.90	19	0.10	2
3	15	4.8	-50.9	137	0.93	128	0.07	9
4	14	0.3	-49.3	7	0.86	6	0.14	1
5	12	4.2	-42.0	15	0.83	13	0.17	6
6	11	16.0	-42.3	63	0.00	0	0.00	0
7	18	11.6	-42.0	43	0.72	31	0.28	12
8	16	4.7	-43.6	25	0.56	14	0.44	11
9	19	16.9	-39.2	33	0.79	26	0.21	7
10	55	18.5	-42.0	68	0.89	60	0.11	7
11	40	3.6	-45.6	30	0.93	28	0.08	2
12	5	0.2	-47.5	3	0.80	2	0.20	1
13	10	8.6	-39.2	17	0.30	5	0.70	12
14	0	0.01	0.0	0	0.00	0	0.00	0
15	22	21.1	-36.4	21	0.55	12	0.45	10
Mean				34		24		5

Table 3. Kokanee spawner counts at five standard locations on Priest Lake, Idaho in 2017.

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

Table 4. Catch, catch per unit effort (CPUE), average total length (TL, mm),minimum total length (TL; mm), and maximum total length (TL; mm) by species for fish sampled from Priest Lake, Idaho in 2017 using standard floating gill nets.

Species	Catch	CPUE ± 80% CI	Avg TL	Min TL	Max TL
Northern Pikeminnow	499	11.3 ± 2.0	333	192	560
Peamouth	116	2.6 ± 0.7	272	119	360
Lake Trout	10	0.2 ± 0.1	503	389	773
Largescale Sucker	6	0.1 ± 0.1	474	420	522
Longnose Sucker	15	0.3 ± 0.2	445	368	579
Smallmouth Bass	17	0.4 ± 0.1	286	152	466
Yellow Perch	4	0.1 ± 0.1	189	158	238
Tench	10	0.2 ± 0.2	415	321	477
Brook Trout	8	0.2 ± 0.1	247	176	301
Kokanee	5	0.1 ± 0.1	348	306	376
Mountain Whitefish	2	0.1 ± < 0.1	280	256	304
Westslope Cutthroat Trout	46	1.1 ± 0.2	397	175	534
Brown Bullhead	4	0.1 ± 0.1	229	222	232
Pumpkinseed	1	< 0.1 ± < 0.1	128	128	128

Table 5. Catch, catch per unit effort (CPUE), average total length (TL, mm), minimum total length (TL; mm), and maximum total length (TL; mm) by species for fish sampled from Upper Priest Lake, Idaho in 2017 using standard floating gill nets.

Species	Catch	CPUE ± 80% CI	Avg TL	Min TL	Max TL
Bull Trout	3	0.4 ± 0.2	387	356	409
Lake Trout	8	1.0 ± 0.6	522	326	720
Largescale Sucker	1	0.1 ± 0.2	504	504	504
Longnose Sucker	1	0.1 ± 0.2	545	545	545
Northern Pikeminnow	105	13.1 ± 5.2	314	186	515
Peamouth	8	1.0 ± 0.6	234	193	289
Westslope Cutthroat Trout	28	3.5 ± 0.8	356	281	449

Table 6. Survival (S) and annual mortality (AM) estimates for Westslope Cutthroat Trout populations in Priest Lake and Upper Priest Lake in 2014 and 2017.

	Priest Lake		Upper Priest Lake	
YEAR	S	AM	S	AM
2014	0.56	0.44	--	--
2017	0.30	0.70	0.58	0.42

Transect	Location
1	48^o 44.105 N x 116^0 51.216 W
	48^o 42.752 N x 116^0 50.490 W
2	48^o 42.752 N x 116^0 50.490 W
	48^o 41.685 N x 116^0 51.965 W
3	48^o 41.685 N x 116^0 51.965 W
	48^o 40.469 N x 116^0 50.052 W
4	48^o 40.469 N x 116^0 50.052 W
	48^o 39.509 N x 116^0 52.258 W
5	48^o 39.509 N x 116^0 52.258 W
	48^o 38.042 N x 116^0 51.267 W
6	48^o 38.042 N x 116^0 51.267 W
	48^o 37.034 N x 116^0 53.687 W
7	48^o 37.034 N x 116^0 53.687 W
	48^o 36.185 N x 116^0 51.942 W
8	48^o 36.185 N x 116^0 51.942 W
	48^o 34.963 N x 116^0 53.804 W
9	48^o 34.963 N x 116^0 53.804 W
	48^o 34.112 N x 116^0 51.784 W
10	48^o 34.112 N x 116^0 51.784 W
	48^o 33.288 N x 116^0 49.723 W
11	48^o 33.288 N x 116^0 49.723 W
	48^o 32.423 N x 116^0 51.475 W
12	48^o 32.423 N x 116^0 51.475 W
	48^o 31.535 N x 116^0 53.247 W
13	48^o 31.535 N x 116^0 53.247 W
	48^o 30.357 N x 116^0 52.023 W
14	48^o 30.357 N x 116^0 52.023 W
	48^o 29.169 N x 116^0 50.815 W
15	48^o 36.208 N x 116^0 51.323 W
	48^o 35.115 N x 116^0 50.215 W

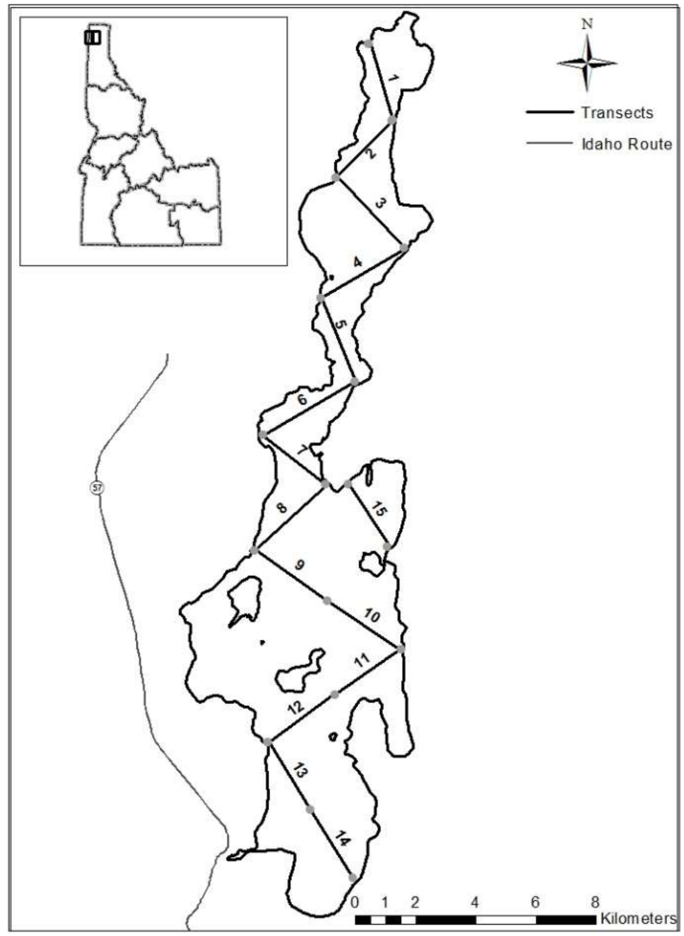

Figure 5. Standard transects on Priest Lake, Idaho used in acoustic surveys of kokanee abundance in 2017.

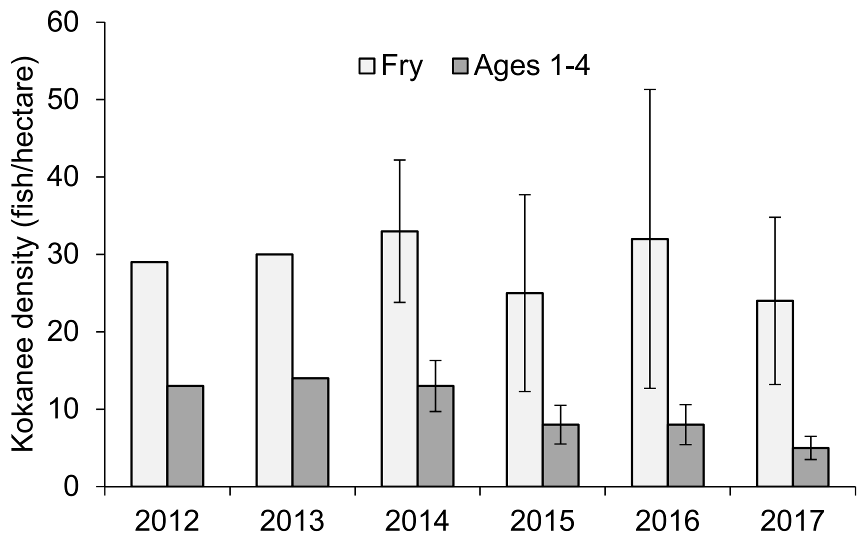

Figure 6. Kokanee density estimates from Priest Lake, Idaho acoustic surveys from 2012 through 2017.

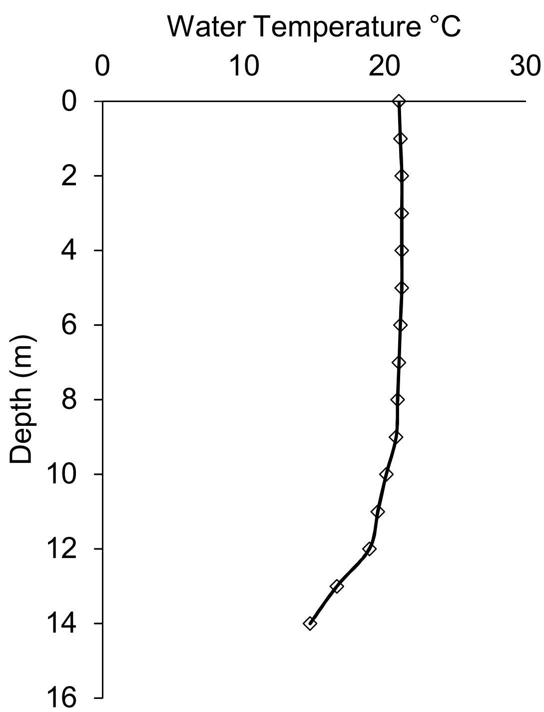

Figure 7. Temperature profile of Priest Lake, Idaho measured in association with our August 2017 acoustic survey.

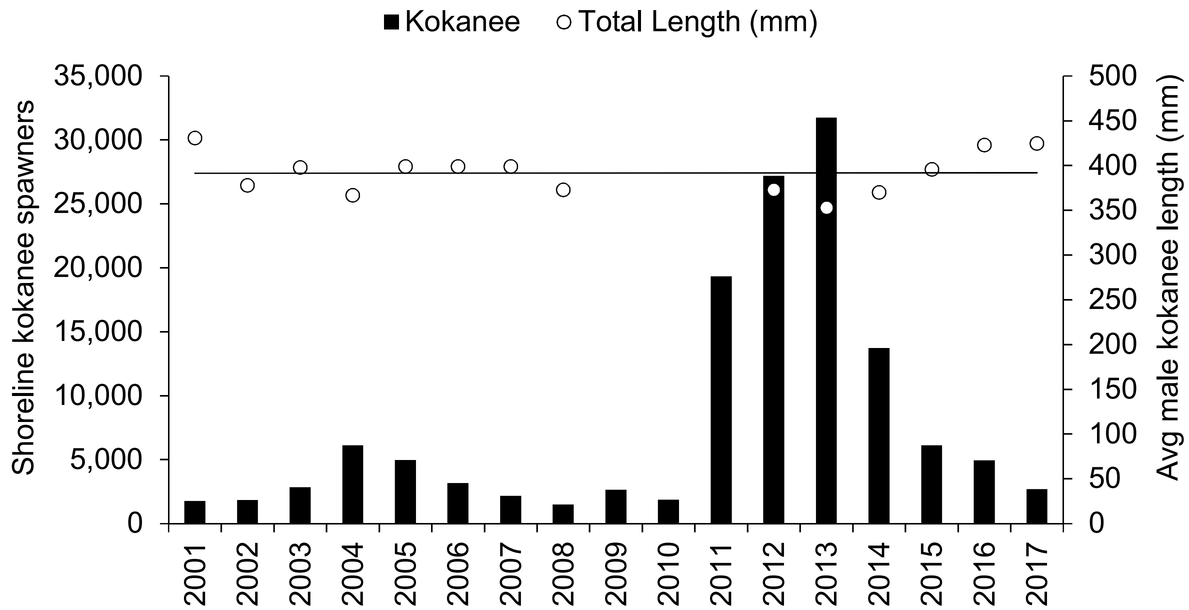

Figure 8. Adult kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 through 2017 and corresponding length of male kokanee spawners.

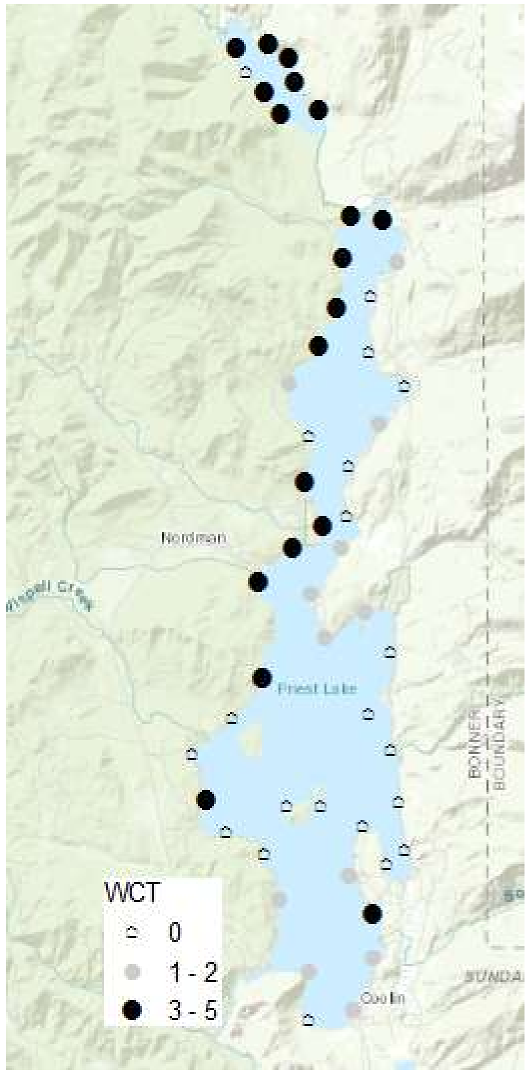

Figure 9. Sample locations and observed catch per net from spring floating gill net surveys of Priest Lake and Upper Priest Lake in 2017.

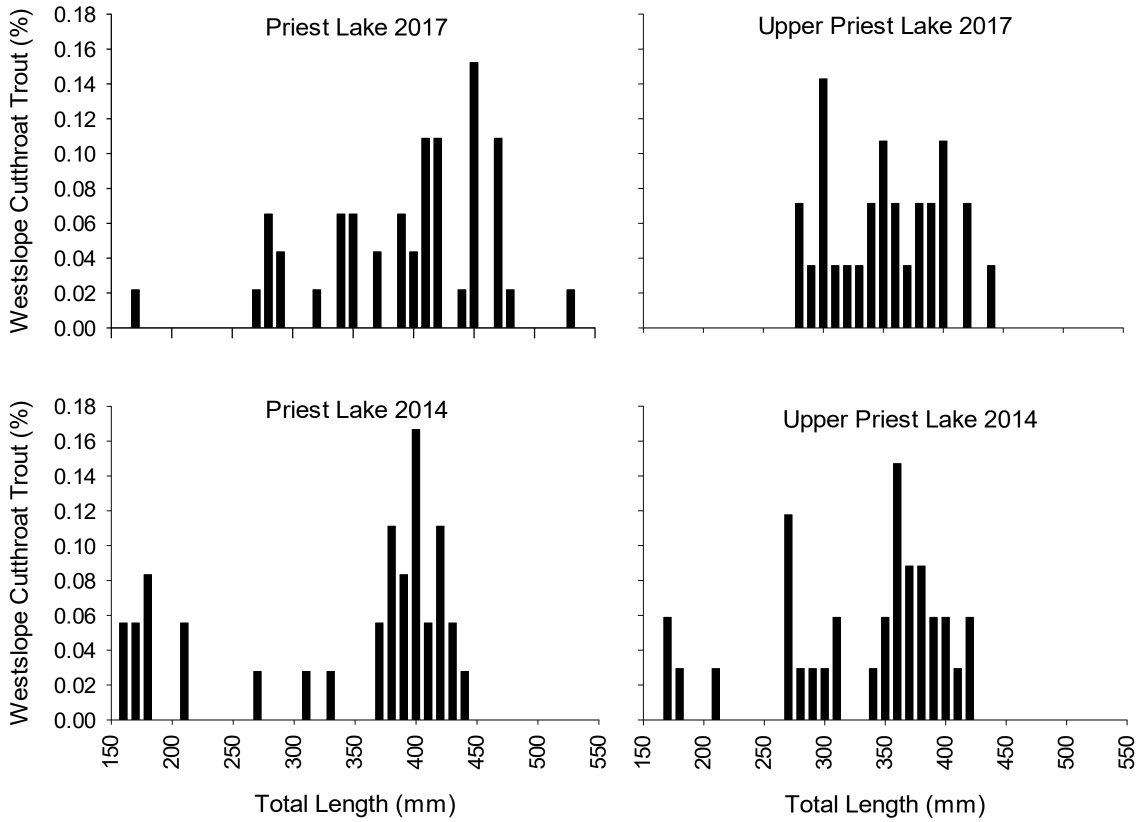

Figure 10. Relative frequency of Westslope Cutthroat Trout total lengths (mm) from spring floating gill net surveys of Priest Lake and Upper Priest Lake in 2014 and 2017.

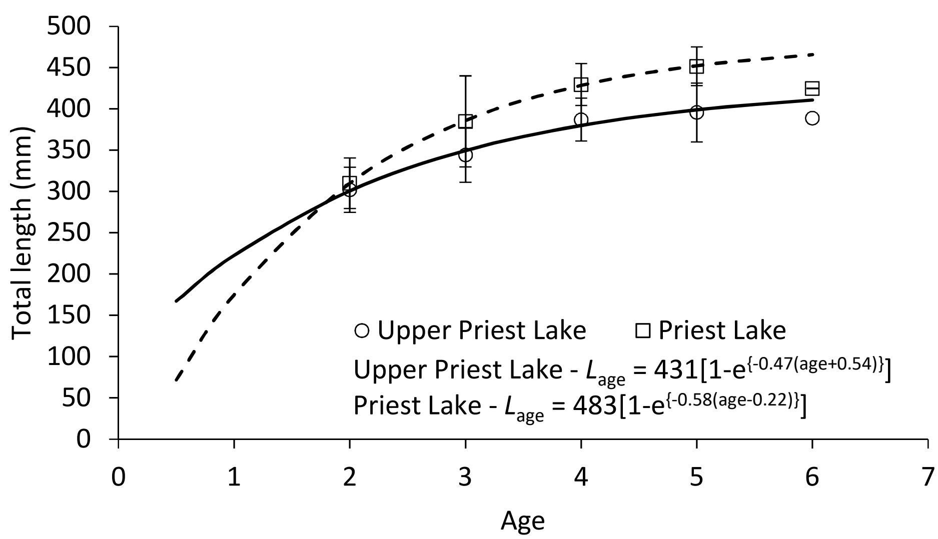

Figure 11. Estimated length-at-age of Westslope Cutthroat Trout in Priest Lake and Upper Priest Lake in 2017.

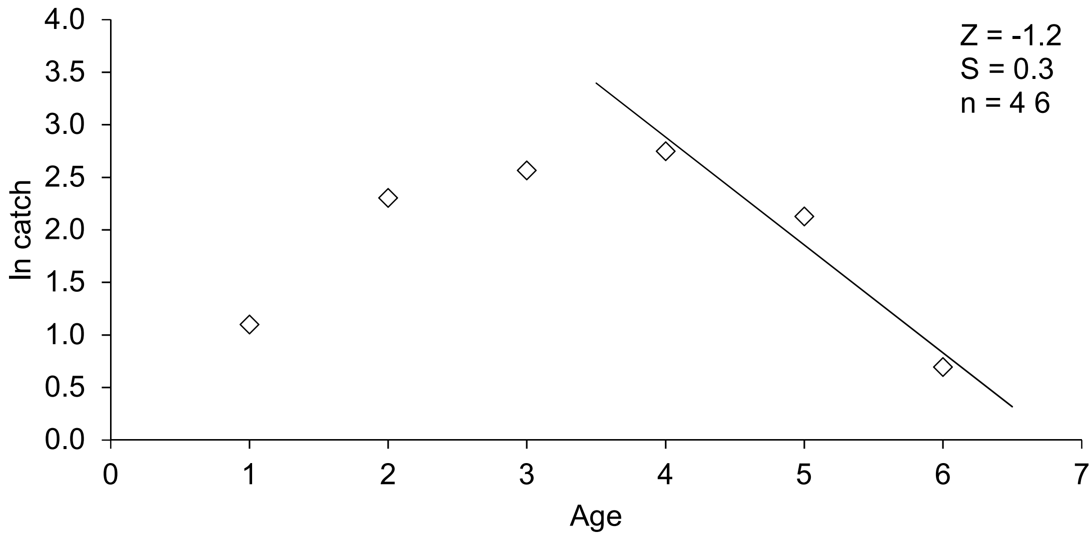

Figure 12. Catch curve used to estimate instantaneous natural mortality of Westslope Cutthroat Trout from Priest Lake in 2017.

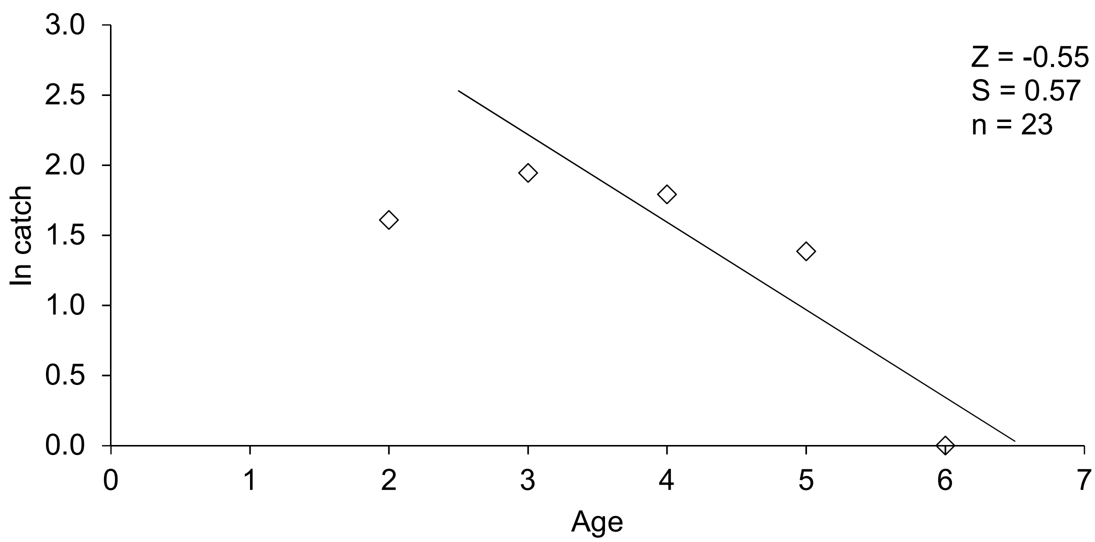

Figure 13. Catch curve used to estimate instantaneous natural mortality of Westslope Cutthroat Trout from Upper Priest Lake in 2017.

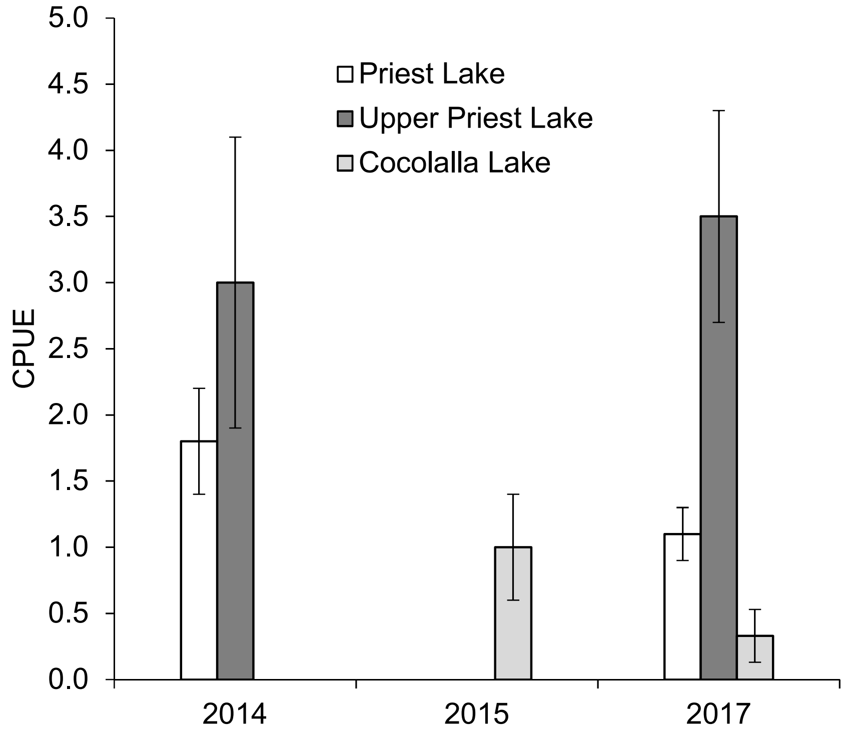

Figure 14. Westslope Cutthroat Trout catch per unit effort (CPUE) comparison from spring floating gill net surveys of Priest Lake, Upper Priest Lake, and Cocolalla Lake in 2014, 2015, and 2017.

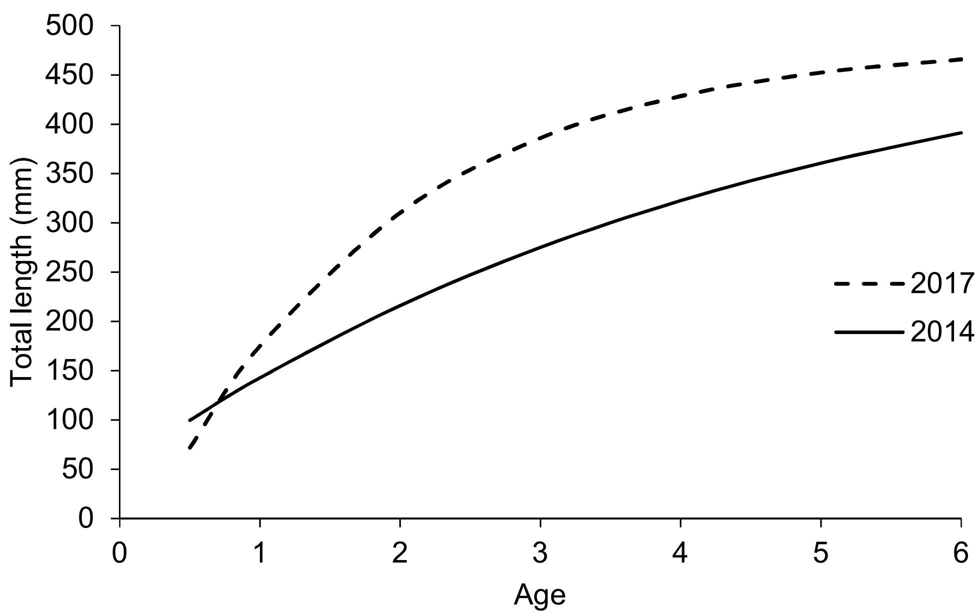

Figure 15. Estimated growth patterns of Westslope Cutthroat Trout in Priest Lake from 2014 and 2017 spring surveys.

HAYDEN AND PRIEST LAKES MYSID SURVEYS

ABSTRACT

We sampled Priest and Hayden lakes in June of 2017 to estimate lake-wide densities of Mysid shrimp *Mysis diluviana*. Mean densities of immature and adult mysids in Hayden and Priest lakes were 73 and 43 mysids/m^2, respectively. Density estimates represented a stable population trend for both waters.

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INTRODUCTION

Mysid shrimp *Mysis diluviana* 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 introductions in three northern Idaho lakes, including 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 Hayden Lake, the introduction of mysids has generally been characterized positively. Mysids are thought to provide beneficial forage in Hayden Lake for multiple fish species (Horner et al. 1986, Lamansky 2011). However, their influence on fish growth has not been definitively assessed.

In Priest Lake, mysids were credited with increasing kokanee growth (Irizarry 1974). However, mysids improved survival of juvenile Lake Trout *Salvelinus namaycush*,, which subsequently collapsed the kokanee fishery as a result of increasing predation. The resulting Lake Trout fishery in Priest Lake largely replaced fisheries for kokanee and Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* (Liter et al. 2009).

Mysids have not been routinely sampled in northern Idaho lakes. The exception to this has been Lake Pend Oreille where a long history of monitoring has been completed. Annual sampling of Lake Pend Oreille showed a sharp decline in shrimp beginning in 2011 (Wahl et al. 2016). The collapse of mysids in Lake Pend Oreille prompted an investigation of mysid abundance in other northern Idaho lakes. Observed declines in abundance could have major effects on the food web and the resulting sport fisheries. This report includes results from our investigations on mysid densities in Hayden and Priest lakes in 2017.

METHODS

We sampled mysid shrimp to estimate density in Hayden and Priest lakes on June 19 and 15, 2017, respectively. All sampling occurred at night during the dark phase of the moon. A total of twelve random sites were sampled on each water body. 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 a deeper zone was not 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. We calculated density as mysids per square meter based on the area of the net mouth and depth of tow. We reported arithmetic mean density and 80% confidence intervals around each estimate. YOY density can be highly variable and is not generally predictive of subsequent immature or adult densities (Wahl et al. 2011). As such, density trends were depicted using only combined immature and adult density.

RESULTS

Density of immature and adult mysids in Hayden Lake varied across sampled locations and ranged from 45 to 155 mysids/m^2 (Table 1) with a mean of 86 ± 12 mysids/m^2 (Figure 1). Mean density of immature and adult mysids from Priest Lake was estimated at 16 ± 4 mysids/m^2

(Figure 2) and varied from 1 to 42 mysids/m^2 (Table 2). Density in both waters was similar to 2016 estimates and generally contributed to weak or absent trends among recent years (Figure 2).

DISCUSSION

Our efforts to describe mysid populations in Hayden and Priest lakes continued to suggest densities are low and moderately stable. We found density estimates were comparable to previous estimates in these waters from 2013 through 2016 (Ryan et al. 2014, Watkins et al. 2018, Ryan et al. 2018, and Ryan et al. 2020). Estimates of mysid density in Hayden Lake were comparable to recently estimated density in Lake Pend Oreille (79 mysids/m^2; Rust et al. 2019), but much lower than historical peaks in abundance in that water. In contrast, Priest lakes was low relative to Lake Pend Oreille. As a result of relatively consistent mysid density trends in our recent sampling history, we suggest sampling frequency may be reduced. We recommend mysid monitoring continue on Priest and Hayden lakes on a bi-annual cycle.

RECOMMENDATIONS

1. Complete bi-annual monitoring of mysid density in Priest and Hayden lakes.

Table 7. Mysid density estimates from Hayden Lake on June 19, 2017. Densities were listed by sample location (UTM, zone 11, WGS84) and life stage (young of year (YOY), immature and adults).

Sample Site	E	N	YOY/m^2	Immature and Adult/m^2	All Ages/m^2
1	522993	5291926	76	73	149
2	523200	5291590	37	54	91
3	522585	5290715	72	175	247
4	521993	5290062	77	76	153
5	522002	5289626	49	121	170
6	522545	5289421	105	49	154
7	521691	5289295	131	84	215
8	521033	5290028	89	66	155
9	521031	5290326	48	33	81
10	520034	5290017	121	24	146
11	519229	5289187	490	64	553
12	518786	5289208	381	51	432

Table 8. Mysid density estimates from Priest Lake on June 15, 2017. Densities were listed by sample location (UTM, zone 11, WGS84) and life stage (young of year (YOY), immature, and adults).

Sample Site	E	N	YOY/m^2	Immature and Adult/m^2	All Ages/m^2
1	511202	5394109	60	42	102
2	509162	5392132	7	10	17
3	510996	5390163	28	22	50
4	510469	5387060	50	17	67
5	509056	5384168	84	17	102
6	510983	5381069	78	18	97
7	506795	5379120	177	16	193
8	509038	5377626	82	6	88
9	511004	5378149	143	20	163
10	510983	5373105	60	5	65
11	508934	5372141	75	18	93
12	511896	5382095	127	1	129

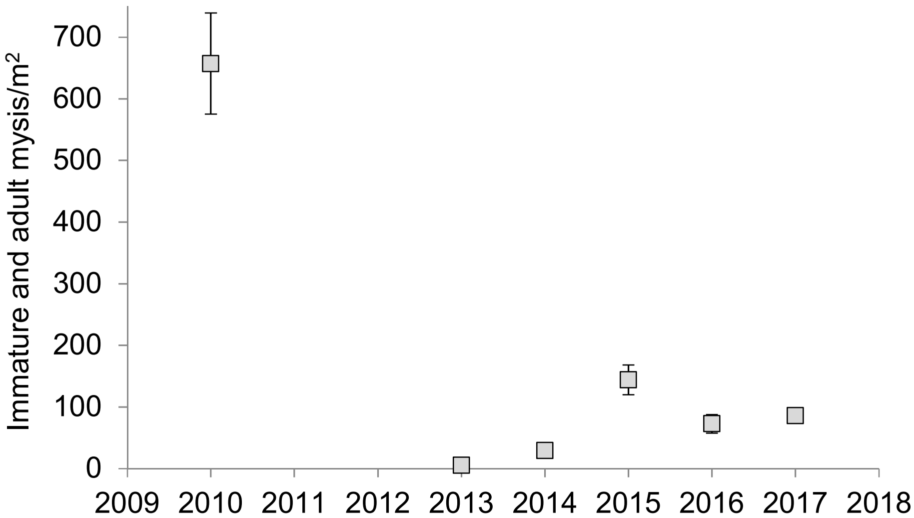

Figure 16. Estimated mean density of immature and adult mysids in Hayden Lake from 2010 through 2017. Error bars represent 80% confidence intervals.

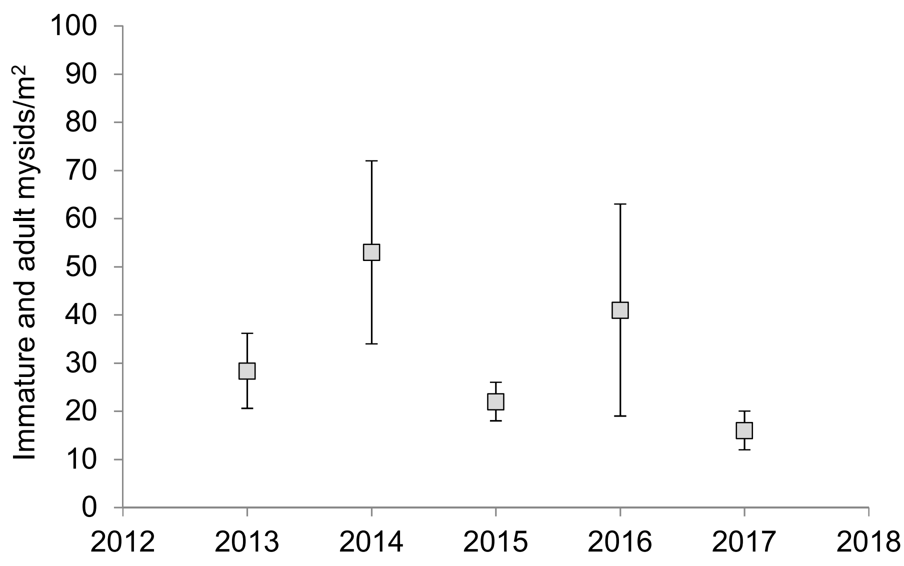

Figure 17. Estimated mean density of immature and adult mysids in Priest Lake from 2013 through 2017. Error bars represent 80% confidence intervals.

PANHANDLE HIGH MOUNTAIN LAKE INVESTIGATIONS

ABSTRACT

In August 2017, we surveyed two high mountain lakes, Hunt Lake and Cutoff Lake, in the Panhandle Region. Information gained was used to evaluate the quality of the fishery in Hunt Lake and survival of hatchery-stocked fish in Cutoff Lake. We sampled fish in both lakes using a combination of gill nets and angling. A total of 31 Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* was sampled from Hunt Lake. Twenty fish were caught by gill nets set overnight. In addition, angling caught 11 fish at a rate of 3.1 fish/h. At Cutoff Lake, 12 Westslope Cutthroat Trout were caught among all survey efforts. A single overnight set gill net caught three fish. Angling caught an additional nine fish at a rate of 1.5 fish/h. Hatchery supplementation appeared to be adequate in both lakes to provide viable fisheries. We recommend continued stocking of Rainbow Trout *Oncorhynchus mykiss* in Hunt and Cutoff lakes at current densities.

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INTRODUCTION

The Idaho Department of Fish and Game currently stocks 51 high mountain lakes within the Panhandle Region to create fishing opportunities for anglers. Lakes are stocked with a variety of species, including Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*, Rainbow Trout *Oncorhynchus mykiss*, Golden Trout *Oncorhynchus aquabonita* and Arctic Grayling *Thymallus arcticus*. Stocking densities are dependent on lake elevation and lakes are stocked either annually or biannually (Fredericks et al. 2002).

In August 2017, we surveyed two high mountain lakes in the Panhandle Region to evaluate the quality of the fishery in Hunt Lake and Cutoff Lake. Hunt Lake is a 5.63-ha lake in the Priest River drainage that is stocked biannually with Westslope Cutthroat Trout. The lake receives medium to heavy recreational use. A one-mile trail provides relatively easily access to Hunt Lake via the Hunt Creek drainage. Cutoff Lake is a 2.13 ha high mountain lake in the Kootenai River drainage that is also stocked biannually with Westslope Cutthroat Trout. From the Cutoff Peak trailhead, the lake is a strenuous six-mile hike, including three miles on trail and three miles cross country. Prior to our survey, an anecdotal report from a recreational user at Cutoff Lake suggested survival of stocked fish may be low.

OBJECTIVES

1. Evaluate in the quality of the fishery in Hunt Lake.

2. Evaluate survival of stocked fish in Cutoff Lake.

METHODS

We sampled fish in Hunt Lake and Cutoff Lake using a combination of gill nets and angling. One standard floating mountain lake gill net was set overnight at each lake and supplemented with angling effort. Standard gill net dimension was 36 m x 1.8 m with 6 m panels of 10, 12.5, 18.5, 25, 33, and 38 mm mesh. We identified species and measured total length (mm) on all fish caught. Stomach contents were examined from one fish in Cutoff Lake and three fish in Hunt Lake. Inlets and outlets of lakes were observed for spawning potential. A depth profile of the lake was taken to roughly describe its bathymetry. Recreational use at each lake was described by counting of the number of camp sites present and qualitative description of site disturbance. We surveyed for amphibians using a coarse visual encounter survey at each lake by walking the perimeter. Observed amphibians or egg masses were identified to species when possible.

RESULTS

A total of 31 Westslope Cutthroat Trout were sampled from Hunt Lake. Twenty fish were caught in one gill net set overnight. In addition, angling caught 11 fish at a rate of 3.1 fish/h. Average TL of Westslope Cutthroat Trout caught was 225 mm and varied from 130 to 284 mm. Three fish of different size classes were selected for diet analysis out of the gill net sample. Midges were the most prolific forage species observed in diets across all size classes. The lake had a maximum depth of 8.2 m Suitable spawning habitat was not observed in the inlet or outlet of the

lake. We observed two primitive camp sites on the lake and multiple groups of hikers. Six different groups of people were observed hiking into or out of the lake. No amphibians were observed.

At Cutoff Lake, 12 Westslope Cutthroat Trout were caught among all survey efforts. A single overnight set gill net caught three fish. Angling caught an additional nine fish at a rate of 1.5 fish/h. Mean TL of fish collected was 286 mm and varied from 105 mm to 400 mm. Diet analysis of one fish showed predominately ants. A depth profile of the lake indicated maximum depth was 5.2 m while the majority of the lake was approximately 4.6 m deep. Inlets and outlets were blocked by debris and likely did not provide suitable spawning habitat. We observed two campsites at the lake, but minimal evidence of recreational use. No amphibians were observed.

DISCUSSION

Hunt Lake had a healthy population of Westslope Cutthroat Trout. Multiple length groups were observed in our survey, suggesting good survival from multiple stocking events. Although recreational use appeared moderate to high, the fish population provided a high catch rate angling experience. We recommend that stocking of Hunt Lake with Westslope Cutthroat Trout continue at current densities.

We observed moderate catch rates of Westslope Cutthroat Trout at Cutoff Lake. We found no evidence suggesting fish survival was limited. The presence of multiple size classes in the lake suggested that overwinter survival of hatchery-stocked fish occurred over several prior years. We recommend that maintaining stocking Cutoff Lake with Westslope Cutthroat Trout at current densities.

RECOMMENDATIONS

1. Continue stocking of Hunt and Cutoff lakes at current densities.

HATCHERY TROUT STOCKING EVALUATIONS

ABSTRACT

In 2017, we continued evaluations of hatchery trout stocking in regional waters. Evaluations included estimation of the relative return of fingerling Rainbow Trout *Oncorhynchus mykiss* stocked in Hayden Lake and Rainbow Trout and Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* stocked in Cocolalla Lake. We also estimated angler use of catchable-size Rainbow Trout in Freeman, Mirror, Round, Sinclair, Smith, and Solomon lakes. We described the relative contribution of stocked fingerling trout as catch rates (fish/net) in standard experimental floating gill nets. Angler use and exploitation were estimated from angler tag returns from targeted fish. Rainbow Trout were not detected in Hayden Lake, while Rainbow Trout and Westslope Cutthroat Trout were observed at low to moderate levels in Cocolalla Lake. Estimated angler exploitation of catchable length Rainbow Trout in regional lakes ranged from 5% at Freeman Lake to 54% at Round and Sinclair lakes. We recommended increasing fingerling Rainbow Trout stocking density in Hayden Lake to increase the probability of detection in future evaluations. In Cocolalla Lake, we recommended discontinuation of Rainbow Trout fingerling stocking with a corresponding increase in stocking of Westslope Cutthroat Trout fingerlings to provide additional opportunity. We recommend continued stocking of catchable-length Rainbow Trout in the evaluated waters. We also recommend investigation of opportunities to reduce nearshore vegetation growth that currently limits angling opportunity in Freeman Lake.

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INTRODUCTION

Hatchery Rainbow Trout *Oncorhynchus mykiss* and Westslope Cutthroat Trout *Oncorhynchus clarkii* are used to provide fishing opportunities throughout the Panhandle Region. Maximizing return of hatchery products is important as they represent a large component of regional fisheries and a substantial expenditure of license dollars. As such, periodic evaluation of hatchery product performance and angler exploitation of these products is completed to insure these resources are used effectively.

In 2017, we continued evaluations of fingerling trout stocking in an effort to improve fisheries in Hayden and Cocolalla lakes (Nelson et al. 1997, Maiolie et al. 2013, Ryan et al. 2014, Watkins et al. 2018, Ryan et al. 2018, Ryan et al. *In review*). Evaluations included investigations on timing, size, and origin of stocked Rainbow Trout and Westslope Cutthroat Trout fingerlings.

In 2017, we also estimated exploitation of catchable size hatchery Rainbow Trout stocked in Freeman, Mirror, Round, Sinclair, Smith, and Solomon lakes to determine how anglers were utilizing hatchery products in these waters. All of these water bodies have long histories of catchable Rainbow Trout stocking to provide fishing opportunities (Table 1, Table 2). However, rates of exploitation on stocked catchable Rainbow Trout in these waters were either previously estimated to be low (Freeman Lake; Fredericks et al. 2011, Koenig 2012), were unknown, or fall stocking efforts had not been evaluated.

OBJECTIVES

1. Estimate relative abundance of Rainbow Trout in Hayden and Cocolalla lakes as an evaluation of current fingerling stocking strategies.

2. Estimate relative abundance of Westslope Cutthroat Trout in Cocolalla Lake as an evaluation of current fingerling stocking strategies.

3. Estimate exploitation of stocked catchable size Rainbow Trout in targeted regional waters.

METHODS

Fingerling Trout Evaluations

We sampled Hayden and Cocolalla lakes using IDFG standardized floating experimental gill nets in an effort to describe relative abundance of hatchery trout. Twenty-four net-nights were fished in Hayden Lake on May 2 and 3, 2017. Sixteen net-nights were fished in Cocolalla Lake on April 26 and 27, 2017. Net set locations were randomly selected throughout the lake (Table 3). All nets were fished overnight. We reported mean catch per unit effort (CPUE, fish/net) as a measure of relative abundance. Captured fish were recorded by net location. We identified all fish, measured total length (mm), and checked individuals for marks.

We intended to use proportional differences in relative abundance to explore the success of different Rainbow Trout stocking groups in Hayden Lake (Table 1). Marks were not available to distinguish every stocking group. As such, we anticipated also using fish lengths to allow coarse identification of stocked groups.

In Cocolalla Lake, we assumed the presence of multiple size classes could be used to distinguish stocking cohorts. Thermally-marked Rainbow Trout and Westslope Cutthroat Trout had been stocked in 2016 in Cocolalla Lake and also provided an opportunity to identify hatchery cohorts (Table 2).

Catchable Rainbow Trout Evaluations

Angler exploitation of hatchery Rainbow Trout was evaluated in Freeman Lake, Mirror Lake, Round Lake, Sinclair Lake, Smith Lake, and Solomon Lake. Exploitation rates were estimated by tagging and releasing catchable size Rainbow Trout with individually numbered T-bar style tags (Floy®). Prior to release, individual fish were tagged at Sandpoint Hatchery. Tags were inserted at an angle into the dorsal musculature just below the dorsal fin of each fish. Tag numbers and total length (TL; mm) were recorded for each fish. Tagged groups were held in a raceway post tagging for one to several days prior to stocking. Tags lost in the loading process or from fish that died post-tagging were removed from our sample. Tagged fish were stocked with the remainder of the stocking request for each water body. We tagged 9% to 17% of each release group. Freeman, Sinclair, and Solomon lakes were stocked with tagged Rainbow Trout in the spring. Round, Smith, and Mirror lakes were stocked with tagged Rainbow Trout in the fall. Tags were printed with the Idaho Department of Fish and Game "Tag You're It" phone number for reporting. Angler tag returns were collected by phone, online (IDFG website), and in person at the IDFG Panhandle regional office.

Exploitation rates on catchable Rainbow Trout were estimated using tag returns as described by Meyer et al. (2012). Tag returns were corrected for tag loss (8.2%), tagged fish mortality (1.0%), and reporting rate (49.4%) based on reported averaged values for hatchery Rainbow Trout in Meyer and Schill (2014). Exploitation was estimated for one year at-large. We also estimated total use of stocked Rainbow Trout by including both harvested and released fish in our calculations. Although we used a previously estimated reporting rate, we also attempted to estimate angler reporting rate at Freeman Lake. Reward tags of $100 value were used only in Freeman Lake. Prior efforts to estimate angler exploitation of Rainbow Trout from this water resulted in few to no tags returned by anglers. We released 10 fish with high-dollar reward tags in addition to 99 non-reward tagged fish to evaluate how reporting rate may have influenced prior estimates of exploitation. We assumed reporting rate for high-dollar reward tags was near 100%. No reward tags were returned, so we also used the reporting rate estimated by Meyer and Schill (2014) to estimate exploitation at Freeman Lake.

RESULTS

Hayden Lake

No Rainbow Trout were captured in our Hayden Lake gillnetting effort. Bycatch in our sampling included Black Crappie *Pomoxis nigromaculatus*, Bluegill *Lepomis macrochirus*, Brown Bullhead *Ictalurus nebulosus*, kokanee *Oncorhynchus nerka*, Northern Pike *Esox lucius*, Pumpkinseed *Lepomis gibbosus*, and Tench *Tinca tinca* (Table 4). Catch rate was highest for kokanee. (0.4 ± 0.2 fish/net, 80% CI).

Cocolalla Lake

Few Rainbow Trout were caught from Cocolalla Lake during our evaluation (0.3 fish/net; Table 5). Bycatch in our sample included Black Crappie, Brook Trout *Salvelinus fontinalis*, Brown Bullhead, Brown Trout *Salmo Trutta*, Channel Catfish *Ictalurus punctatus*, Largescale Sucker *Catostomus macrocheilus*, Longnose Sucker *Catostomus catostomus*, Peamouth *Mylocheilus caurinus*, Rainbow x Westslope Cutthroat Trout Hybrids, Westslope Cutthroat Trout, and Yellow Perch *Perca flavescens* (Table 5). Peamouth and Yellow Perch were the most abundant fishes in our survey. Brown Trout and Brook Trout were the most abundant salmonids in our survey. Although thermal marks were used to label hatchery cohorts released in Cocolalla Lake, we did not clearly identify marks in the few Rainbow Trout and Westslope Cutthroat Trout collected in our survey. Frequency of fish lengths caught suggested one Rainbow Trout and two Westslope Cutthroat Trout cohorts were present in our sample (Figure 1). Fish lengths suggested that Rainbow Trout represented fish released in 2016 and Westslope Cutthroat Trout represented fish released in 2015 and 2016.

Freeman Lake

Anglers reported harvesting two tagged Rainbow Trout from our April 2017 stocking event at Freeman Lake. One additional tagged fish was caught and released. No reward tags were returned by anglers. We estimated adjusted exploitation at 5% and total use at 7% (Table 6). All angler tag reports indicated fish were caught within two months post-release.

Mirror Lake

Twenty-three harvested Rainbow Trout with tags from our September 2017 stocking were reported by anglers fishing Mirror Lake. An additional eight tagged fish were caught, released, and reported by anglers. One fish was harvested by an angler, but the angler indicated it was harvested only because it was tagged. Adjusted exploitation and use of Rainbow Trout was estimated at 52% and 72%, respectively (Table 6). Angler reports indicated a majority of the Rainbow Trout stocked in September 2017 were caught within four months post-release. However, anglers continued to catch fish from this release group throughout the full evaluation period and into the following year.

Round Lake

Eighteen harvested Rainbow Trout with tags from our September 2017 stocking were reported by anglers fishing Round Lake. One additional tagged fish was caught, released, and reported by an angler. Adjusted exploitation and use of Rainbow Trout was estimated at 54% and 56%, respectively (Table 6). Angler reports indicated a majority of the Rainbow Trout stocked in September 2017 were caught within four months post-release. Similar to Mirror Lake, anglers continued to catch fish from this release group throughout the full evaluation period and beyond one year at-large.

Sinclair Lake

Anglers reported harvesting 18 tagged Rainbow Trout from our June 2017 stocking event at Sinclair Lake. All fish reported were harvested. We estimated adjusted exploitation and use at 54% (Table 6). The majority angler tag reports indicated fish were caught within two months post-release. However, one tag was reported approximately six months post-release.

Smith Lake

We estimated adjusted exploitation and use on Rainbow Trout stocked in Smith Lake in September 2017 at 38% and 40%, respectively (Table 6). Estimates represented reported harvest of 17 fish. One additional fish was caught and harvested only because it was tagged. Catches of tagged fish were distributed relatively evenly from September 2017 through July 2018. One additional fish was harvested beyond the evaluation period in September 2018.

Solomon Lake

We estimated adjusted exploitation of Rainbow Trout stocked in Solomon Lake in May and June of 2017 at 15% and 18%, respectively (Table 6). Estimates reflected reported harvest of 10 tagged fish from the May stocking group and seven from the June stocking group. Anglers reported releasing additional tagged fish and or harvesting additional fish because they were tagged from both stocking groups. As a result, adjusted use was estimated to be higher for the May (30%) and June (21%) stocking groups. All of the fish reported by anglers within the evaluation period were caught between May and September. Although the period of angler exploitation was narrow within the first year, we also received four reports from anglers who caught tagged Rainbow Trout more than one year post-release. Both stocking groups in 2017 were represented in these tag reports.

DISCUSSION

Fingerling Trout Evaluations

Our 2017 fingerling Rainbow Trout evaluations suggested that returns on released fish in Hayden and Cocolalla lakes were low, which is consistent with prior evaluations (Figure 2). Rainbow Trout fingerling stocking was discontinued in Cocolalla Lake in 2016 because of consistently low detections post-release. We anticipate transitioning hatchery supplementation in Cocolalla Lake from fingerling to catchable size Rainbow Trout in 2018. Although detection of stocked fingerling Rainbow Trout post-release has also been low in Hayden Lake, continuation of fingerling stocking evaluations is recommended. The intent of future evaluations would be to determine how stocking density has affected catch rates in our evaluations. Stocking density of fingerling Rainbow Trout released in Hayden Lake in recent years has been low, at a requested level of 23 fish/ha. In comparison, stocking rate of fingerling Rainbow Trout in Cocolalla Lake during the same period was requested at 115 fish/ha. Rainbow Trout fingerlings were stocked at a density of 31 fish/ha in Hayden Lake in 2017 with an interest in increasing detectability if low to moderate survival occurs.

Westslope Cutthroat Trout continued to be detected in surveys of Cocolalla Lake, suggesting stocked fingerlings survive at some level. Although we detected Westslope Cutthroat

Trout, catch rate was lower than in previous surveys. However, catch rates on salmonid species were generally low in our 2017 survey relative to prior survey years, suggesting lake conditions may have influenced salmonid survival or catch rates in our survey effort differently than in prior years. Despite the catch rate of Westslope Cutthroat Trout being low in 2017 relative to previous survey years, continued stocking at current or increased rates is recommended as a method for maintaining diverse angling opportunity for coldwater fish in Cocolalla Lake.

Catchable Rainbow Trout Evaluations

Estimated exploitation on catchable Rainbow Trout in our evaluations suggested angler use of hatchery products varied from low to high levels of exploitation. Variation in angler use described in our work was consistent with that observed statewide (Cassinelli 2014). We hypothesized estimates of exploitation on catchable Rainbow Trout were in part influenced by angler effort. In general, those waters where we estimated exploitation was highest represented fisheries with relatively easy fishing access. In contrast, waters with difficult access or conditions that may limited fishability of the water body had lower exploitation. For example, Solomon Lake is accessed by a rough forest road and had limited shoreline accessibility. Estimated exploitation of Rainbow Trout from Solomon Lake was correspondingly low relative to other waters included in our evaluations. Estimates of angler effort were not available for the waters evaluated in this study to fully evaluate this hypothesis.

Angler exploitation of catchable Rainbow Trout was moderate to high for all waters where fall stocking events were evaluated. Estimates of exploitation in these waters were greater than previous evaluations of spring stocked Rainbow Trout in the same waters. Differences between spring and fall evaluations represented harvest rates 6% to 21.5% higher, with the greatest differences occurring in Mirror and Round lakes (Ryan et al. 2020, Hardy et al. 2010). These three lakes are thought to be popular ice fisheries and angler use of these fish likely represented the popularity of these waters during the winter fishery period. However, no specific documentation was available to directly link our results to periods of fishable ice cover in northern Idaho. Although, angler reported harvest of hatchery products was high during the winter fishery period, harvest occurred throughout the evaluation period and suggested survival of stocked fish was high post-release and provided fishing opportunity throughout the year. Because we observed that fall stocking in these waters was successful, we recommend continued application of this stocking strategy at these locations. We also recommend fall stocking strategies be considered in other locations where winter fisheries or early spring fisheries may benefit.

We did not find evidence that angler reporting rate influenced angler exploitation at Freeman Lake. No high-dollar reward tags placed on Rainbow Trout in Freeman Lake were returned during the evaluation, suggesting none were caught. Meyer et al. (2012) demonstrated high-dollar reward tags are returned at rates approaching 100%. In addition, species composition observed during a 2016 survey of Freeman Lake suggested Rainbow Trout were present in the lake post-release (Ryan et al. 2020).We conclude that anglers are not fishing for or not catching many Rainbow Trout at Freeman Lake. Watkins et al. (2018*)* suggested improving access to open non-vegetated water near the shoreline may improve angler access for Rainbow Trout. We recommend localized removal of heavy vegetation around shoreline access points on Freeman Lake be considered as a method of improving angler use.

RECOMMENDATIONS

1. Increase stocking density of Rainbow Trout fingerlings in Hayden Lake to improve understanding of how stocking density influences the detection of Rainbow Trout fingerlings.

2. Continue stocking of Westslope Cutthroat Trout fingerlings at current or increased rates to maintaining diverse angling opportunity for coldwater fish in Cocolalla Lake.

3. Investigate options for littoral vegetation control in Freeman Lake to enhance angler access.

4. Continued the use of fall stocking of catchable size Rainbow Trout where it currently is used to provide extended fishing opportunities.

5. Consider the use of fall stocking of catchable size Rainbow Trout in other regional waters that may benefit from seasonally extended fishing opportunities.

Table 9. History of Rainbow Trout stocking in Hayden Lake between 2011 and 2017.

Year	Period	Hatchery	Strain/type	Size	Number	Mark
2011	Fall	Grace	Triploid Troutlodge Kamloop	3-6 in. fingerlings	39,600	Ad Clipped
2011	Spring	Nampa	Triploid Troutlodge Kamloop	catchable	472	
2011	Spring	Hagerman	Triploid Troutlodge Kamloop	3-6 in. fingerlings	268,800	
2012	Spring	Grace	Hayspur Rainbow Triploid	3-6 in. fingerlings	18,000	
2012	Spring	Nampa	Triploid Troutlodge Kamloop	catchable	4,832	
2013	Fall	Grace	Hayspur Rainbow Triploid	3-6 in. fingerlings	39,312	
2014	Fall	Cabinet Gorge	Hayspur Rainbow Triploid	3-6 in. fingerlings	38,400	50% Ad Clipped
2015	Fall	Cabinet Gorge	Hayspur Rainbow Triploid	> 6 in. fingerlings	36,520	50% Ad Clipped
2015	Spring	Nampa	Hayspur Rainbow Triploid	catchable	8,867	
2016	Fall	Cabinet Gorge	Unspecified Rainbow Trout	> 6 in. fingerling	25,344	Thermal Marked
2016	Spring	Nampa	Unspecified Rainbow Trout	12 in. catchable	1,535	
2017	Fall	Cabinet Gorge	Unspecified Rainbow Trout	> 6 in. fingerling	50,700	Thermal Marked

Table 10. History of Westslope Cutthroat Trout and Rainbow Trout fingerling stocking in Cocolalla Lake between 2011 and 2017.

Year	Period	Hatchery	Species/type	Size	Number	Mark
2011	Spring	Sandpoint	Triploid Troutlodge Kamploop	3-6 inch fingerlings	25,200	
2011	Fall	Cabinet Gorge	Westslope Cutthroat Trout	> 6 inches - fingerlings	1,740	
2011	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	22,548	
2012	Spring	Cabinet Gorge	Triploid Troutlodge Kamploop	< 3 inch - fry	30,405	
2012	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	20,750	
2013	Spring	Cabinet Gorge	Triploid Troutlodge Kamploop	3-6 inch fingerlings	26,000	
2013	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	19,984	
2014	Spring	Cabinet Gorge	Hayspur Rainbow Triploid	3-6 inch fingerlings	27,150	
2014	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	20,130	
2015	Spring	Cabinet Gorge	Hayspur Rainbow Triploid	3-6 inch fingerlings	35,250	
2015	Fall	Cabinet Gorge	Westslope Cutthroat Trout	< 3 inch - fry	6,182	
2015	Fall	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	5,067	
2015	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	37,317	
2016	Spring	Cabinet Gorge	Rainbow Trout	3-6 inch fingerlings	25,200	Thermal marked
2016	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	31,200	Thermal marked
2017	Spring	Cabinet Gorge	Westslope Cutthroat Trout	3-6 inch fingerlings	23,994	Thermal marked

Table 11. Locations sampled during Rainbow Trout stocking evaluations on Hayden and Cocolalla lakes from April 26 to May 3, 2017.

Water	Date	Net	Latitude	Longitude
Hayden Lake	5/2/2017	1	47.7573	-116.7229
Hayden Lake	5/2/2017	2	47.7527	-116.7213
Hayden Lake	5/2/2017	3	47.7805	-116.6824
Hayden Lake	5/2/2017	4	47.7503	-116.7557
Hayden Lake	5/2/2017	5	47.7496	-116.7009
Hayden Lake	5/2/2017	6	47.7509	-116.7036
Hayden Lake	5/2/2017	7	47.7724	-116.6820
Hayden Lake	5/2/2017	8	47.7838	-116.7011
Hayden Lake	5/2/2017	9	47.7669	-116.7413
Hayden Lake	5/2/2017	10	47.7805	-116.6741
Hayden Lake	5/2/2017	11	47.7478	-116.6948
Hayden Lake	5/2/2017	12	47.7664	-116.7473
Hayden Lake	5/2/2017	13	47.7685	-116.7236
Hayden Lake	5/3/2017	14	47.7527	-116.7109
Hayden Lake	5/3/2017	15	47.7876	-116.6898
Hayden Lake	5/3/2017	16	47.7739	-116.7077
Hayden Lake	5/3/2017	17	47.7720	-116.7096
Hayden Lake	5/3/2017	18	47.7671	-116.7178
Hayden Lake	5/3/2017	19	47.7795	-116.6870
Hayden Lake	5/3/2017	20	47.7817	-116.6931
Hayden Lake	5/3/2017	21	47.7581	-116.6923
Hayden Lake	5/3/2017	22	47.7639	-116.7527
Hayden Lake	5/3/2017	23	47.7538	-116.7230
Hayden Lake	5/3/2017	24	47.7667	-116.7439
Cocolalla Lake	4/26/2017	1	48.1182	-116.6181
Cocolalla Lake	4/26/2017	2	48.1201	-116.6182
Cocolalla Lake	4/26/2017	3	48.1394	-116.6147
Cocolalla Lake	4/26/2017	4	48.1257	-116.6125
Cocolalla Lake	4/26/2017	5	48.1290	-116.6127
Cocolalla Lake	4/26/2017	6	48.1292	-116.6206
Cocolalla Lake	4/26/2017	7	48.1362	-116.6045
Cocolalla Lake	4/26/2017	8	48.1257	-116.6206
Cocolalla Lake	4/26/2017	9	48.1237	-116.6178
Cocolalla Lake	4/27/2017	10	48.1290	-116.6153
Cocolalla Lake	4/27/2017	11	48.1219	-116.6234
Cocolalla Lake	4/27/2017	12	48.1257	-116.6235
Cocolalla Lake	4/27/2017	13	48.1237	-116.6262
Cocolalla Lake	4/27/2017	14	48.1236	-116.6148
Cocolalla Lake	4/27/2017	15	48.1380	-116.6155
Cocolalla Lake	4/27/2017	16	48.1345	-116.6048

Table 12. Species, catch, average total length (TL), minimum and maximum total length, and catch rate (CPUE) from a gillnetting survey completed to evaluate Rainbow Trout stocking in Hayden Lake during 2017.

Species	Catch	Avg TL	Min of TL	Max of TL	CPUE	±80% C.I.
Black Crappie	11	236	168	289	0.5	0.3
Bluegill	10	146	105	182	0.5	0.3
Brown Bullhead	7	266	200	304	0.3	0.2
Kokanee	64	307	207	370	2.9	0.6
Northern Pike	11	912	791	1200	0.5	0.2
Pumpkinseed	2	130	127	133	0.0	0.1
Tench	8	443	420	464	0.4	0.4

Table 13. Species, catch, average total length (TL), minimum and maximum total length, and catch rate (CPUE) from a gillnetting survey completed to evaluate Rainbow Trout and Westslope Cutthroat Trout stocking in Cocolalla Lake during 2017.

Species	Catch	Avg TL	Min of TL	Max of TL	CPUE	±80% C.I.
Brook Trout	8	307	230	343	0.5	0.3
Brown Bullhead	2	285	280	290	0.1	0.1
Brown Trout	11	413	345	463	0.7	0.2
Channel Catfish	8	428	373	469	0.5	0.4
Largescale Sucker	6	454	410	473	0.4	0.5
Longnose Sucker	2	426	422	430	0.1	0.1
Peamouth	26	297	236	340	1.7	0.8
Rainbow x Cutthroat Trout Hybrid	1	433	433	433	0.1	0.1
Rainbow Trout	4	358	345	370	0.3	0.1
Westslope Cutthroat Trout	5	396	350	480	0.3	0.2
Yellow Perch	15	165	148	198	1.0	1.2

Table 14. Rainbow Trout stocked, proportion tagged, estimated adjusted exploitation (μ), and estimated total use by waterbody and stocking date for selected lakes in the Panhandle Region.

Water	Stocking date	# Stocked	% Tagged	Adjusted μ	Adjusted use
Freeman Lake	4/28/2017	765	14%	0.05	0.07
Mirror Lake	9/20/2017	1080	9%	0.52	0.72
Round Lake	9/19/2017	550	14%	0.54	0.56
Sinclair Lake	6/5/2017	500	15%	0.54	0.54
Smith Lake	9/27/2017	900	11%	0.38	0.40
Solomon Lake	5/10/2017	445	17%	0.15	0.30
Solomon Lake	6/9/2017	500	15%	0.18	0.21

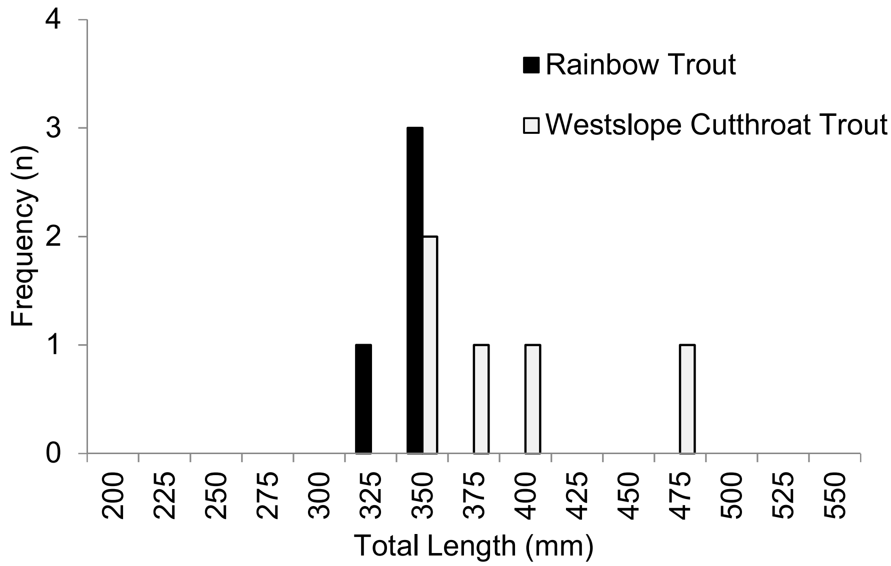

Figure 18. Length-frequency of Rainbow Trout and Westslope Cutthroat Trout caught in floating gill nets from Cocolalla Lake in 2017.

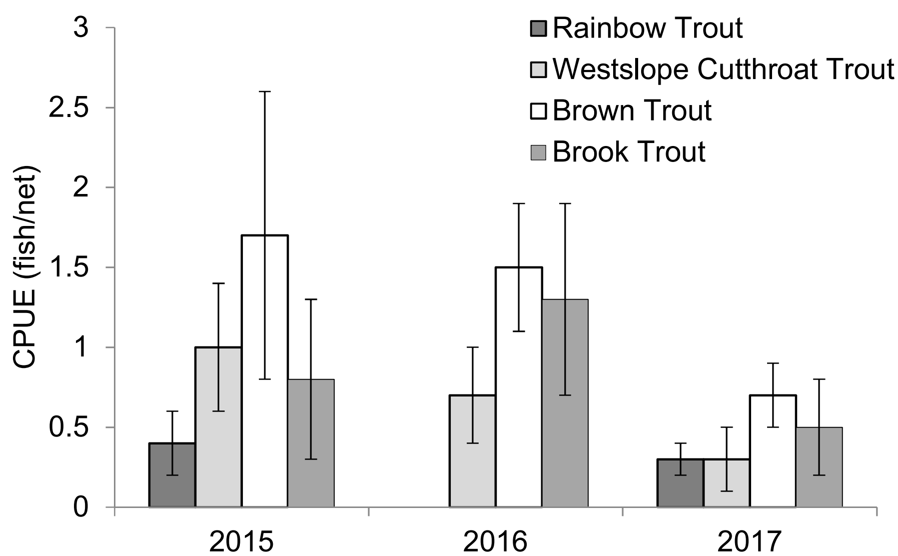

Figure 19. Catch rate (fish/net) of Rainbow Trout, Westslope Cutthroat Trout, Brown Trout, and Brook Trout by year from spring stocking evaluations of Cocolalla Lake.

BONNER LAKE BURBOT STOCKING EVALUATION

ABSTRACT

The Idaho Department of Fish and Game and Kootenai Tribe of Idaho have worked collaboratively to develop a Burbot *Lota lota* hatchery supplementation program designed to increase abundance of Burbot in the Kootenai River system and restore lost angling opportunity. Excess hatchery Burbot were available from 2013 through 2016. These fish were stocked in Bonner Lake to provide additional angling opportunity. In 2017, we sampled Burbot in Bonner Lake to assess the effectiveness of the supplementation effort. We caught 0.3 ± 0.3 (80% C.I.) and 9.3 ± 2.1 Burbot per net-night in hoop and trammel nets, respectively. The majority (98%) of Burbot collected in our survey were assigned by parental based tagging to the 2015 year class. Our observations suggested Burbot post-stocking survival was not consistent among stocking cohorts. We recommend monitoring continue on an annual basis to assess the survival of stocking cohorts and to identify stocking strategies that maximize survival.

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INTRODUCTION

Burbot Lota lota are native to the Kootenai River drainage. Following construction of Libby Dam on the Kootenai River near Libby Montana, wild production of Burbot in the Idaho reach of the Kootenai River collapsed. In response, the Idaho Department of Fish and Game and Kootenai Tribe of Idaho developed a hatchery supplementation program to increase abundance of Burbot in the system and restore lost angling opportunity.

Bonner Lake is located in Boundary County, Idaho, 14 km east of Bonners Ferry, Idaho. The 9.7 ha lake has a mean depth of 6.7 m and a maximum depth of 18 m. Bonner Lake is managed as a mixed species fishery. Rainbow Trout *Oncorhynchus mykiss* and kokanee *Oncorhynchus nerka* are stocked annually in the lake. A compliment of warmwater fish species are also present and include Largemouth Bass *Micropterus salmoides*, Yellow Perch *Perca flavescens*, and Pumpkinseed *Lepomis gibbosus*. Excess Burbot from the Kootenai hatchery program were available from 2013 through 2016. In an effort to utilize excess production and provide additional angling opportunity, Burbot were stocked in Bonner Lake. Bonner Lake was selected as a stocking location for excess Burbot primarily because of its location within the Kootenai drainage and potential to provide adequate over summer habitat (i.e., 18 m max depth).

In 2017, we sampled Burbot in Bonner Lake to assess the effectiveness of the supplementation effort. Specifically, we looked to identify if Burbot stocked in Bonner Lake survived and grew to adequate size to provide angling opportunity.

METHODS

We sampled Burbot in Bonner Lake following ice off from April 17-20, 2017. Hoop nets and trammel nets were used to conduct targeted sampling. Hoop nets were 3.1 m long with seven hoops (58-36 cm), two throats, and 5 cm outer mesh. These nets were set parallel to the lake shore at nine randomly assigned locations (Table 1). Bait, made up of frozen fish, was placed in a mesh bag inside each hoop net. Sinking trammel nets were configured with two outer panels of 25.4 cm multifilament mesh and a single 2.5-cm inner multifilament mesh. Trammel nets were 48.8 m long, 1.8 m high, and were set perpendicular to shore at nine randomly assigned locations (Table 1). We measured relative abundance of Burbot in Bonner Lake as catch per net-night (CPUE). Catch rates from hoop nets and trammel nets were compared in an effort to select a preferred gear for future sampling efforts.

All fish caught were measured for total length. We described growth of release groups where possible by examining the increase in mean annual total length-at-age relative to mean length of the cohort at stocking.

Stocking success was evaluated by comparing the relative return of release groups using various tagging methods. Prior stocking events varied by time, age, and size at release (Table 2). Parental based tagging (PBT) or passive integrated transponder (PIT) tags assigned individual fish to brood year. PBT evaluations were completed by removing a fin clip from each Burbot collected. Fin clips were stored on Whatman paper prior to analysis. Analysis was completed by the Idaho Department of Fish and Game Eagle Fish Genetics Laboratory. Half duplex PIT tags were inserted in the body cavity prior to stocking. Tagging occurred prior to stocking by Kootenai Tribe of Idaho hatchery staff. Two juvenile Burbot cohorts (2013 and 2014) were tagged and stocked in 2014. All Burbot collected were scanned with a PIT tag reader upon collection.

Detected PIT tags were referenced to a tagging database to assign individuals to brood year and stocking cohort.

RESULTS

We caught 0.3 ± 0.3 (80% C.I.) and 9.3 ± 2.1 Burbot per net-night in hoop and trammel nets, respectively. Burbot TL varied from 237 to 424 mm and they were roughly distributed by length in two cohorts (Figure 1). The majority (98%) of Burbot collected in our survey were assigned by PBT to the 2015 year class. Mean TL of 2015 fish was 278 mm. It was not possible to directly describe growth for the 2015 cohort because three groups of 2015 Burbot were released into Bonner Lake, including two release years and two release seasons. Juvenile Burbot in the 2015 cohort were not segregated by parent at the hatchery prior to release, prohibiting the PBT-identification of individuals in the 2015 cohort. Two individuals from the 2014 cohort were identified by PIT tags. Total length of the two Burbot from the 2014 year class captured in our survey was 398 and 424 mm. The 2014 year class was stocked in October at a mean TL of 110 mm, representing a nearly 300 mm increase in TL post-stocking.

DISCUSSION

Observations of two stocking cohorts in our survey suggested that post-stocking survival of Burbot was not consistent among cohorts. Despite four age classes and six cohorts of Burbot stocked in Bonner Lake in years prior to our survey, our sampling only detected two cohorts. We were unable to clearly evaluate similarities in the timing of stocking events or size at stocking for fish sampled because of the inability to assign individuals in the 2015 year class to a release group. The surviving individuals from the 2014 year class resulted from a late-October release of small age-0 fish. Releases across all years varied from 80 mm age-0 fish to 265 mm age-1 fish. We recommend monitoring continue on an annual basis to assess the survival of stocking cohorts and to allow for the identification of stocking strategies that maximize survival. We also recommend a standardized tagging approach be used for all release groups to improve our ability to detect difference between groups.

We found Burbot stocked in October of 2014 grew to a moderate size over three growing seasons in Bonner Lake. Mean TL at time of capture represented quality length (Fisher et al. 1996) and was considered adequate to provide an appealing angling experience. A total of only 82 fish was stocked in this cohort. Understandably, this cohort was not strongly represented in the catch. We recommend manipulation of stocking density and monitoring of growth to identify a balance between higher densities (i.e., more fish) and growth to maximize fishing opportunity for anglers.

We caught more Burbot in trammel nets than in hoop nets. Our primary interest in evaluating more than one gear type was to determine a suitable gear type for sampling Burbot in Bonner Lake. Specifically, we were interested in sampling fish from which tissues could be taken and tags could be assessed. Because hoop nets caught so few fish, we recommend trammel nets be used as the primary gear type for sampling Burbot in Bonner Lake.

RECOMMENDATIONS

1. Continue monitoring abundance and growth of Burbot stocked in Bonner Lake to better describe what factors influence post-stocking survival and growth.

2. Adjust stocking density to balance satisfactory catch rates with mean length.se trammel nets to conduct future Burbot monitoring in Bonner Lake.

Table 15. Burbot sampling locations by gear type from a survey of Bonner Lake in April 2017.

Water	Site	Latitude	Longitude	Gear
Bonner Lake	1	48.72735	-116.11087	Trammel
Bonner Lake	2	48.72677	-116.10989	Trammel
Bonner Lake	3	48.72601	-116.11095	Trammel
Bonner Lake	4	48.72496	-116.10914	Trammel
Bonner Lake	5	48.72465	-116.10688	Trammel
Bonner Lake	6	48.72353	-116.10652	Trammel
Bonner Lake	7	48.72330	-116.10614	Trammel
Bonner Lake	8	48.72307	-116.10559	Trammel
Bonner Lake	9	48.72408	-116.10549	Trammel
Bonner Lake	10	48.72759	-116.11119	Hoop
Bonner Lake	11	48.72719	-116.11054	Hoop
Bonner Lake	12	48.72585	-116.10906	Hoop
Bonner Lake	13	48.72552	-116.10818	Hoop
Bonner Lake	14	48.72461	-116.10883	Hoop
Bonner Lake	15	48.72427	-116.10855	Hoop
Bonner Lake	16	48.72366	-116.10627	Hoop
Bonner Lake	17	48.72334	-116.10647	Hoop
Bonner Lake	18	48.72337	-116.10536	Hoop

Table 16. Burbot stocking history in Bonner Lake.

Year class	Stocking year	Total released	PIT tagged	Date released	Batch TL (mm)
2013	2014	18	18	10/30/2014	224
2014	2014	82	82	10/30/2014	110
2015	2015	276	0	10/16/2015	90
2015	2016	430	0	9/8/2016	265
2015	2016	1452	0	5/12/2016	210
2016	2016	1882	0	10/11/2016	80

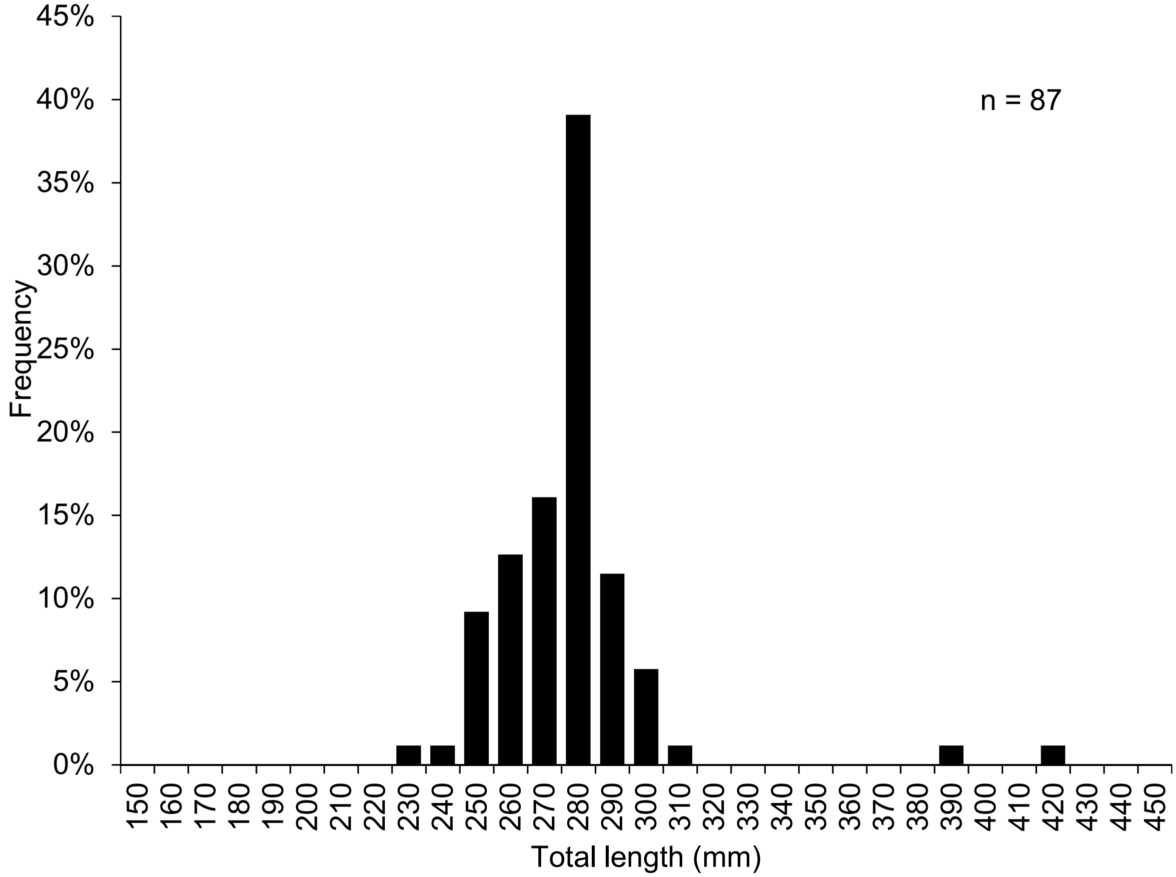

Figure 20. Length frequency distribution of Burbot collected from Bonner Lake in April 2017 using hoop nets and trammel nets.

PEND OREILLE FALL WALLEYE INDEX 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 drainage of Idaho. Walleye *Sander vitreus* are a recent addition to this drainage and their influence on the of Lake Pend Oreille fishery is uncertain. Fall Walleye index netting (FWIN) surveys of Lake Pend Oreille and the Pend Oreille River in 2011 and 2014 suggested the Walleye population was likely expanding in both abundance and distribution. In 2017, we replicated the FWIN survey to improve understanding of current abundance and distribution of the Walleye population. Catch rate of Walleye in our survey was 4.3 fish/net. Ten age classes were present in the samples, representing Walleye of age-0 through age-10. Proportional stock density of the sampled population was 86. A mean visceral fat index was 3.1 and 4.0 for male and female Walleye, respectively. Forty-four percent of Walleye sampled, including male and female Walleye, were mature. Length-at-50% maturity was 580 mm for female Walleye and 400 mm for male Walleye. An increasing trend in Walleye abundance in the Pend Oreille drainage was apparent from the results of our survey. We interpreted catch rates in our survey as representing a low- to moderate density-population relative to other Walleye populations in the western U.S. However, it appears Walleye abundance is expanding exponentially in the system.

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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 drainage (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, but less is known about their abundance, distribution, and associated impacts on the present fish community. However, Walleye have the potential to negatively impact salmonid fish assemblages where these populations overlap, thus creating concern for fishery managers (Baldwin et al. 2003).

Walleye are non-native in the Pend Oreille drainage and were first 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 continue to persist (Horn et al. 2009). This upstream population is believed to be the source of introduction into LPO and the POR. In 2011 and 2014, standardized Walleye monitoring was completed to better describe the current status of the population. These surveys suggested Walleye were likely expanding in both abundance and distribution.

Our objective in 2017 was to continue a Walleye monitoring program to improve understanding of current abundance and distribution of Walleye in LPO and the POR. Continued monitoring of Walleye abundance and distribution is essential for fisheries managers to understand how the introduction of this new piscivorous species may impact the existing fish community of the Pend Oreille drainage.

METHODS

We completed a survey of Walleye abundance and distribution in LPO and the POR following standardized Fall Walleye Index Netting (FWIN) protocols described in the FWIN Manual of Instructions (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 (Appendix A). These areas contained water depths typically associated with Walleye habitat and consistent with FWIN protocol. Much of LPO was not compatible with the selected sampling protocol due to existing bathymetry. In addition to survey effort in the northern portion of the basin, we sampled a limited portion of the southernmost tip of LPO (Idelwild and Scenic Bays) to assist in describing distribution on a larger scale. Bathymetry also limited available sampling locations in this zone. 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 FWIN protocol and prior knowledge of catch rate variability described in our 2011 and 2014 FWIN surveys in this waterbody.

We used monofilament experimental gill nets described in the FWIN protocol 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 m 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. Catch per unit effort (CPUE), calculated as fish per net-night, was used to describe relative abundance of Walleye and other species. The arithmetic mean of CPUE was used to describe relative abundance.

Upon removal from gill nets, all Walleye were measured for total length (TL; mm) and weighed (g). All non-target species were measured for TL and a subsample was weighed. We collected otoliths from all Walleye and from a subsample of Northern Pike *Esox lucius* for age estimation. We estimated age of Walleye by examining whole otoliths under a dissecting microscope or by breaking otoliths centrally, browning, sanding, and viewing the cross-section. 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 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 was held constant using approximate maximum lengths observed in our survey to account for limited catch of older age classes. Catch-at-age was reported as a descriptor of annual recruitment.

We used two indices to describe the body condition of Walleye. Specifically, we estimated a visceral fat index (VFI) 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 (GFI) as a measure of condition. GFI was calculated as the ratio of gonad weight to body weight.

We estimated rates of sexual maturity in captured Walleye by examining all Walleye and classifying each individual as mature or immature (Duffy et al. 2000). Maturation rates are inversely related to growth rate and may reflect shifting population dynamics (Gangl and Pereira 2003, Schneider et al. 2007). We determined total length and age at 50% maturity 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).

The FWIN survey protocol was developed to specifically gain information about Walleye. However, bycatch in the survey is common and provides an opportunity to improve knowledge of other fish species in the system. We used catch rates (fish/net) of non-target fish species caught in our survey to describe potential trends in fish abundance. Trends in abundance were evaluated by comparing catch rates to prior FWIN surveys of the Pend Oreille drainage in 2011 and 2014 (Fredericks et al. 2013, Watkins et al. 2018). Significant changes in CPUE by species were described using a non-parametric Kruskal–Wallis test by ranks ($\alpha = 0.20$). Differences between years were described using a Wilcoxon rank sum test in a *post hoc* evaluation ($\alpha = 0.20$). Statistical tests were completed using SYSTAT (Systat Software Inc.).

We also used length and age information from Northern Pike to gain some insight on an apparent increase in the species in recent years. Age was estimated by removing leading pelvic fin rays at the proximal end using wire dykes. Fin rays were air dried, mounted in epoxy, cross-sectioned at the base on a Buehler Isomet saw (Illinois Tool Works Inc., Lake Bluff, Illinois), sanded for viewing clarity, and viewed on a compound microscope under 10x magnification.

RESULTS

Our FWIN survey of LPO and the POR was conducted from October 1 through October 6, 2017. We fished 46 gill net-nights among all sampled areas. A total of 199 Walleye were collected, comprising 9.0% of the total catch (Table 1). Walleye CPUE ranged from 0 to 19 Walleye per net and were captured at 35 of the 46 sampled sites. Mean CPUE for Walleye of all age classes was 4.3 fish/net (± 1.0, 80% CI). Although we did not capture Walleye in every net, we did capture Walleye in representative samples throughout LPO and the POR (Figure 1). Walleye catch was distributed across all areas where netting occurred. As an example, 53% of Walleye captured were caught in LPO which represented 50% of the nets set in the survey.

Walleye sampled in our survey represented a range of sizes. Total length of sampled Walleye varied from 125 to 767 mm (Figure 2). We observed an increase in the diversity of lengths represented in the population as compared to previous survey efforts. PSD of the sampled population was 86 (80-91; 95% CI). Walleye of stock length (249 mm minimum) and greater made up 87% of the sampled population. Eighteen percent of the sampled Walleye were of preferred length (509 mm minimum) or greater. Sampled Walleye generally appeared robust. Mean VFI was 3.1 and 4.0 (± 0.3, 0.4; 80% CI) for male and female Walleye, respectively (Table 2). Mean GSI was 2.0 and 1.1 for male and female Walleye, respectively Table 2). VFI and GSI values were comparable to index values from previous years (Table 2).

Ten age classes were present in the collected samples, representing Walleye from age-0 to age-10 (Figure 3). The majority of Walleye sampled were assigned to age classes zero to four. Age-2 fish were the strongest year class detected. No Walleye sampled were estimated to be nine years of age. We found the number of age classes represented in the population continued to increase from previous surveys (Figure 3).

Walleye in the Pend Oreille system grew rapidly (Figure 4). Mean length of age-2 fish was 441 and 425 mm for females and males, respectively. Growth rates of sampled Walleye varied by sex. The maximum length observed of male Walleye was 678 mm, while females reached a maximum observed length of 767 mm. Growth rates were comparable to previous surveys (Figure 5).

Sex of Walleye sampled in our survey was slightly skewed toward males (59%) over females (41%; Figure 6). Forty-four percent of Walleye sampled, including male and female Walleye, were mature. Length-at-50% maturity was 580 mm for female Walleye and 400 mm for male Walleye. Mature Walleye observed in our sample were assigned to multiple year classes. However, the estimated female diversity index (0.59) was low.

We collected 22 other species as bycatch associated with Walleye netting (Table 1). Peamouth *Mylocheilus caurinus* (10.9%) and Yellow Perch *Perca flavescens* (31.1 %) were the most commonly encountered species (Table 1). Significant variation in CPUE was detected for Black Crappie *Pomoxis Negromaculatus*, Black Bullhead *Ameiurus melas*, Brown Trout *Salmo Trutta*, Lake Whitefish *Coregonus clupeaformis*, Longnose Sucker *Catostomus catostomas*, Northern Pike, Northern Pikeminnow, Peamouth, Rainbow Trout *Oncorhynchus myskiss* x Westslope Cutthroat *Oncorhynchus clarki lewisi* hybrids, Smallmouth Bass *Micropterus dolomieu*, Tench *Tinca tinca*, and Walleye over the history of FWIN surveys (Table 3). Catch rates of Northern Pike, Smallmouth Bass, and Walleye demonstrated significant increases across surveys. In contrast, decreases in catch rates were detected for Black Bullhead, Brown Trout, Longnose Sucker, Northern Pikeminnow, and Tench. Significant variation in catch rates

of Black Crappie, Peamouth, and Rainbow Trout x Westslope Cutthroat Trout hybrids were generally interpreted to represent annual variation in catch without directional trend.

We found Northern Pike were not widely distributed throughout the surveyed area and generally represented few age classes. Northern Pike were caught in two primary areas, including the Clark Fork Delta and shallow bays along the northern shore of Lake Pend Oreille (Oden Bay and Kootenai Bay). Total length of Northern Pike varied from 625 mm to 1,114 mm. Age classes represented in our catch of Northern Pike were limited and included fish 1–5 years of age (Figure 7). Mean length-at-age-5 was 974 mm (Figure 8).

DISCUSSION

An increasing trend in Walleye abundance in the Pend Oreille drainage was apparent from the results of our FWIN survey. Specifically, we observed catch rates nearly double from those observed in 2014 (2.2 fish/net; Watkins et al. 2018). Increasing representation across a spectrum of age classes also suggested the population was more robust than previously observed and appears to be growing exponentially. Although we described an increase in relative abundance of Walleye, we interpreted catch rates in our survey as still representing a low to moderate density population relative to other Walleye populations in the western U.S.

Walleye growth, condition, and age-at-maturity observed across FWIN surveys of the Pend Oreille drainage continued to suggest resources were not limiting Walleye production. Fredericks et al. (2013) suggested Pend Oreille drainage Walleye grew fast and were physically robust relative to other Walleye populations in the region and across North America. Dynamic rates observed in our survey were consistent with prior surveys of this population, indicating the population continues to be highly productive. These results were consistent with an expanding population, aligning with our observations of catch rate in this and prior surveys.

Relative abundance trends for non-target species varied. Generally, significant increases in relative abundance were detected for non-native predators, including Walleye, Smallmouth Bass, and Northern Pike, while decreasing relative abundance was associated with native fishes and less common species in the fish community. Observed trends shared commonalities with other surveys within the drainage. For example, Ryan et al. (*In review)* detected a negative trend in relative abundance of Northern Pikeminnow in the POR in concert with the expansion of Smallmouth Bass in that system. Although no specific relationship between these species or others was investigated in our survey, influential species interactions seem plausible. Brown Trout and Black Bullhead were detected in FWIN surveys in multiple years, but were generally caught sporadically. We concluded that patterns in catch rates for these species were likely less meaningful given the scope and effort of our survey.

We found evidence that Northern Pike in LPO were more abundant in 2017 than in prior FWIN survey efforts. Northern Pike were not an intended target of our survey, but have long been present in the Pend Oreille drainage and were detected in prior surveys (Watkins et al. 2018). Anecdotal angler reports prior to our survey suggested Northern Pike were more abundant than historically observed (pre-2016). Especially noted were frequent angler encounters in the area of the Clark Fork River delta. Angler encounters had previously been infrequent (Ryan and Jakubowski 2013, Bouwens and Jakubowski 2016). The mechanism for recent increases is not clear, but age structure of fish collected in this survey suggested the recent abundance pulse was related to a limited period of production, rather than a gradual increase in the population. Northern Pike were not detected in the POR. We are uncertain whether the observed increase in Northern

Pike relative abundance will continue. However, we recommend a continued focus on monitoring their population trend in association with future FWIN surveys.

RECOMMENDATIONS

1. Continue FWIN surveys on a three year rotation to evaluate changes in relative abundance and distribution of Walleye, as well as for non-target species caught as bycatch.

Table 17. Catch summary of fish sampled in a FWIN survey of Lake Pend Oreille and the Pend Oreille River, Idaho during 2017. Summary statistics included catch (*n*) and percent catch by species, average total length (Avg TL), standard deviation of measured total lengths (SD TL), average weight (Avg WT), and standard deviation of measured fish weights (SD WT).

Species	*n*	% Catch	Avg TL	SD TL	Avg WT	SD WT
Black Crappie	216	10%	130	59	36	52
Brown Bullhead	41	2%	261	29	243	84
Brown Trout	3	0%	572	123	--	--
Bull Trout	1	0%	602	--	--	--
Kokanee	3	0%	211	61	90	63
Lake Whitefish	185	8%	367	46	377	136
Largemouth Bass	13	1%	266	103	856	--
Largescale Sucker	75	3%	474	87	1404	527
Longnose Sucker	23	1%	424	65	1076	154
Mountain Whitefish	21	1%	348	27	421	116
Northern Pike	28	1%	854	124	5221	2490
Northern Pikeminnow	199	9%	352	89	489	375
Peamouth	240	11%	296	37	251	87
Pumpkinseed	25	1%	129	22	78	45
Rainbow Trout	2	0%	244	60	74	--
Smallmouth Bass	165	7%	337	88	746	483
Tench	75	3%	443	73	1325	508
Walleye	199	9%	433	131	1031	1056
Westslope Cutthroat Trout	7	0%	331	68	362	209
Yellow Perch	685	31%	169	49	92	81

Table 18. Walleye gonadal somatic index (GSI) and visceral fat index (VFI) values by year and sex from FWIN surveys of Lake Pend Oreille and the Pend Oreille River, Idaho. Summary statistics included sample size (n), mean index values, standard deviation of index values (SD), and 80% confidence values (CI 80%) around mean estimates.

		GSI				VFI			
Year	Sex	n	Mean	SD	CI 80%	n	Mean	SD	CI 80%
2011	F	16	0.8	1.3	0.4	16	4.5	2.0	0.6
2011	M	41	2.0	1.2	0.2	41	3.5	1.3	0.3
2014	F	59	1.9	1.7	0.3	59	4.8	2.9	0.5
2014	M	45	1.6	1.4	0.3	45	3.1	2.4	0.5
2017	F	71	1.1	1.2	0.2	70	4.0	2.8	0.4
2017	M	100	2.0	1.4	0.2	96	3.1	2.1	0.3

Table 19. Results of comparisons of species-specific catch rates from FWIN surveys of the Pend Oreille drainage in 2011, 2014, and 2017. Values reported include *p*-values and identified significant differences in CPUE by year at *α* = 0.20 by species. Differing letter values represent significant differences. Shaded values represent insignificant variation in CPUE across survey years.

Species	*p*	2011	2014	2017
Black Crappie	0.22	a	a	b
Bluegill	0.41	--	--	--
Brown Bullhead	0.27	--	--	--
Black Bullhead	0.07	a	b	c
Brown Trout	0.04	a	a	b
Bull Trout	0.48	--	--	--
Kokanee	0.35	--	--	--
Lake Whitefish	0.00	a	b	a
Largemouth Bass	0.58	--	--	--
Largescale Sucker	0.71	--	--	--
Longnose Sucker	0.00	a	b	b
Mountain Whitefish	0.40	--	--	--
Northern Pike	0.00	a	b	c
Northern Pikeminnow	0.06	a	b	b
Peamouth	0.14	ab	a	b
Pumpkinseed	0.95	--	--	--
Rainbow Trout	0.50	--	--	--
Rainbow x Cutthroat	0.11	a	b	b
Smallmouth Bass	0.06	a	ab	b
Tench	0.14	a	ab	b
Walleye	0.00	a	b	c
Westslope Cutthroat Trout	0.99	--	--	--
Yellow Perch	0.60	--	--	--
Redside Shiner	0.31	--	--	--

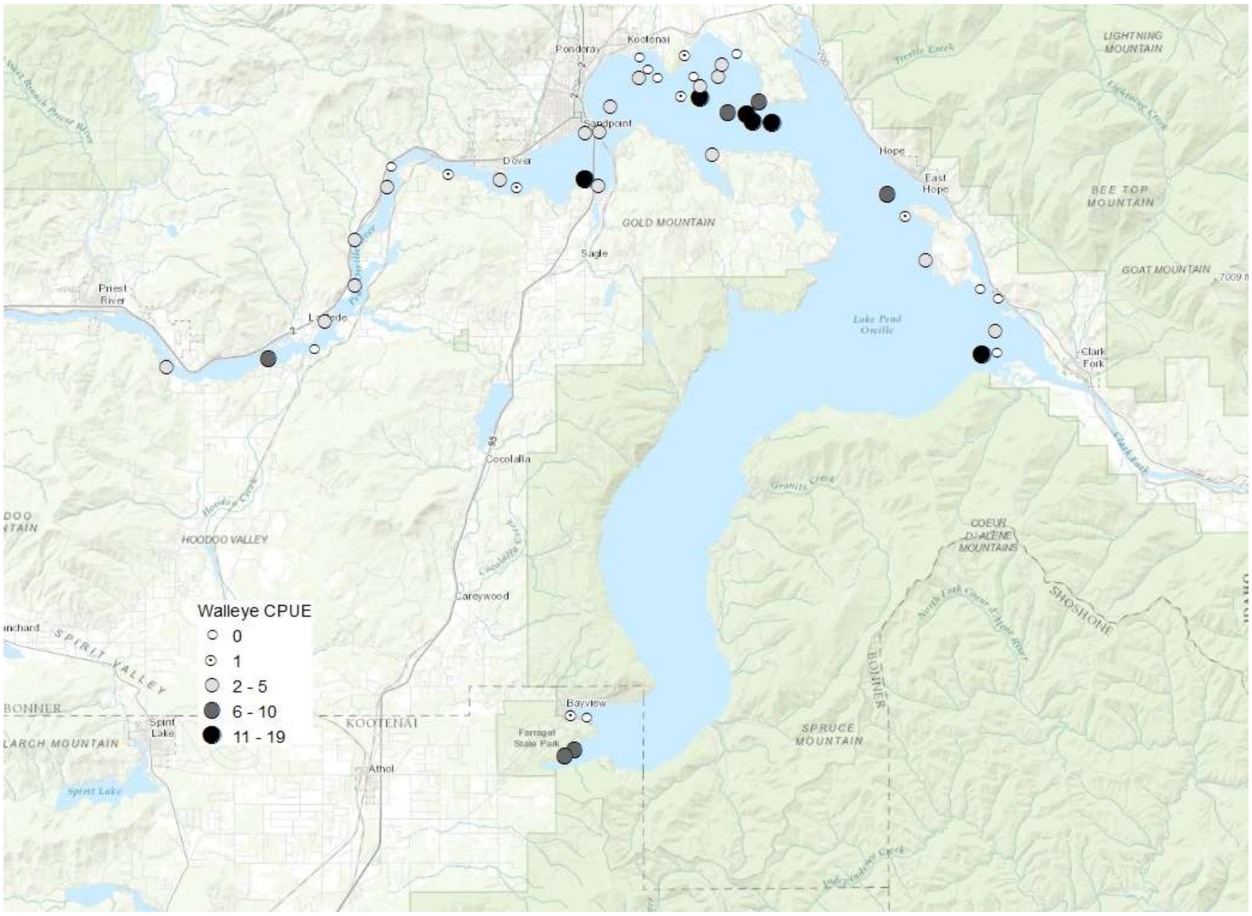

Figure 21. Fall Walleye index netting sampling locations in the Pend Oreille drainage, Idaho during 2017. Sampling sites are displayed with corresponding Walleye CPUE (fish/net-night).

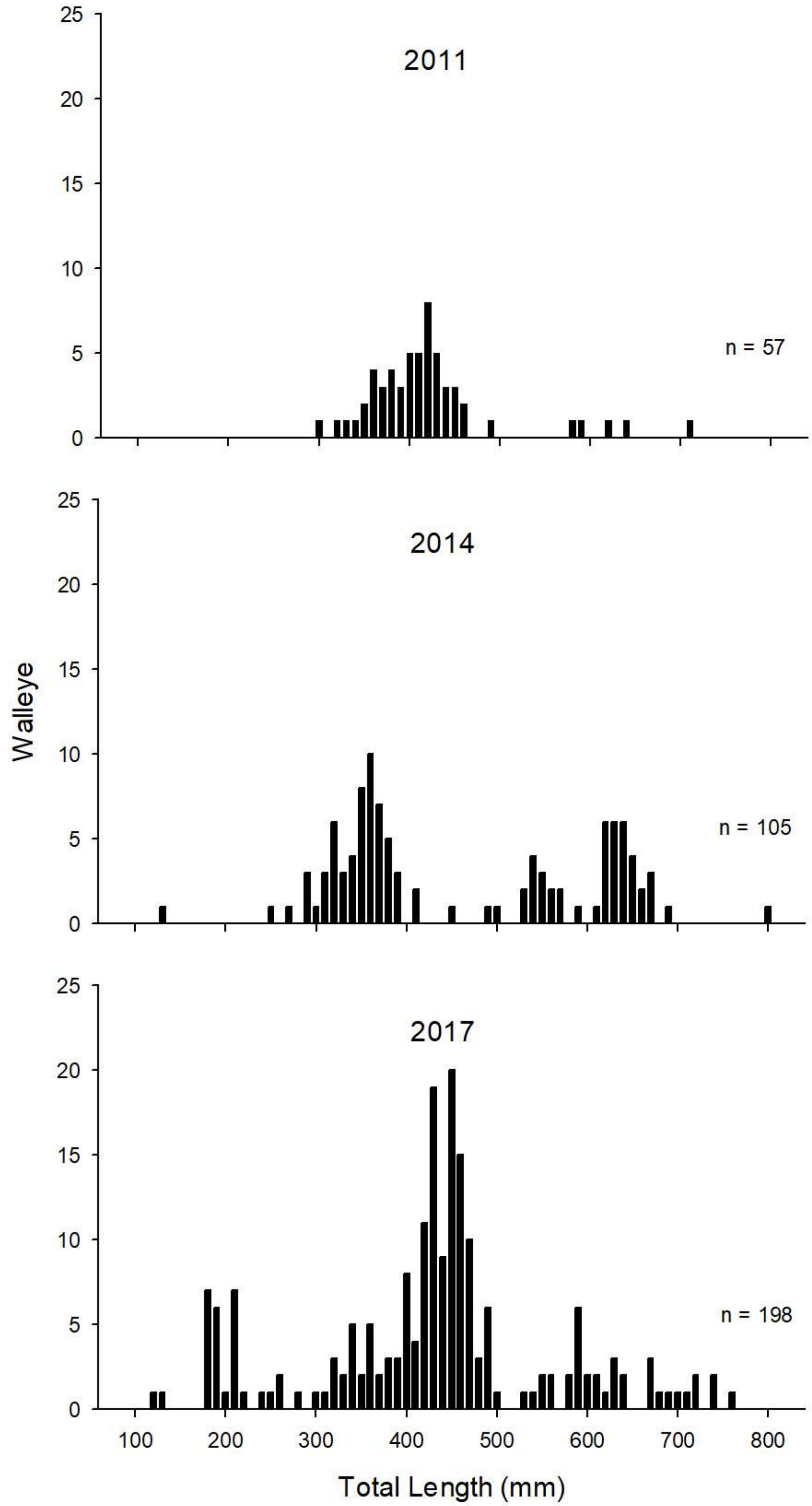

Figure 22. Length-frequency of sampled Walleye by total length from FWIN surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, and 2017.

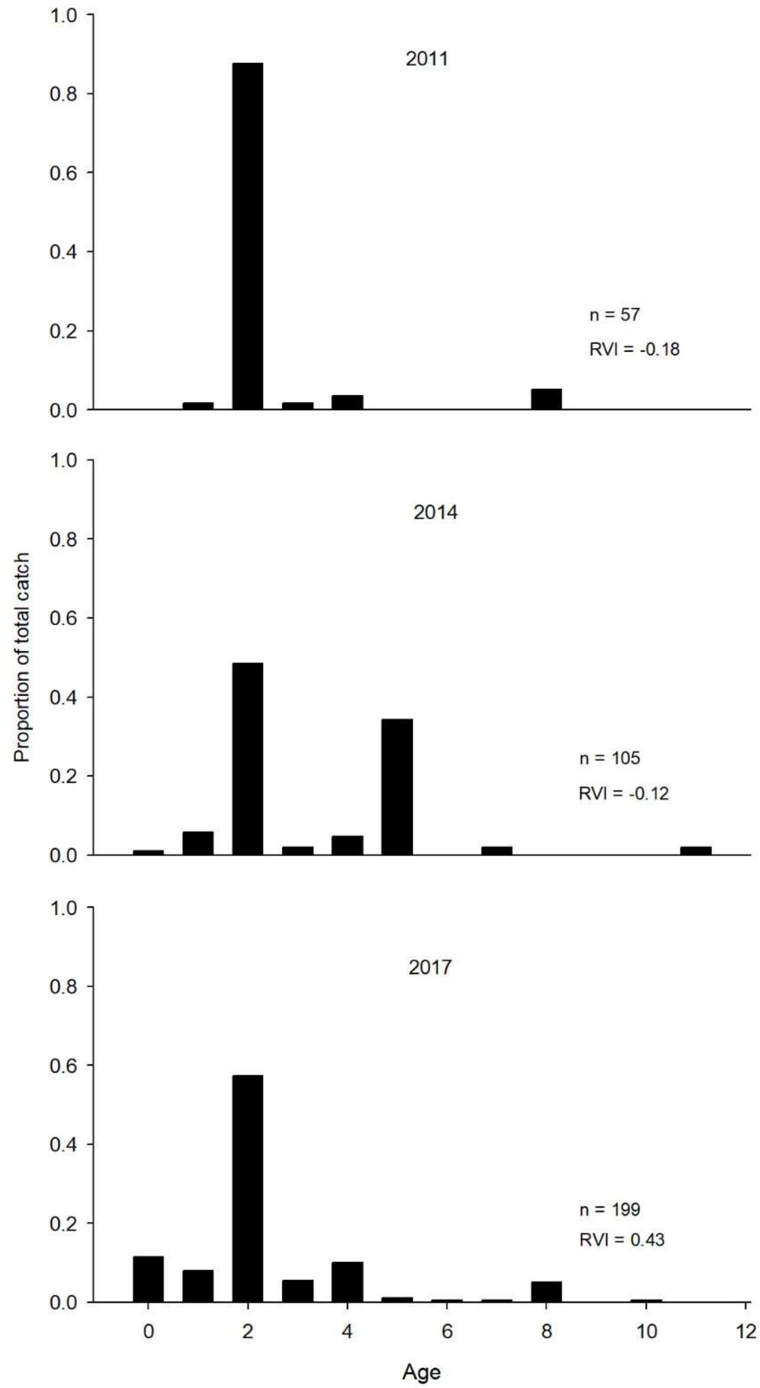

Figure 23. Age-frequency of sampled Walleye in FWIN surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, and 2017.

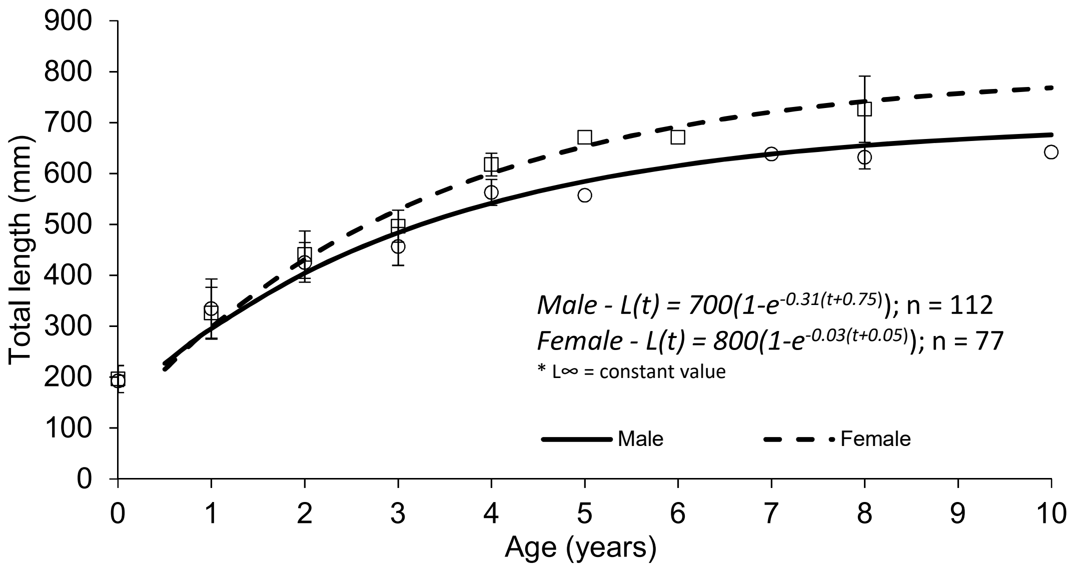

Figure 24. Mean total length-at-age of male and female Walleye collected in a FWIN survey of Lake Pend Oreille and the Pend Oreille River, Idaho during 2017.

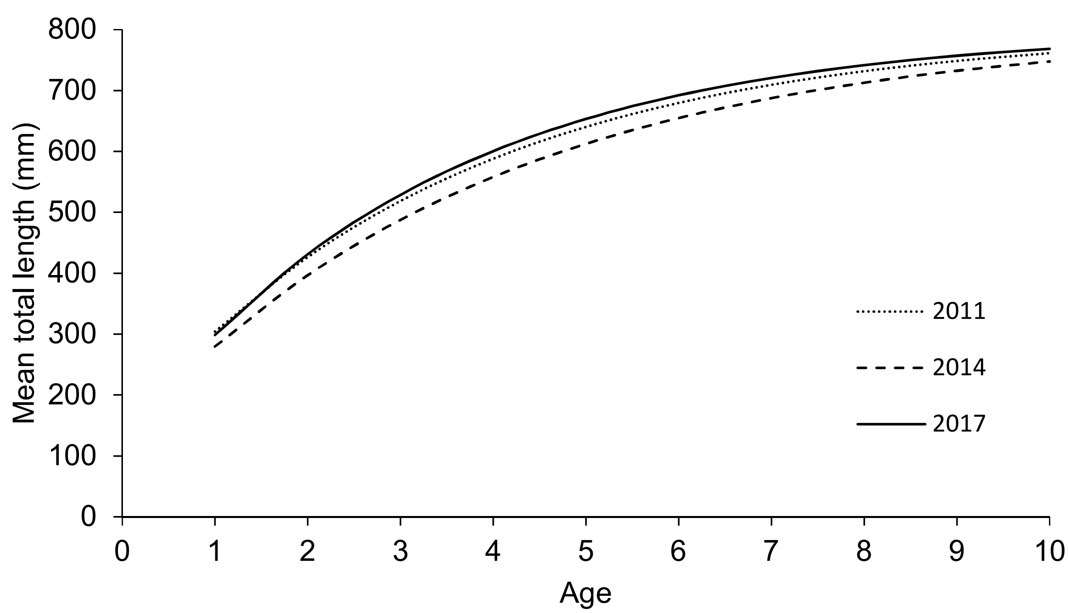

Figure 25. Growth rates of female Walleye collected in FWIN surveys of Lake Pend Oreille and the Pend Oreille River, Idaho in 2011, 2014, and 2017.

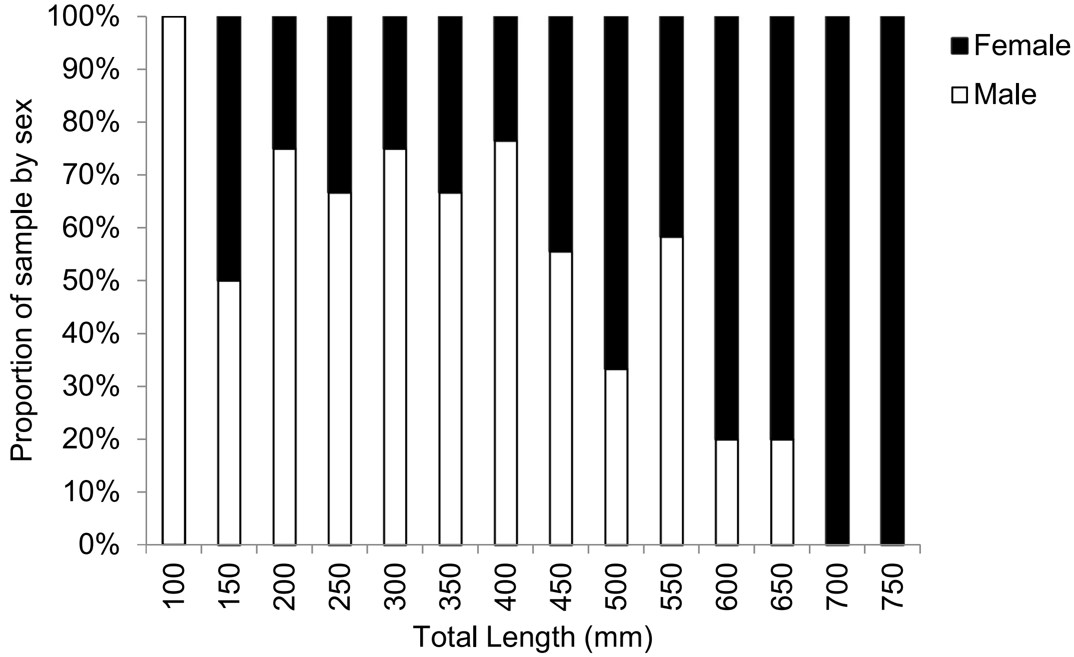

Figure 26. Proportions of male and female Walleye in a FWIN survey of Lake Pend Oreille and the Pend Oreille River, Idaho during 2017.

Figure 27. Fall Walleye index netting sampling locations in the Pend Oreille drainage, Idaho during 2017. Sampling sites are displayed with corresponding Northern Pike CPUE (fish/net-night).

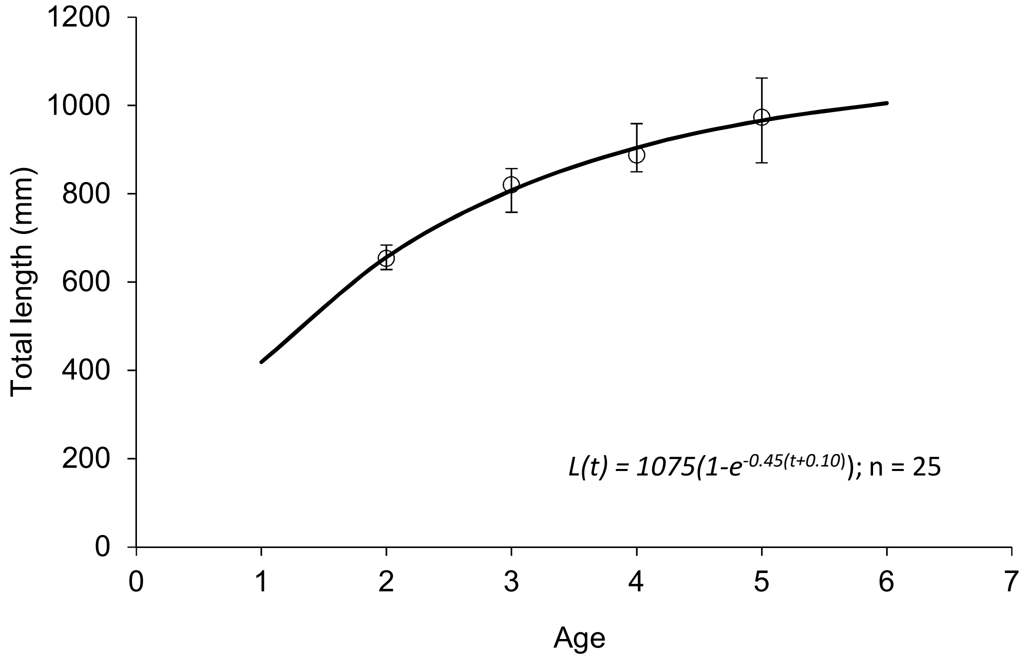

Figure 28. Mean total length-at-age of Northern Pike collected in a FWIN survey of Lake Pend Oreille and the Pend Oreille River, Idaho during 2017.

NORTHERN SECTION LOWLAND LAKE INVESTIGATIONS

ABSTRACT

A lowland lake survey was performed on Solomon Lake on May 31 and June 1, 2017 to evaluate fish community composition and the effectiveness of Rainbow Trout *Oncorhynchus mykiss* stocking used to provide a recreational fishery. We surveyed Solomon Lake in accordance with Idaho Department of Fish and Game lowland lake sampling protocols. We found low species diversity, including only Rainbow Trout and Pumpkinseed *Lepomis gibbosus*. Pumpkinseed were the most abundant fish species (529.8 ± 248 fish/hr). Rainbow Trout encountered in our survey primarily represented recently stocked fish. We recommend hatchery Rainbow Trout supplementation in Solomon Lake continue at current densities.

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) manages lowland lakes to provide diverse angling opportunities. Lowland lake surveys are conducted periodically to assess the composition of the fish community. In addition, multiple lowland lakes within the Panhandle region are routinely stocked to enhance quality of fishing opportunities. Lowland lake surveys also provide a means of evaluating the current stocking rates and frequencies.

Solomon Lake is located in Boundary County about 19.5 km northeast of Bonners Ferry, Idaho. The lake has a surface area of 5 hectares. While no depth measurements were taken, it was noted that the lake has a small littoral zone with most of the shoreline having a sharp bathymetric drop off. The lake is surrounded by public land. However, shoreline access is limited due to the steep surrounding shoreline. An unimproved dirt boat launch exists on the east end of the lake.

Solomon Lake is managed as a put-and-take fishery for Rainbow Trout *Oncorhynchus mykiss* under general regional bag and possession limits (IDFG 2013). The current management strategy was adopted in the mid-1990s following evidence that overwinter survival was low in some years and limited the application of a put-and-grow fishery (Nelson et al. 1996). In 2017, we completed a lowland lake survey to evaluate current fish community composition and the effectiveness of current stocking strategies.

METHODS

We conducted a lowland lake survey on Solomon Lake on May 31 and June 1, 2017. Our survey was conducted following the IDFG standard lowland lakes survey protocol (IDFG 2012). Fish were collected using two floating and two sinking standard experimental gill nets and by night electrofishing. We also planned to employ trap nets, but the slope of the shoreline was too steep for trap nets to effectively fish. As a result, we did not include them in our survey. The width of the lake was also too narrow to set gill nets perpendicular to the shoreline, so nets were set parallel to the shoreline. A floating and sinking net were set on each side of the lake (Table 1). Gill nets were set overnight (approximately 14 hours soak time). A boat-mounted electrofisher was used to sample the entire shoreline on the same night gill nets were fished.

All fish captured were identified and measured (total length, mm). We weighed (g) all fish collected in our electrofishing effort. Fish collected from gill nets were not weighed, but weights were estimated from a linear log-transformed length-weight regression model developed from electrofishing data. We estimated relative abundance as catch per unit effort (CPUE) for electrofishing (fish/h) and gillnetting (fish/net) samples. Variation around CPUE estimates was described using 80% confidence intervals calculated using methods for normally distributed data. 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 in our survey was described using length-frequency histograms and stock density indices (Anderson and Neumann 1996) for primary species targeted by anglers. We used Fisheries Analysis and Modeling Simulator (FAMS, Slipke and Maceina 2014) software to calculate proportional stock density (PSD) estimates. Average relative weight (W_r; Wege and Anderson 1978) was used to describe the condition of Pumpkinseed *Lepomis gibbosus* collected in our survey. We described variation around W_r estimates using 80% confidence intervals calculated using methods for normally distributed data. We did not calculate

PSD for Rainbow Trout because size was predominately related to hatchery rearing rather than in-lake growth. In addition, only Pumpkinseed ≥ 50 mm were include in W_r estimates.

RESULTS

Solomon Lake contained a simple fish community. We observed only Rainbow Trout and Pumpkinseed (Table 2). Pumpkinseed were the most abundant fish observed, comprising 96% of the total catch and 66% of the biomass. Electrofishing was the most efficient method of capture for Pumpkinseed (529.8 ± 248 fish/hour; ± 80% CI). Rainbow Trout comprised 4% of the catch and 34% of the biomass.

Rainbow Trout collected from Solomon Lake represented primarily hatchery produced fish that were stocked in the lake on May 10, 2017. Total length varied from 192 to 427 mm (Table 2; Figure 1). Although general appearance and size suggested that most Rainbow Trout were recently stocked, we also observed a larger individual with good fin condition. This suggests that some carryover of hatchery products from previous years or wild production may occur.

Pumpkinseed sampled in our survey were generally small and of below average condition. Pumpkinseed total lengths varied from 43 mm to 157 mm (Table 2; Figure 1). The PSD of pumpkinseed was one, indicating a majority of the fish present were below quality length. The mean relative weight was 89, suggesting that condition was also below average (Figure 2).

DISCUSSION

Hatchery-origin Rainbow Trout were observed in Solomon Lake and likely provided the primary recreational angling opportunity in the lake. Based our survey, Rainbow Trout were primarily from a recent stocking event. Our observations suggested survival of stocked Rainbow Trout in the lake beyond one year was low. Our observation was consistent with Nelson et al. (1996), who observed poor return on fingerling trout stocked in the lake and suggested it related to poor overwinter survival. As such, a put-and-take fishery remains a good strategy for this lake. We recommend continued stocking of Rainbow Trout at catchable size. Stocking density relative to angler use of these hatchery products was not a focus of this lowland lake survey, but was evaluated in 2017 (Stocking Evaluations, *see this report*). That evaluation suggested anglers caught 20% to 30% of stocked fish, representing a moderate use level. Based on catch rates observed in our survey and estimated angler use, we recommend current stocking densities be maintained.

Pumpkinseed were not previously described as part of the Solomon Lake fish community. No record of stocking Pumpkinseed was found, suggesting this species was illegally introduced. The Pumpkinseed population in Solomon Lake exhibited both high density and biomass, but likely provided minimal recreational opportunity. Slow growth, although not measured directly, was likely the cause of poor size structure within the population. Poor size structure is relatively common among Pumpkinseed populations in the region and specifically within the Boundary County area. For example, a survey of Bonner Lake in 2014 also described a poor size structure Pumpkinseed population (PSD = 12; Watkins et al. 2018). Pumpkinseed in Bonner Lake were found in combination with an abundant predator population, suggesting habitat conditions (e.g., water temperature, growing season, primary productivity) likely influenced population performance rather than species assemblage. Although the Pumpkinseed population in Solomon

Lake is providing a poor fishery, it is unlikely to negatively influence the put-and-take Rainbow Trout fishery since residence time of Rainbow Trout in the lake is believed to be low.

RECOMMENDATIONS

1. Continue stocking catchable-sized Rainbow Trout at current densities.

Table 20. Sample locations by date and methods used in a survey of Solomon Lake in 2017. Electrofishing encompassed the entire shoreline.

Water	Date	Gear type	Latitude	Longitude
Solomon Lake	6/1/2017	Floating Gill net	48.800426	-116.107699
Solomon Lake	6/1/2017	Sinking Gill net	48.800116	-116.106997
Solomon Lake	6/1/2017	Sinking Gill Net	48.798002	-116.105023
Solomon Lake	6/1/2017	Floating Gill Net	48.797761	-116.103880

Table 21. Descriptive statistics from a lowland lake survey of Solomon Lake on May 31 and June 1, 2017. Statistics summarized by species include catch (n), proportion of catch by number and biomass, minimum and maximum total length (TL; mm), and catch rates (± 80% C.I.) by gear type.

Species	n	% catch	% biomass	Min TL	Max TL	Electrofishing (fish/h)	Gill net (fish/net)	Trap net (fish/net)
Rainbow Trout	14	4%	34%	192	427	16.3(8.5)	0.8(0.6)	--
Pumpkinseed	386	96%	66%	43	157	529.8(248.1)	7.3(5.7)	--

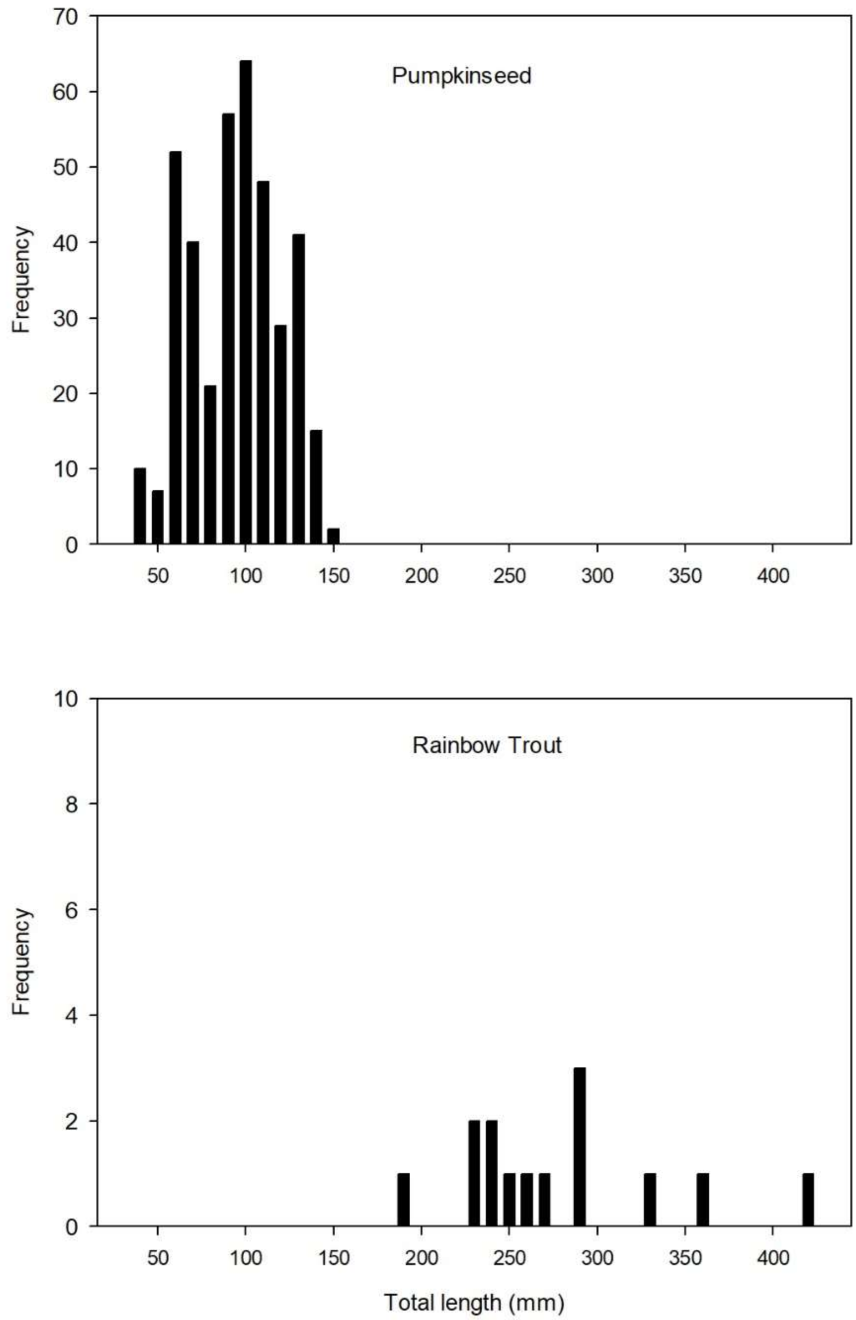

Figure 29. Length-frequency distribution of Pumpkinseed and Rainbow Trout collected from Solomon Lake using boat electrofishing and gill nets on May 31 and June 1, 2017.

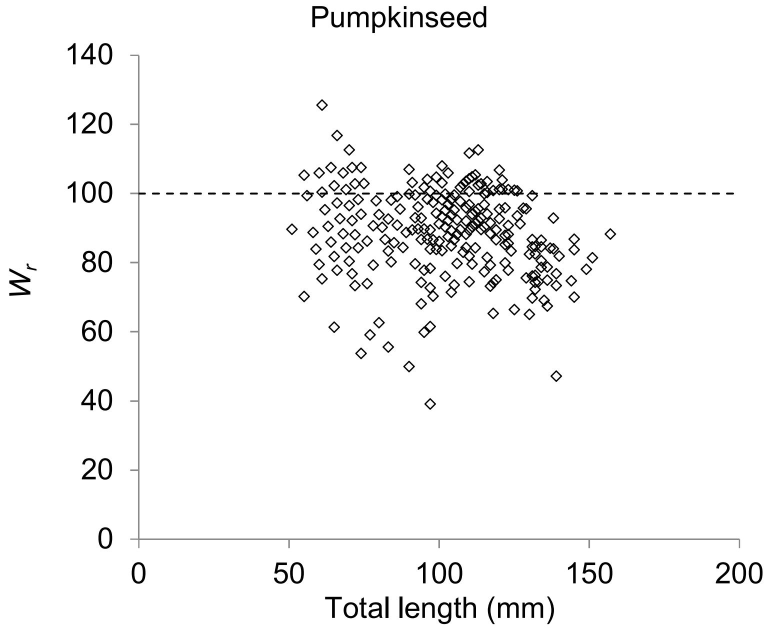

Figure 30. Relative weight (W_r) by total length (mm) of Pumpkinseed ≥ 50 mm collected from Solomon Lake on May 31 and June 1, 2017.

SOUTHERN SECTION LOWLAND LAKE INVESTIGATIONS

ABSTRACT

Holistic fish community monitoring is useful for understanding coarse-scale fishery shifts and managing public fisheries. We conducted standard lowland lake surveys on Hauser and Rose lakes during May–June of 2017 to understand fish assemblage structure and population characteristics of popular game fish species. Fish community composition was relatively similar between the study lakes, but Hauser Lake had higher species richness. In particular, Hauser Lake was occupied by coldwater salmonids, whereas Rose Lake was not. A major focus of our study was to assess the warmwater fish assemblages in each lake. We documented good size structure of adult Black Crappies *Pomoxis nigromaculatus* in both lakes, but poor size structure of Largemouth Bass *Micropterus salmodies* relative to other Panhandle Region lowland lakes with general bass angling rules. The Bluegill *Lepomis macrochirus* population in Rose Lake was more abundant than Hauser Lake with better size structure.

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) routinely samples lowland lakes around the state to assess trends in fish assemblages and populations of popular game species, and to better understand the efficacy of local stocking programs. Lowland lakes in the Panhandle Region support a diversity of angling opportunities and are a focal point of fisheries management. There are around 42 natural lowland lakes in the Panhandle Region that support significant fisheries, and periodic assessments are conducted on these water bodies using standard methods (IDFG 2012) to implement the most appropriate management actions.

OBJECTIVES

1. Characterize fish assemblage structure in Hauser and Rose lakes.

2. Estimate size structure of game fish species in Hauser and Rose lakes.

3. Compare trends in fish assemblage- and population-level structure.

STUDY AREA

Hauser Lake is located in Kootenai County at the northernmost portion of the Rathdrum Prairie, west of Rathdrum, Idaho. It is classified as a mesotrophic water body. The lake has a surface area of 218 ha and elevation of 667 m. Hauser Creek is the most significant tributary to Hauser Lake, originating on Rathdrum Mountain and entering the lake near the north end. Hauser Lake is one of the Panhandle Region's most popular lowland lakes and supports a fishery mainly for warmwater species.

Rose Lake is located in Kootenai County approximately 10 km west of Cataldo, Idaho. The lake has a surface area of 149 ha and elevation of 653 m. Rose Lake lies along the lower Coeur d'Alene River, but is not considered one of the "chain lakes" due to lack of access via the river. The lake supports a warmwater fishery and is an important regional resource given its good access and close proximity to the city of Coeur d'Alene, Idaho.

The warmwater fisheries in Hauser and Rose lakes are important local resources for Panhandle anglers, thus necessitating monitoring to understand fish assemblage trends. Standard lowland Lake surveys have been conducted with some regularity (Davis 1996; Fredericks 2002; Liter 2011). Wild fish comprise the majority of game species in Hauser Lake, with the exception of Channel Catfish and tiger muskellunge *Esox masquinongy* × *E. Lucius.* These species are stocked to provide respective opportunities for harvest- and trophy-oriented anglers. Hauser Lake has better bank fishing access than Rose Lake, which contributes to its continued popularity. Long-term fish assemblage monitoring data is available for both lakes, although it is somewhat sparse for Rose Lake.

METHODS

Lowland lakes were surveyed during late spring following IDFG's standard lowland lakes survey protocol (IDFG 2012). Surveys were conducted during May 17–19, 2017 on Hauser Lake and May 31–June 2, 2017 on Rose Lake. A simple random sampling design was used to allocate

effort to various 400 m-long shoreline units. Per the standard lowland lakes sampling guidelines, modified fyke nets (1 × 2 m frame; 12.7 mm bar-measure mesh; 15.2 m lead), floating and sinking experimental gill nets (45 × 1.8 m; 5 panels with 50, 64, 76, 88, and 100-mm stretch-measure mesh), and nighttime boat electrofishing (Smith-Root model VVP-15b electrofisher [Smith-Root, Inc., Vancouver, Washington, USA]) were used to sample fishes. Floating and sinking gill nets were paired at each site whereby a single floating and sinking gill net were set parallel to one another in close proximity to the shoreline and the center of the site. Modified fyke nets were fished perpendicular to the shoreline, near the center of the site, and leads were staked to the bank. Gill and modified fyke nets were set during the evening and fished until the following morning to encompass two crepuscular periods (Miranda and Boxrucker 2009; Pope et al. 2009). Electrofishing effort consisted of a single, 600 s pass allocated to each sampling site proceeding in a clockwise direction around each lake. Electrofishing output was standardized to 3,000 W based on ambient water conductivity and temperature (Miranda 2009). Two netters collected fish from the bow of the boat during sampling. Catch-per-unit-effort (CPUE) was summarized as the number of fish sampled per net/h for each species sampled using nets and as the number of fish sampled per minute of electrofishing. A summary of the number of sites and gear deployments at each study lake is provided in Table 1.

Total length (TL; mm) and weight (g) were measured from all fishes. Proportional size distribution (PSD) was estimated to summarize length-frequency information for sport fish species (Neumann et al. 2012), namely,

$$PSD = (a / b) \times 100,$$

where a is the number of fish greater than or equal to the minimum quality length and b is the number of fish greater than or equal to the minimum stock length (Neumann et al. 2012).

RESULTS

A total of 2,514 fish (*n* [Hauser Lake] = 860; *n* [Rose Lake] = 1,654) representing 13 species were sampled during the effort (Table 2; Table 3). The warmwater fish assemblages were almost entirely similar between study lakes, with the exception of *Esox* spp and Smallmouth Bass *Micropterus dolomieu* (Table 2). Wild salmonid species (i.e., Brook Trout *Salvelinus fontinalis* and Rainbow Trout *Oncorhynchus mykiss*) were present in Hauser Lake, but not in Rose Lake. Species richness was higher in Hauser Lake (S = 12) than in Rose Lake (S = 9; Table 2).

Both relative abundance and size structure of warmwater sport fish species were different between study lakes, and showed mixed, species-dependent patterns in the relationship between abundance and size. For example, electrofishing and modified fyke net data suggest that Bluegill *Lepomis macrochirus* were most abundant in Rose Lake (mean CPUE = 4.6 fish/minute and 103.2 fish/net-night, respectively; Table 4), and the size structure of those individuals was poorer in Hauser (PSD = 22) than Rose Lake (PSD = 70; Table 2; Figure 1). Electrofishing catch rates for Largemouth Bass (*Micropterus salmodies*) were highest in Hauser Lake (mean CPUE = 0.03 fish/minute; Table 4), and size structure of that population (PSD = 24) was higher than for that of Rose Lake (PSD = 12; Table 2; Table 4; Figure 3). Trout species were only present in Hauser Lake where we documented Rainbow Trout and Brook Trout. Catch-per-unit-effort of hatchery Channel Catfish (*Ictalurus punctatus*) were highest for sinking gillnets and mean CPUE and variance estimates were similar between lakes, suggesting that abundance is comparable. A complete summary of stock characteristics and length distributions for all game fish species can be found in Tables 3–4 and Figures 1–5.

DISCUSSION

Monitoring fish assemblages is an integral part of fishery management because community shifts can result in undesirable effects on populations. This is particularly true in mixed warmwater and coldwater fisheries with complex biological interactions. Periodic assessment of fish communities allows managers to document critical shifts in assemblage structure and population characteristics of species at various trophic levels. As such, IDFG's lowland lake surveys provide holistic information that may be used to explain trends in angler-realized management outcomes. In the case of lowland lakes in the Panhandle Region, periodic monitoring also allow fishery managers an opportunity to assess stocking strategies and supports adaptive utilization of hatchery fishes. Our assessment of Hauser and Rose lakes indicates that both fisheries are meeting management objectives relative to the IDFG State Fishery Management Plan.

Channel Catfish have been stocked periodically in both lakes since the late-1980s (Carter-Lynn et al. 2015). Recent evaluations of Channel Catfish exploitation indicate that hatchery catfish are being adequately utilized by anglers and contributing to fish assemblage diversity (Maiolie et al. 2013; Carter-Lynn et al. 2015). Carter-Lynn et al. (2015) and Maiolie et al. 2013 noted that growth rates in many northern Idaho lakes (including Hauser and Rose lakes) had slowed and compromised size structure. Moreover, size structure was poor relative to populations in systems at the same latitude. In Hauser Lake, PSD was estimated at 2 in 2011; however, our results show that PSD has increased substantially (2017 PSD = 26). This is a pattern consistent with results reported by Watkins et al. (*in prep*) for Fernan Lake. Conversely, Channel Catfish PSD decreased slightly between 2012 (PSD = 15) and 2017 (PSD = 2) in Rose Lake. The study herein evaluated size structure using sinking gill net data as opposed to baited tandem hoop nets, and utilized a smaller sample size. However, our data were sufficient for calculating meaningful estimates of size structure (Vokoun et al. 2001). Within lakes, the stark differences in size structure are likely related to changes in growth (Carter-Lynn et al. 2015; Michaletz et al. 2011) and not fishing mortality (Allen and Hightower 2010), as the most recent (2011) angler exploitation rates estimated for Channel Catfish (Hauser Lake μ = 11.7%; Rose Lake μ = 18.9%; Fredericks et al. 2013) are low compared to other put-grow-and-take fisheries for Channel Catfish (Michaletz et al. 2008). However, our exploitation rates were similar to those for Channel Catfish in Lake Lowell (8%; Koenig 2015), located in southern Idaho. Stocking rates of Channel Catfish were recently reduced by ~50% throughout the Panhandle Region beginning in 2014, so it is unclear whether changes in density-dependent growth or sampling error are responsible for the discrepancy in size structure estimates, particularly given the understanding that Channel Catfish growth had not been compromised at higher densities during the initial stages of stocking. Future fishery assessments may seek to evaluate population dynamics of Channel Catfish using multiple gears to understand the mechanism underlying recent population shifts. Nonetheless, in both systems hatchery Channel Catfish appear to be sufficiently contributing to the fishery and are providing reasonable angling opportunity according to by most angler accounts.

Hauser and Rose lakes support popular mixed-species warmwater fisheries, primarily for Bluegill and Largemouth Bass (Fredericks et al. 2002). Estimates of Largemouth Bass size structure have fluctuated considerably over the past 37 years of monitoring (Davis 1996; Davis et al. 1997; Fredericks et al. 2002; Liter et al. 2011). In comparison to other lakes in the Panhandle Region managed with general bass angling rules, the Largemouth Bass population in Hauser Lake exhibits similar size structure; however, estimates for Rose Lake are lower-than-average and have exhibited a declining trend through time. Because Largemouth Bass exploitation has decreased considerably throughout the region, we assume that the trends we have observed over

the past 30+ years more likely reflect changes in fish community composition (MacRae and Jackson 2001) and associated effects from increased biological interactions rather than harvest.

Bluegill were stocked into both lakes in 1990 and support the most significant Bluegill fisheries in the region. The Bluegill fisheries in both lakes have been consistent in recent history based on data from survey work and angler anecdote (Fredericks 2002; Liter et al. 2011). Liter et al. (2011) reported that Bluegill PSD was 16 and that 47% of the total lowland lake survey catch was comprised of Bluegill in Hauser Lake during 2007. In addition, the authors reported relatively high CPUE of Bluegill. Our results were congruent with the 2007 survey in terms of Bluegill size structure, but not abundance. Modified fyke net and electrofishing CPUE declined from the previous Hauser Lake survey and was considerably lower than Rose Lake for both gears. Interestingly, Liter et al. (2011) documented few Pumpkinseed *L. gibbosus* (i.e., ~2% of total catch), while the species comprised over 12% of the catch in 2017. Because Pumpkinseed appear to have increased in abundance and have potential to compete with Bluegill (Mittelbach 1988; Osenberg et al. 1988), it is possible that those interactions have negatively influenced recruitment. Future sampling may focus on the influence of an increasing Pumpkinseed population on the Bluegill and Largemouth Bass fisheries. Bluegill was more dominant in the catch at Rose Lake, comprising almost 50% of the total catch. However, differences in Pumpkinseed relative abundance between the two lakes were difficult to discern because electrofishing and modified fyke net CPUE exhibited opposite patterns (Table 3). To our knowledge, Bluegill stock characteristics have not been estimated in Rose Lake because Liter et al. (2011) were unable to conduct a sufficient amount of sampling, so historical comparisons cannot be made. However, the current Bluegill population in Rose Lake has the potential to produce high quality angling into the near future.

Northern Pike (*Esox lucius*) have been present in Rose Lake since at least the early 1980s, but have not been documented in Hauser Lake. Based on the results of our sinking gillnet CPUE, Northern Pike in Rose Lake occur at lower abundance than populations in the "Chain Lakes," but exhibit similar stock structure otherwise (Watkins et al. *in prep*). The *Esox* spp. fishery offered by hatchery tiger muskellunge likely discourages the illegal introduction of Northern Pike. Therefore, despite tiger muskellunge being at low abundance in Hauser Lake, the continued presence of a sterile *Esox* spp. at a regulated abundance may be an important tool for regulating Northern Pike transfers and maintaining a higher level of management control. Continued monitoring will be important for understanding if Northern Pike are introduced to Hauser Lake and what the potential threats to the existing fish community may be.

RECOMMENDATIONS

1. Periodically monitor study lakes to assess fish assemblage and population characteristics changes.

2. Monitor Largemouth Bass population characteristics in study lakes to maintain quality angling opportunities.

3. Conduct Northern Pike index monitoring survey on Rose Lake to compliment "Chain Lakes" baseline dataset.

4. Publicize Rose Lake Bluegill fishery.

5. Estimate angler use and exploitation of tiger muskellunge.

Table 22. Number of sites sampled with various gears (floating GN = floating gill net; sinking GN = sinking gill net) used during standardized lowland lakes surveys of Hauser and Rose lakes (2016).

	Gear data			
Water body	Modified fyke	Floating GN	Sinking GN	Electrofishing
Hauser Lake	6	5	5	6
Rose Lake	5	5	5	6

Table 23. Fish species sampled from Hauser and Rose lakes (2017). Species include Black Crappie (BCR), Bluegill (BLG), Brook Trout (BKT), Brown Bullhead (BBH), Channel Catfish (CAT), Largemouth Bass (LMB), Northern Pike (NPK), Pumpkinseed (PKS), Rainbow Trout (RBT), Smallmouth Bass (SMB), Tiger Muskellunge (TMK), Tench (TNC), and Yellow Perch (YLP).

	Species												
Water body	BCR	BLG	BKT	BBH	CAT	LMB	NPK	PKS	RBT	SMB	TMK	TNC	YLP
Hauser Lake	X	X	X	X	X	X		X	X	X	X	X	X
Rose Lake	X	X		X	X	X	X	X				X	X

Table 24. Sample size (*n*), total length (mm, with standard deviation), length range (Min–Max) statistics, and proportional size distribution (PSD) for fish populations sampled from Hauser and Rose lakes (2017).

Species	*n*	Total length		PSD
		Mean	Min–Max	
Hauser Lake				
Black Crappie	50	197.2 (19.1)	111–305	34
Bluegill	337	120.8 (1.8)	45–212	22
Brook Trout	4	247.0 (16.8)	197–267	--
Brown Bullhead	12	288.9 (6.7)	235–310	100
Channel Catfish	98	367.5 (6.3)	242–540	26
Largemouth Bass	123	222.1 (5.9)	64–423	24
Pumpkinseed	104	130.4 (2.5)	41–197	27
Rainbow Trout	10	316.9 (33.0)	165–485	25
Smallmouth Bass	1	256.0 (0.0)	--	--
Tiger Muskellunge	3	637.3 (171.5)	379–962	--
Tench	28	408.3 (11.1)	247–484	--
Yellow Perch	88	156.5 (3.5)	68–255	10
Rose Lake				
Black Crappie	28	204.0 (8.3)	108–280	61
Bluegill	824	149.4 (1.7)	45–260	70
Brown Bullhead	238	262.0 (1.5)	194–310	99
Channel Catfish	68	346.9 (5.1)	227–412	2
Largemouth Bass	49	242.0 (8.0)	121–362	12
Northern Pike	6	527.3 (72.3)	335–727	--
Pumpkinseed	105	116.3 (2.8)	64–196	20
Tench	258	381.3 (4.2)	140–482	--
Yellow Perch	77	155.2 (3.7)	68–213	8

Table 25. Estimates of catch-per-unit-effort (CPUE) for fish species sampled from Fernan, Lower Twin, and Spirit lakes using electrofishing (CPUE = fish/min), floating gill nets (CPUE = fish/net-night), sinking gill nets (CPUE = fish/net-night), and modified fyke nets (CPUE = fish/net-night) during 2016. Numbers in parentheses represent one standard error about the mean.

Species	Electrofishing	Floating gill net	Sinking gill net	Modified fyke net
		Hauser Lake		
Black Crappie	<0.01 (<0.01)	1.4 (0.5)	5.2 (1.7)	1.0 (0.7)
Bluegill	0.08 (0.02)	1.4 (0.7)	0.6 (0.4)	6.5 (2.5)
Brook Trout	0	0.2 (0.2)	0.4 (0.2)	0.0 (0.0)
Brown Bullhead	<0.01 (<0.01)	0	0.4 (0.4)	1.0 (0.6)
Channel Catfish	<0.01 (<0.01)	0.8 (0.4)	16.8 (4.8)	0.0 (0.0)
Largemouth Bass	0.03 (<0.01)	0.0 (0.0)	0.2 (0.2)	0.0 (0.0)
Pumpkinseed	0.02 (<0.01)	0.0 (0.0)	0.0 (0.0)	2.7 (1.3)
Rainbow Trout	0	1.4 (0.7)	0.0 (0.0)	0.0 (0.0)
Smallmouth Bass	<0.01 (<0.01)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Tiger Muskellunge	0.0 (0.0)	0.2 (0.2)	0.0 (0.0)	0.0 (0.0)
Tench	<0.01 (<0.01)	0.0 (0.0)	0.2 (0.2)	4.0 (1.9)
Yellow Perch	0.01 (<0.01)	0.0 (0.0)	5.6 (2.7)	1.7 (0.9)
		Rose Lake		
Black Crappie	0.05 (0.03)	1.3 (0.3)	2.0 (1.5)	3.0 (2.3)
Bluegill	4.6 (1.3)	3.7 (2.0)	4.3 (3.0)	103.2 (32.2)
Brown Bullhead	0.1 (0.1)	0.0 (0.0)	0.0 (0.0)	46.4 (30.1)
Channel Catfish	0.2 (0.06)	2.7 (2.2)	15.0 (6.5)	0.0 (0.0)
Largemouth Bass	0.8 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Northern Pike	0.02 (0.02)	0.3 (0.3)	0.7 (0.07)	0.4 (0.2)
Pumpkinseed	1.5 (0.6)	0.0 (0.0)	0.0 (0.0)	1.8 (1.3)
Tench	0.08 (0.05)	1.0 (0.6)	2.7 (0.9)	48.4 (19.0)
Yellow Perch	0.7 (0.1)	0.0 (0.0)	7.3 (3.7)	2.4 (1.0)

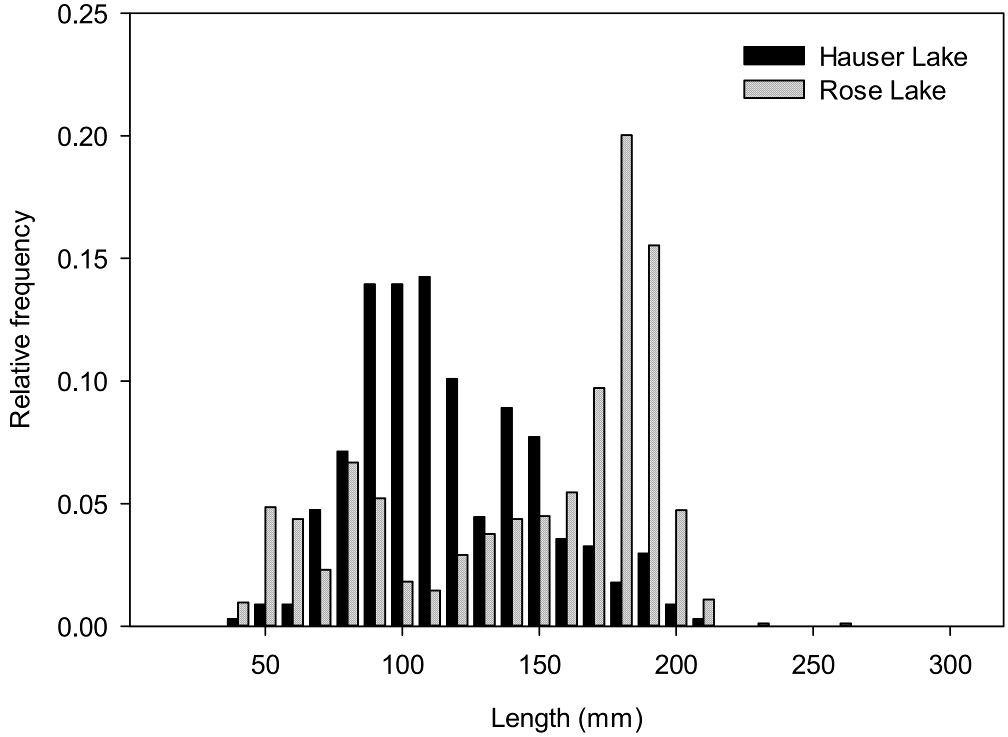

Figure 31. Length-frequency distributions for Bluegill sampled from Hauser and Rose lakes (2017).

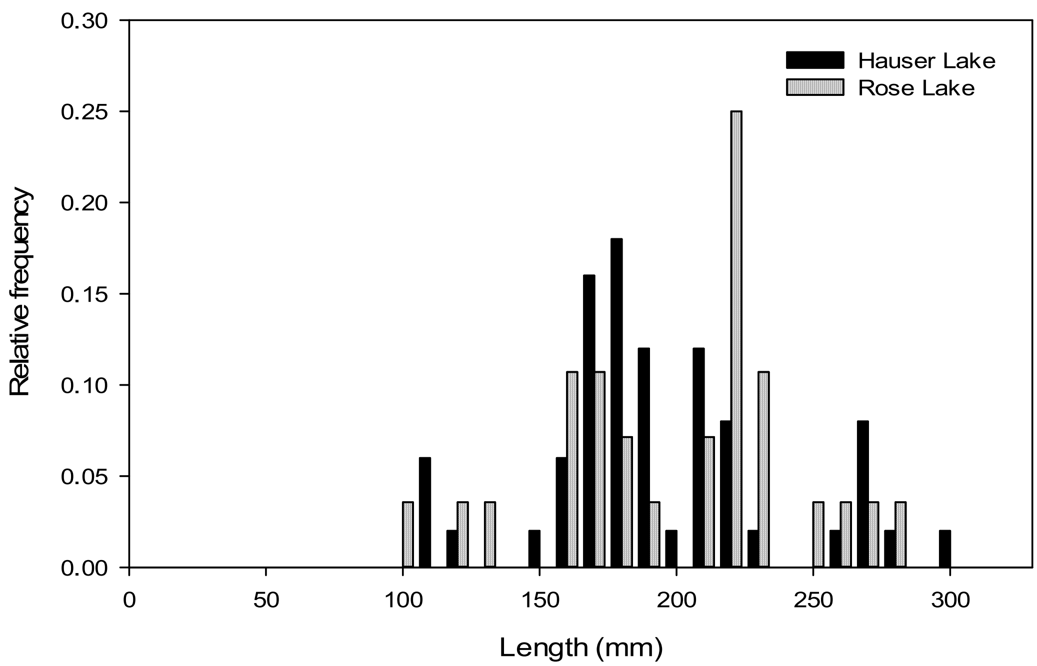

Figure 32. Length-frequency distributions for Black Crappie sampled from Hauser and Rose lakes (2017).

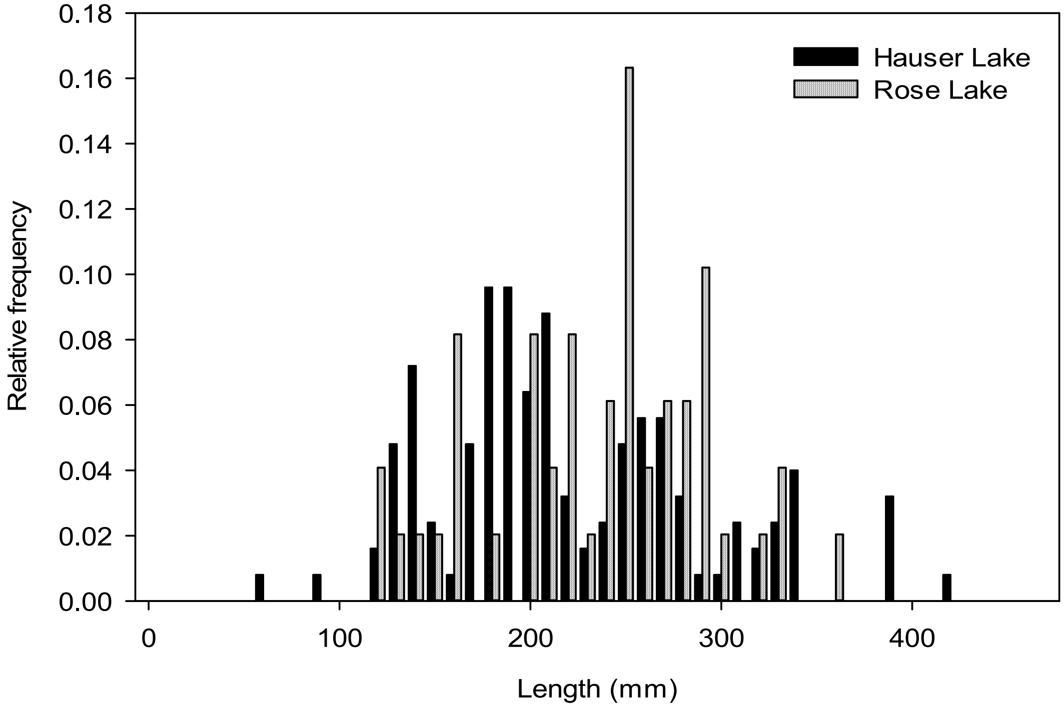

Figure 33. Length-frequency distributions for Largemouth Bass sampled from Hauser and Rose lakes (2017).

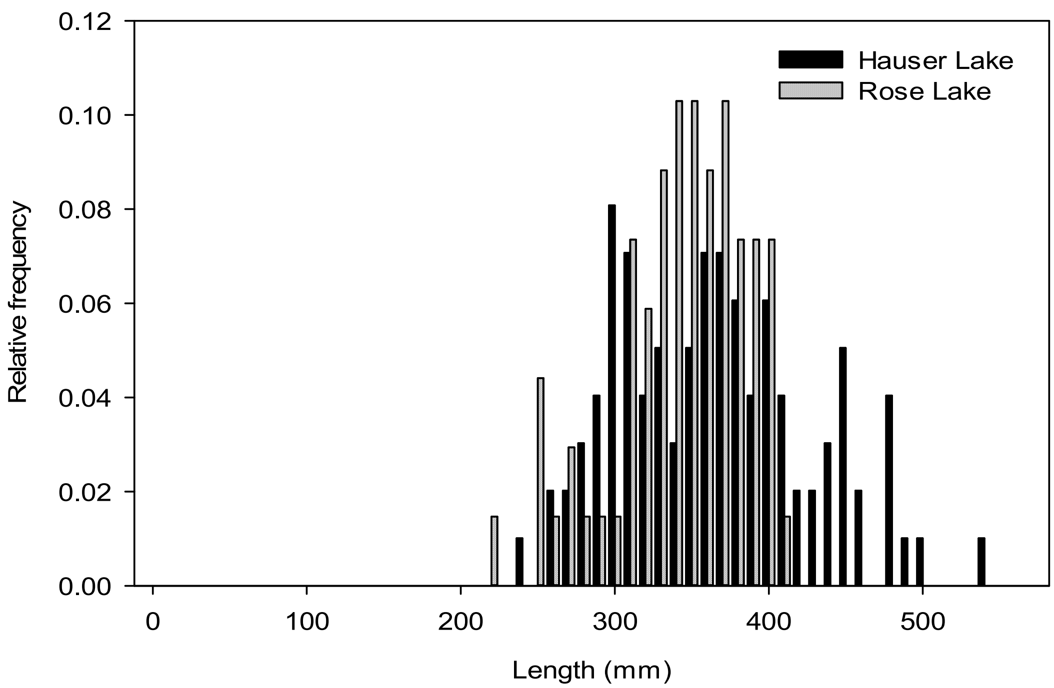

Figure 34. Length-frequency distribution for Channel Catfish sampled from Hauser and Rose lakes (2017).

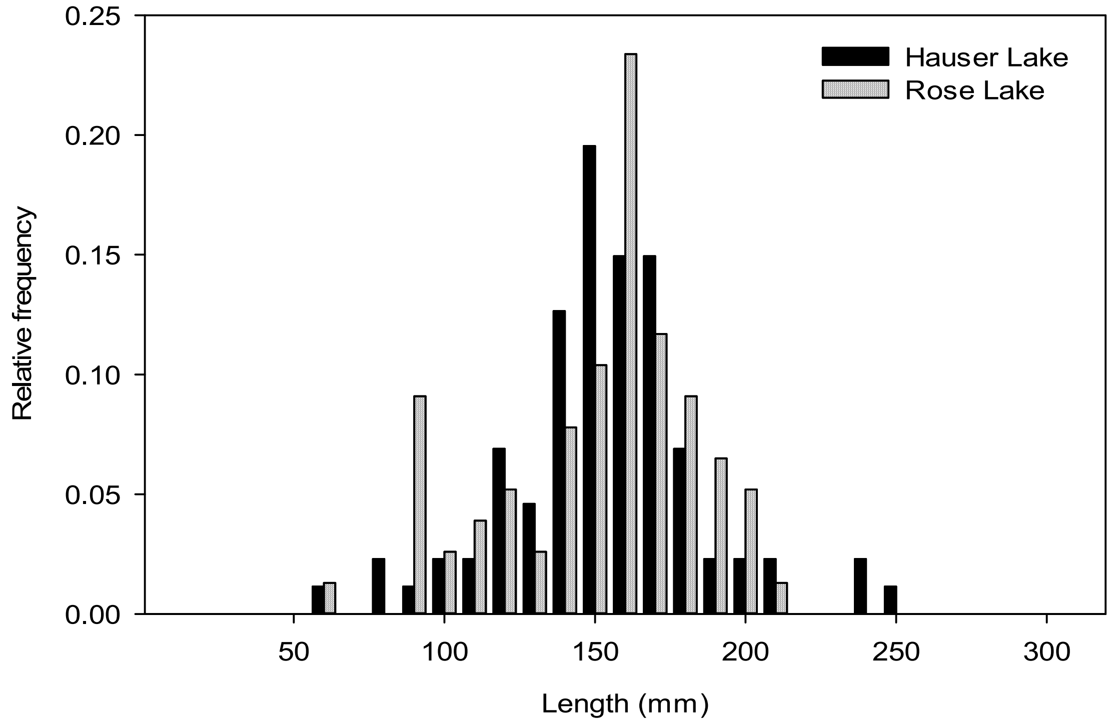

Figure 35. Length-frequency distributions for Yellow Perch sampled from Hauser and Rose lakes (2017).

HATCHERY RAINBOW TROUT EXPLOITATION

ABSTRACT

Catchable Rainbow Trout *Oncorhynchus mykiss* are an important part of Idaho's coldwater fisheries management program. Stocking catchable trout allows managers to instantaneously provide fishing opportunity where none would otherwise exist and to enhance existing fish assemblages. Costs associated with producing catchable Rainbow Trout have increased and the funds available to raise those products have remained static. Given these constraints, along with the increased desire to provide angling opportunities for catchable trout, there has been a need to scrutinize the distribution of catchables in Panhandle Region waters. We assessed patterns in return-to-creel of catchable Rainbow Trout in several water bodies (i.e., Dismal, Elsie, and Lower Glidden lakes) to better understand utilization of hatchery products in those fisheries. We sought to establish a baseline understanding of return-to-creel rates with the ultimate goal of maintaining effective distribution of catchables around the region. Return-to-creel varied from 10% (August stocking in Dismal and Elsie lakes) to 43% (July stocking in Lower Glidden Lake). In general, return-to-creel rates were highest in Lower Glidden Lake (31) among all stocking groups, followed in order by Elsie (15%) and Dismal lakes (10%). Exploitation and total use of catchables tended to decline as a function of stocking date in Elsie and Lower Glidden lakes, whereby earlier stocking groups were better utilized. We recommend discontinuation of catchable Rainbow Trout stocking in Dismal Lake and reallocation of catchable products elsewhere.

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INTRODUCTION

Idaho Department of Fish and Game's (IDFG) hatchery fish program is an important component of coldwater fishery management in the state of Idaho. The resident fish hatchery program in Idaho supports ten facilities (Koenig e++t al. 2011) that raise and stock sport fish species used to enhance coldwater fishing opportunity. Catchable Rainbow Trout *Oncorhynchus mykiss* (typically released at 203–350 mm; hereafter referred to as "catchables") are the single most significant coldwater hatchery product used statewide, and the production of catchables accounts for 50% of the total annual resident fish hatchery program budget (Koenig et al. 2011).

Statewide evaluations of return-to-creel of catchables have been a focal point for IDFG research in recent history. Specifically, the Department has had an interest in understanding the rearing conditions, culture techniques, and stocking strategies that influence angler return of hatchery products. This interest emerged from rising demand for catchables and increasing costs to raise such products. As such, there has been substantial statewide emphasis on the refinement of techniques used to raise catchables and the subsequent distribution of those fish to maximize angler return. Recent work suggests that stocking "magnum" catchables (mean TL = 305 mm) in waters > 20.2 ha and standard catchables (mean TL = 254 mm) in water < 20.2 ha results in the most efficient return-to-creel of this resource (Cassinelli 2016). Given the limited availability of catchables and the static funds available to resident hatcheries, regional fishery management programs need to better understand patterns in return-to-creel among stocked water bodies. Regional assessments of catchable utilization can facilitate the efficient use of available hatchery products and maximize opportunity for the angling public.

Evaluations of return-to-creel of catchables have been common in the Panhandle Region, especially since the development of reliable tag reporting and tag loss corrections (Liter and Fredericks 2011; Meyer et al. 2012), and the "Tag! You're It!" reporting system. Previous studies have produced important information that has been used to more effectively distribute hatchery catchables in Panhandle Region waters so as to maximize angler use and exploitation. With this study, we sought to estimate return-to-creel of catchables in three alpine lakes that receive stockings during June–August.

OBJECTIVES

1. Evaluate return-to-creel rates of hatchery catchables in Dismal, Elsie, and Lower Glidden lakes.

STUDY AREA

Dismal Lake is located in Shoshone County near the headwaters of West Fork Bluff Creek, a tributary to the St. Joe River. It is an alpine lake (i.e., >1,000 m elevation) with a surface area of 2.4 ha and elevation of 1,630 m. The lake's known fish assemblage is comprised entirely of hatchery Rainbow Trout. The annual stocking request for Dismal Lake is 270 catchable Rainbow Trout, and these fish are stocked in July.

Elsie Lake is located in Shoshone County approximately 5.5 km south of Osburn, Idaho in the East Fork Big Creek Drainage, a tributary to the South Fork Coeur d'Alene River. It is an alpine lake with a surface area of 6.5 ha and elevation of 1,546 m. The lake's known fish assemblage is comprised of hatchery Rainbow Trout and wild Brook Trout *Salvelinus fontinalis*.

Catchable Rainbow Trout stocking occurs bi-weekly from June through August (six stocking events), with a total stocking request of 3,600 fish.

Lower Glidden Lake is an alpine lake located in Shoshone County approximately 4.6 km northeast of Mullan, Idaho. The lake lies near the headwaters of Canyon Creek, a tributary to the South Fork Coeur d'Alene River. Lower Glidden Lake has a surface area of 5.7 ha and elevation of 1,710 m. The lake's known fish assemblage is comprised of hatchery Rainbow Trout and wild Brook Trout. Catchable Rainbow Trout stocking occurs bi-weekly during July and August (four stocking events), with a total stocking request of 2,250 fish.

METHODS

Angler exploitation of catchables was evaluated monthly (June–August) in study waters to assess trends in return-to-creel throughout the angling season. Catchables were measured and fitted with an orange, non-reward FD-94 T-bar anchor tag (76 mm; Floy Tag Inc., Seattle Washington, USA) and released into study waters along with their associated stocking group. We attempted to tag 10% of the individuals from each stocking group, and tagging typically occurred 1–2 days prior to stocking. Tagged individuals were randomly sampled from each stocking group. Each tag was uniquely numbered and inserted near the posterior end of the dorsal fin of each Rainbow Trout. All tags also possessed the telephone number and web address for IDFG's "Tag! You're It!" reporting hotline. Angler exploitation was estimated using the non-reward tag reporting estimator described by Meyer et al. (2012), namely,

$$\mu' = \mu / [\lambda\ (1\text{–}Tag_l)(1\text{–}Tag_m)]$$

where μ' is the adjusted angler exploitation rate, μ is the unadjusted exploitation rate (i.e., number of fish reported divided by the number of fish tagged), λ is the species-specific angler reporting rate (54.5%; Meyer and Schill 2014), Tag_l is the tag loss rate (8.2%), and Tag_m is the tagging mortality rate (1.0%). Annual angler exploitation rates were estimated for each stocking group (i.e., month) after one year at-large.

RESULTS

We tagged ~100 standard catchables per stocking group and a total of 898 tagged Rainbow Trout was released during the study. Anglers reported catching 88 tagged catchables among all three study lakes (Table 1). We estimated adjusted exploitation rates varying from 10–43%. Estimated angler exploitation of hatchery Rainbow Trout in Dismal Lake was 10% and total angler use was 12% from a single stocking event in July. Within lakes with multiple stocking events, exploitation rates varied from 10–18% (mean = 15%; Elsie Lake) and 18–43% (mean = 31%; Lower Glidden Lake). Mean estimated total use of hatchery Rainbow Trout in Elsie and Lower Glidden Lakes was 18% and 41%, respectively. Tag returns tended to decline throughout the season in Elsie and Lower Glidden Lakes. In general, tagged fish were at-large for no longer than two months in all three systems. The majority of tagged catchables caught by anglers were harvested rather than released (Table 1).

DISCUSSION

Our results suggest that angler use of catchable Rainbow Trout varies considerably among alpine lakes in the Panhandle Region. Based on our knowledge of these fisheries and the local public, it is likely that both angler effort and trout performance relative to stocking period influence the observed differences in return-to-creel of catchables. A combination of access and proximity to rural towns likely influenced return to creel rates. For example, Lower Glidden Lake exhibited the highest mean angler exploitation and use, and Dismal Lake the lowest. Lower Glidden Lake is close to several rural communities in the Silver Valley area and requires little travel across unmaintained roads for access. By comparison, Dismal Lake is over three times as far from an incorporated town and access to Elsie Lake is only possible via lengthy travel across primitive backcountry roads. Despite the remote setting and difficulty of access to Dismal and Elsie lakes, the surrounding area receives relatively high recreational use throughout the summer. As such, effectively publicizing angling opportunities for catchables in these water bodies may increase angler use.

Mean total use of catchables in Lower Glidden Lake met the statewide return-to-creel objective (40%) for standard catchables (IDFG 2013). However, our total use estimate was largely influenced by high returns of tagged fish stocked during the first stocking event in early July. The seasonal pattern in angler use was generally consistent with Elsie Lake as well; however, peak estimates of use also occurred from early-July groups stocked in Elsie Lake. This pattern may motivate changes in how catchables are distributed in alpine lakes during the fishing season. Late-June is often characterized by relatively cold temperatures above 1,500 m elevation and substantial snow and ice is generally present. As such, angling effort may be minimal due to access issues and limitations to overnight use. In addition, ice cover and cold temperatures may negatively influence bottom-up production during late-June and limit survival of catchables. A combination of low survival and angler use during early summer ice-out may result in poorer return-to-creel of catchables stocked during June. Return to creel could be increased if stocking occurred toward the end of June or early-July, just prior to the Fourth of July holiday.

Angler use of catchables tended to be lowest for groups stocked during August. This pattern is consistent with what has been observed in lowland lakes in the Panhandle Region, whereby the latest stocking events result in the poorest return rates of catchables (Watkins et al. *in prep*). We are uncertain about what influences this pattern; presumably, survival of catchables in alpine lakes should be good during the latter part of the summer. Recreational use in areas around our study lakes is generally high during late-summer as well. However, recreational use around these lakes tends to wane around late-August and likely limits return-to-creel of catchables stocked during August in a similar fashion to those stocked during mid-June. We recommend follow-up sampling and communication with hatchery staff about seasonal observations relative to angling use at the time of stocking in Elsie and Lower Glidden lakes to evaluate associations with return-to-creel of catchables. Similarly, it is worth considering the use of fry stocking instead of catchable stocking as a more inexpensive alternative, particularly for Dismal Lake.

RECOMMENDATIONS

1. Consider switching from catchable Rainbow Trout stocking to fry stocking in Dismal Lake to save costs and allow for reallocation of catchable products elsewhere.

2. Move timing of first catchable stocking to late-June in Elsie Lake to improve angler use.

3. Publicize Rainbow Trout fishing opportunities in all three lakes.

4. Re-assess exploitation and use of catchables in the future to evaluate changes in product use and angler behavior.

5. Work with hatchery staff to assess angler use at the time of stocking.

Table 26. Summary information from catchable Rainbow Trout return-to-creel study conducted during 2017–2018. Included is the number of hatchery Rainbow Trout tagged, harvested, and released in release groups organized by month after one year at-large. Exploitation (harvested) and total use (harvested and released combined) are shown with 90% confidence intervals.

Release date	Total tagged	Harvested / released	Exploitation	Total use
		Dismal Lake		
July	100	5 / 1	11.3% ± 8.5	13.3% ± 9.4
		Elsie Lake		
June 21	100	8 / 1	17.7% ± 11.0	19.9% ± 11.7
June 26	100	8 / 1	17.7% ± 11.0	19.9% ± 11.7
July 10	99	9 / 4	20.1% ± 11.9	29.1% ± 14.7
July 24	100	7 / 0	15.5% ± 10.2	15.5% ± 10.2
		Lower Glidden Lake		
July 10	100	21 /3	46.5% ± 19.5	55.4% ± 21.7
July 24	99	16 / 4	35.8% ± 16.6	42.5% ± 18.4
August	100	10 / 8	22.1% ± 12.5	39.9% ± 17.7

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 24–26, 2017. We estimated a total abundance of 7,505,082 and 396,209 kokanee in Lake Coeur d'Alene and Spirit Lake, respectively. The Lake Coeur d'Alene kokanee population had above average abundance of adult fish during 2017, but the relatively low abundance of age-1 fish confirmed the presence of a weak 2016 year-class. We also documented a weak 2016 year-class in Spirit lake; however, total abundance in Spirit Lake has been low relative to our most recent surveys. Mean total length of adult kokanee in Lake Coeur d'Alene was 283 mm, which meets the longstanding management objective. We again documented below average adult kokanee densities in Spirit Lake, suggesting that several years of consecutively low recruitment and high adult mortality have manifested in the fishery. Size structure of kokanee in Spirit Lake was better than in previous years (mean age-3 TL = 255 mm) and growth improved. Recruitment during 2014–2016 was relatively low, suggesting that the trends in growth, and subsequently size structure, may continue to improve. However, recruitment was strong again in 2017. 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 of recruitment 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, consistently entertaining, and requires simple 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 policy 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.

Kokanee were introduced to Lake Coeur d'Alene in 1937 by the IDFG to establish a harvest-oriented fishery (Goodnight and Mauser 1978; Hassemer and Rieman 1981; Maiolie and Fredericks 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 from an early-spawning stock (Meadow Creek, British Columbia) into Lake Coeur d'Alene; 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 1976; 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, the kokanee population has not been highly influenced by abundance of predators, but rather by environmental conditions, particularly spring flooding.

Kokanee populations are 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 form. This dynamic was shown in Lake Coeur d'Alene where weak year-classes have resulted from high spring runoff events (i.e., 1996 flooding). 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. The IDFG maintains long-term data on kokanee population dynamics and abundance in Lake Coeur d'Alene 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 provided to anglers.

Late-spawning kokanee were also transplanted from Lake Pend Oreille to Spirit Lake in the late-1930s (Maiolie and Fredericks 2013), and this stock has essentially supported the wild component of the fishery. According to Rieman and Meyers (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 and Fredericks 2013). However, it has been thought that beaver

dams and limited spawning habitat precluded them from naturalizing and significantly contributing to the fishery. Recent population assessments have shown that abundance of wild late-spawning adults has been high, so stocking was discontinued in 2010. In fact, recent kokanee assessments have shown fish are exhibiting slow growth relative to other systems, likely due to density-dependent effects.

OBJECTIVES

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

2. Estimate abundance and describe population characteristics of kokanee populations 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 1). 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 water level approximately 2.5 m. In addition to creating more littoral habitat and shallow-water areas, the increased water level created more pelagic habitat for open-water 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 close proximity to several major cities (i.e., Coeur d'Alene, Spokane), Lake Coeur d'Alene generates high angling effort, contributing considerably to state and local economies.

Spirit Lake

Spirit Lake is located in Kootenai County near the town of Spirit Lake, Idaho (Figure 2). 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 flow typically becomes subterraneous and contributes to the Rathdrum Aquifer. Spirit Lake is considered

mesotrophic having the following water quality concentrations: chlorophyll *a* = 5.3 µg/L (Soltero and Hall 1984), total phosphorus = 18 µg/L, and Secchi depth = 3.9 m (Rieman and Meyers 1991).

The fishery in Spirit Lake has two main components—kokanee and warmwater species. Size structure of kokanee in Spirit Lake has been poor in recent years and anglers have generally lost interest in the fishery. When conditions allow, the lake supports a popular ice fishery targeting kokanee and yellow perch *Perca flavescens*.

METHODS

Fish sampling and hard structure processing

Population monitoring

During 2017, kokanee were sampled from Spirit Lake and Lake Coeur d'Alene on July 24 and 25–26, 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 1992). The trawl consisted of a fixed frame (3.2 × 2.0 m) and a single-chamber mesh net (6.0-mm delta-style No. 7 multifilament nylon twine, knotless mesh). Further, 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. Further information on the trawl can be found in Bowler et al. (1979), Rieman (1992), and Maiolie et al. (2004).

Trawling was conducted at 21 and 5 predetermined transects throughout Lake Coeur d'Alene and Spirit Lake, respectively (Figure 1; Figure 2). 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 abundance estimates (Maiolie and Fredericks 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 layer at each transect (Rieman 1992). 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.

Ages of fish sampled were estimated using otoliths. Otoliths were removed following the procedure outlined by Schneidervin and Hubert (1986) and horizontally mounted in epoxy using PELCO flat embedding molds (Ted Pella, Inc., Redding, California, USA). Otoliths were cross-sectioned transversely with sections bracketing the nucleus to capture early annuli. Resulting cross-sections were polished with 1,000 grit sandpaper and viewed using a dissecting microscope to estimate age.

Lake Coeur d'Alene spawner assessment

Kokanee spawner length and age structure was estimated to evaluate growth objectives. Mature adults were sampled during October 16–19, 2017 using sinking experimental gill nets (46.0 × 1.8 m with panels of 50, 64, 76, 88, and 100-mm stretch-measure mesh). Gill nets were fished overnight in the vicinity of Higgens Point in Wolf Lodge Bay where kokanee index netting has historically occurred. Sampled fishes were sexed and measured for TL (mm). In addition,

otoliths were removed from five 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.

Data Analysis

Age structure of both populations and Lake Coeur d'Alene spawners 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. Growth was summarized by estimating mean length-at-age at time of capture for kokanee populations in each lake.

RESULTS

Lake Coeur d'Alene

Population monitoring

We sampled a total of 675 kokanee by trawling in Lake Coeur d'Alene. We estimated a total population abundance of 7,505,082 kokanee and density of 682 kokanee/ha. Age-specific abundance was estimated in order to track long-term trends and to provide insight on recruitment of adults to the fishery. We estimated abundances of approximately 2.1 million age-0, 54,000 age-1, 4.4 million age-2, and 900,000 age-3/4 kokanee based on trawling (Table 1). The highest kokanee fry densities were observed in the northern portion of the lake (Section 1; Figure 1), particularly near Wolf Lodge Bay. We observed much lower abundance of fry in Sections 2 and 3. The highest adult abundance was observed in Section 2.

Kokanee sampled by trawling varied in length from 25–245 mm TL (Figure 3) and varied in age from 0–3 years old (Figure 4). Estimates of mean length-at-age were only slightly variable and represented uniform growth rates among individuals (Figure 5).

Spawner assessment

Spawning kokanee varied in length from 238–305 mm TL and all were estimated to be three years old. Similar to past years, female kokanee represented a smaller proportion of the sample (Figure 6). Mean TL was 291 mm (SD = 9.0) and 282 mm (SD = 6.5) for male and female kokanee, respectively. Overall mean TL was 283 mm (SD = 10.4). Mean TL of kokanee spawners in 2017 was higher than in 2016, and most fish met or exceeded the adult length objective (Figure 7).

Spirit Lake

Population monitoring

We sampled a total of 286 kokanee by trawling in Spirit Lake. We estimated a total abundance of 396,209 kokanee. We estimated abundances of 287,804 age-0, 1,755 age-1, 62,891 age-2, and 42,317 age-3 kokanee based on trawling (Table 2). We estimated a total density of around 681 kokanee/ha and a density of 73 age-3 kokanee/ha (Table 2). An average number of fry were sampled, and there did not appear to be any pattern in age-specific abundance around the lake; kokanee tended to be well-distributed across all transects. The weak 2016 weak year-class was confirmed by low abundance of age-1 fish.

Kokanee sampled during trawling varied in length from 32–267 mm TL (Figure 8; mean = 93, SD = 80.2) and varied in age from 0–3 years old (Figure9). Estimates of mean length-at-age had little variability, with the exception of age-2 and age-3 kokanee (Figure 5).

DISCUSSION

Lake Coeur d'Alene

The kokanee population in Lake Coeur d'Alene has supported a productive harvest fishery over the past several years, and angling was reportedly good again during 2017. In the past, the population has been negatively affected by adverse environmental conditions, namely high inflows (Maiolie and Fredericks 2013); however, flow conditions over the past decade appear to have been largely favorable and allowed for a strong kokanee population. Abundance of young-of-year kokanee, as indexed by trawling, appears to be lower than 10-year mean, but more than three-fold higher than 2016. This pattern is consistent with age-0 abundance in Spirit Lake and could be a product of regional environmental conditions. Regardless of the cause, we expect that relatively weak year-classes produced during 2015–2016 will actually benefit the fishery by improving growth, and as a result, length-at-age of adults.

We found that adult spawner size that exceeded the desired range and was slightly above the most recent 20 year average (Figure 9). Our mean length estimate in 2017 (TL= 283 mm) was within the desired range and most adult kokanee were likely of desirable size to anglers. 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 and Fredericks 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 and Fredericks 2013). The fishery has tended to follow suit whereby angling effort tracks adult abundance and size structure; however, the fishery can be variable due to winter ice conditions as well. The variability in the fishery seems to have persisted in recent history. Spirit Lake does not have any pelagic predators, unlike other large northern Idaho lakes (i.e., Lake Pend Orielle, Lake Coeur d'Alene), so its kokanee population serves as a baseline for which other populations

can be compared (Maiolie and Fredericks 2013). The absence of predators also allows kokanee to reach high densities in Spirit Lake. As such, the kokanee population often exhibits strong density-dependent growth, thus depressing size structure and leading to decreased interest among anglers.

Based on sampling in 2017, overall kokanee abundance has declined substantially compared to our most recent surveys. This pattern has likely been influenced by relatively poor recruitment during 2015–2016 and apparently high mortality of adults from age-2 to age-3 during 2016–2017. Prior to this time, high recruitment had created strong density-dependent growth and dramatically reduced size structure of the adult population. It has been demonstrated in other nearby systems (e.g., Dworshak Reservoir) that adult mortality can be high when density compromises body condition (Wilson et al. 2010). More age-3 kokanee are now surpassing 200 mm TL and mean length of age-3 fish was 255 mm. The relatively small size of adults has reduced angler interest largely because catchability can decrease in conjunction with adult length. Consistent with results from Lake Coeur d'Alene, we found that 2016 produced another weak year-class of kokanee in Spirit Lake. At this stage, several weak year-classes during 2015–2016 may benefit the fishery as long as recent cohorts sustain spawning stocks sufficient for replacement. Follow-up sampling should be conducted to better understand long-term trends in kokanee population abundance and size structure.

RECOMMENDATIONS

1. Continue annual kokanee population monitoring on Lake Coeur d'Alene and Spirit Lake.

Table 27. Estimated abundance of kokanee from midwater trawl surveys in Lake Coeur d'Alene, Idaho, from 1979–2017.

Year	Age class				Total
	Age-0	Age-1	Age-2	Age-3/4	
2017	2,114,549	53,927	4,437,410	899,195	7,505,082
2016	690,170	729,709	2,461,281	1,306,550	2,967,710
2015	349,683	3,664,419	5,307,640	135,809	9,457,551
2014	2,877,209	2,153,877	2,790,295	319,080	8,140,461
2013	1,349,000	3,663,000	1,319,000	373,000	6,704,000
2012	--	--	--	--	--
2011	3,049,000	1,186,000	1,503,000	767,000	6,505,000
2010	660,400	2,164,100	1,613,300	506,200	4,943,900
2009	731,600	1,611,800	2,087,400	333,600	4,764,400
2008	3,035,000	3,610,000	1,755,000	28,000	8,428,000
2007	3,603,000	2,367,000	136,000	34,000	6,140,000
2006	7,343,000	1,532,000	91,000	33,900	8,999,000
2005	--	--	--	--	--
2004	7,379,000	1,064,000	141,500	202,400	8,787,000
2003	3,300,000	971,000	501,400	182,300	4,955,000
2002	3,507,000	934,000	695,200	70,800	5,207,000
2001	7,098,700	929,900	193,100	25,300	8,247,000
2000	4,184,800	783,700	168,700	75,300	5,212,600
1999	4,091,500	973,700	269,800	55,100	5,390,100
1998	3,625,000	355,000	87,000	78,000	4,145,000
1997	3,001,100	342,500	97,000	242,300	3,682,000
1996	4,019,600	30,300	342,400	1,414,100	5,806,400
1995	2,000,000	620,000	2,900,000	2,850,000	8,370,000
1994	5,950,000	5,400,000	4,900,000	500,000	12,600,000
1993	5,570,000	5,230,000	1,420,000	480,000	12,700,000
1992	3,020,000	810,000	510,000	980,000	5,320,000
1991	4,860,000	540,000	1,820,000	1,280,000	8,500,000
1990	3,000,000	590,000	2,480,000	1,320,000	7,390,000
1989	3,040,000	750,000	3,950,000	940,000	8,680,000
1988	3,420,000	3,060,000	2,810,000	610,000	10,900,000
1987	6,880,000	2,380,000	2,920,000	890,000	13,070,000
1986	2,170,000	2,590,000	1,830,000	720,000	7,310,000
1985	4,130,000	860,000	1,860,000	2,530,000	9,370,000
1984	700,000	1,170,000	1,890,000	800,000	4,560,000
1983	1,510,000	1,910,000	2,250,000	810,000	6,480,000
1982	4,530,000	2,360,000	1,380,000	930,000	9,200,000
1981	2,430,000	1,750,000	1,710,000	1,060,000	6,940,000
1980	1,860,000	1,680,000	1,950,000	1,060,000	6,500,000
1979	1,500,000	2,290,000	1,790,000	450,000	6,040,000

Table 28. Estimated abundance of kokanee from midwater trawl surveys in Spirit Lake, Idaho, from 1981–2017.

Year	Age class				Total	Age-3/ha
	Age-0	Age-1	Age-2	Age-3		
2017	287,804	1,755	62,891	42,317	396,209	73
2016	11,940	28,332	307,544	30,612	378,428	53
2015	7,598	60,828	2,104,886	368,167	2,541,479	629
2014	44,295	720,648	653,945	231,356	1,650,245	396
2013	--	--	--	--	--	--
2012	--	--	--	--	--	--
2011	1,092,000	185,700	382,300	65,500	1,725,400	112
2010	138,200	459,900	88,800	61,600	748,500	105
2009	260,700	182,600	75,900	30,000	549,200	51
2008	281,600	274,400	188,800	56,400	801,200	96
2007	439,919	210,122	41,460	20,409	711,910	35
2006	--	--	--	--	--	--
2005	508,000	202,000	185,000	94,000	989,100	161
2001–04	--	--	--	-	--	--
2000	800,000	73,000	6,800	7,800	901,900	13
1999	286,900	9,700	50,400	34,800	381,800	61
1998	28,100	62,400	86,900	27,800	205,200	49
1997	187,300	132,200	65,600	6,500	391,600	11
1996	--	--	--	--	--	--
1995	39,800	129,400	30,500	81,400	281,100	142
1994	11,800	76,300	81,700	19,600	189,400	34
1993	52,400	244,100	114,400	11,500	422,400	20
1992	--	--	--	--	--	--
1991	458,400	215,600	90,000	26,000	790,000	45
1990	110,000	285,800	84,100	62,000	541,800	108
1989	111,900	116,400	196,000	86,000	510,400	150
1988	63,800	207,700	78,500	148,800	498,800	260
1987	42,800	164,800	332,800	71,700	612,100	125
1986	15,400	138,000	116,800	35,400	305,600	62
1985	149,600	184,900	101,000	66,600	502,100	116
1984	3,300	16,400	148,800	96,500	264,900	168
1983	111,200	224,000	111,200	39,200	485,700	68
1982	526,000	209,000	57,700	48,000	840,700	84
1981	281,300	73,400	82,100	92,600	529,400	162

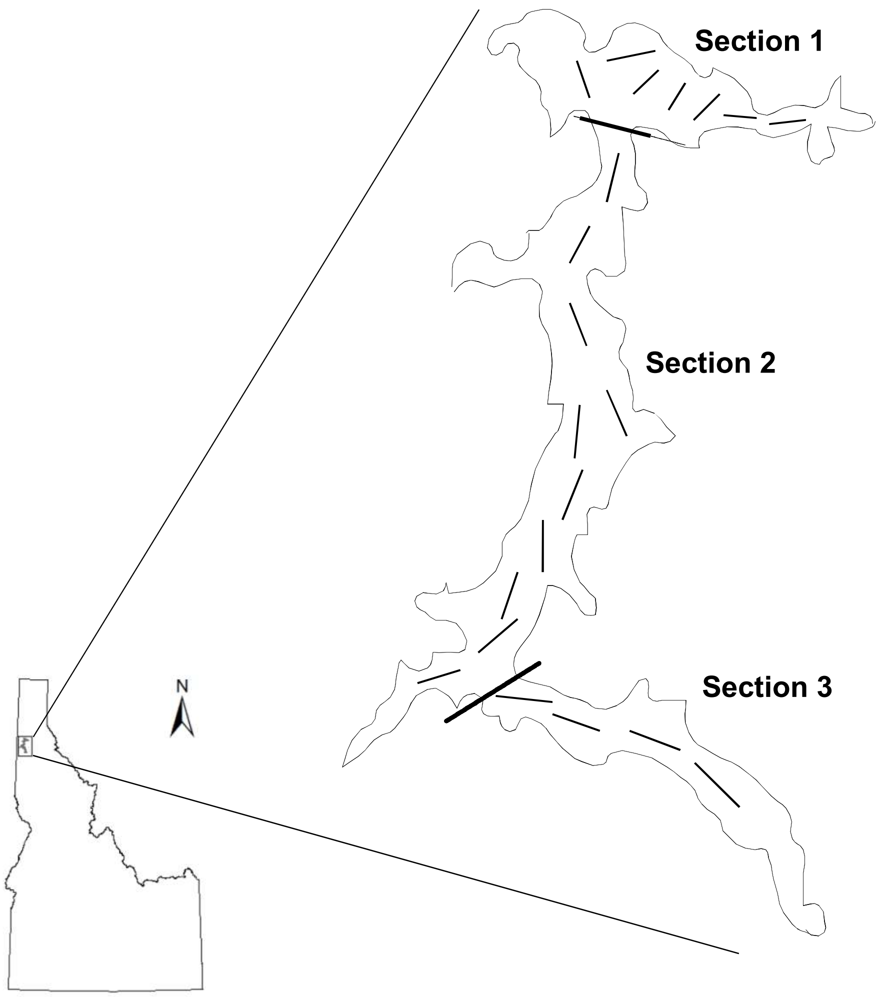

Figure 36. Approximate location of historical trawling transects used to estimate abundance of kokanee in Lake Coeur d'Alene, Idaho.

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

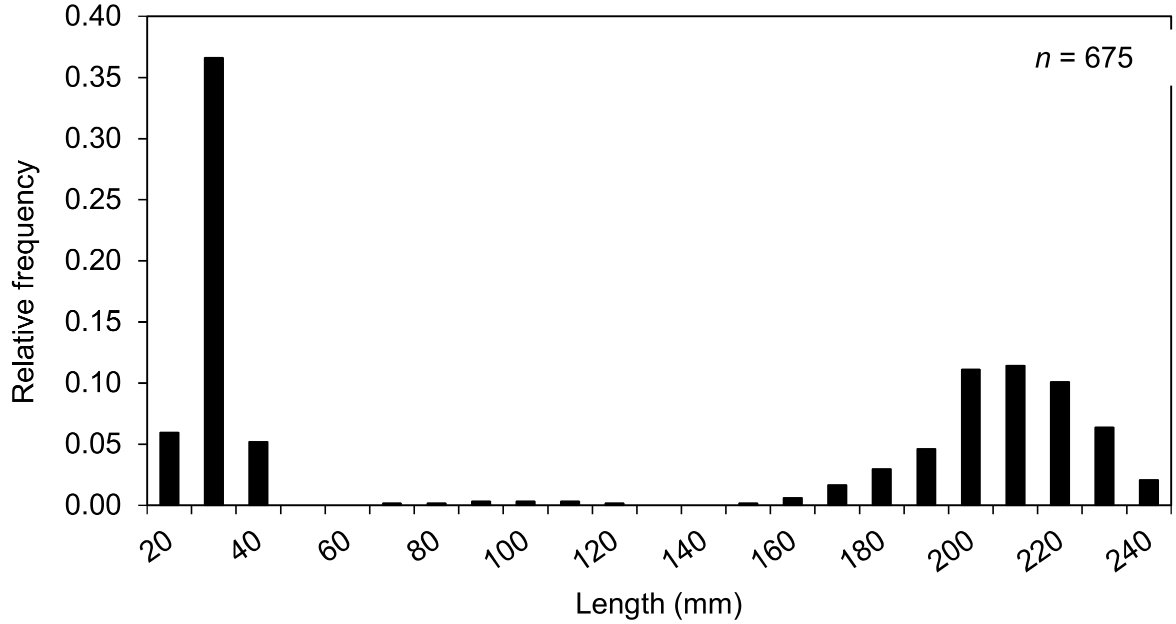

Figure 38. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho during August 25–26, 2017.

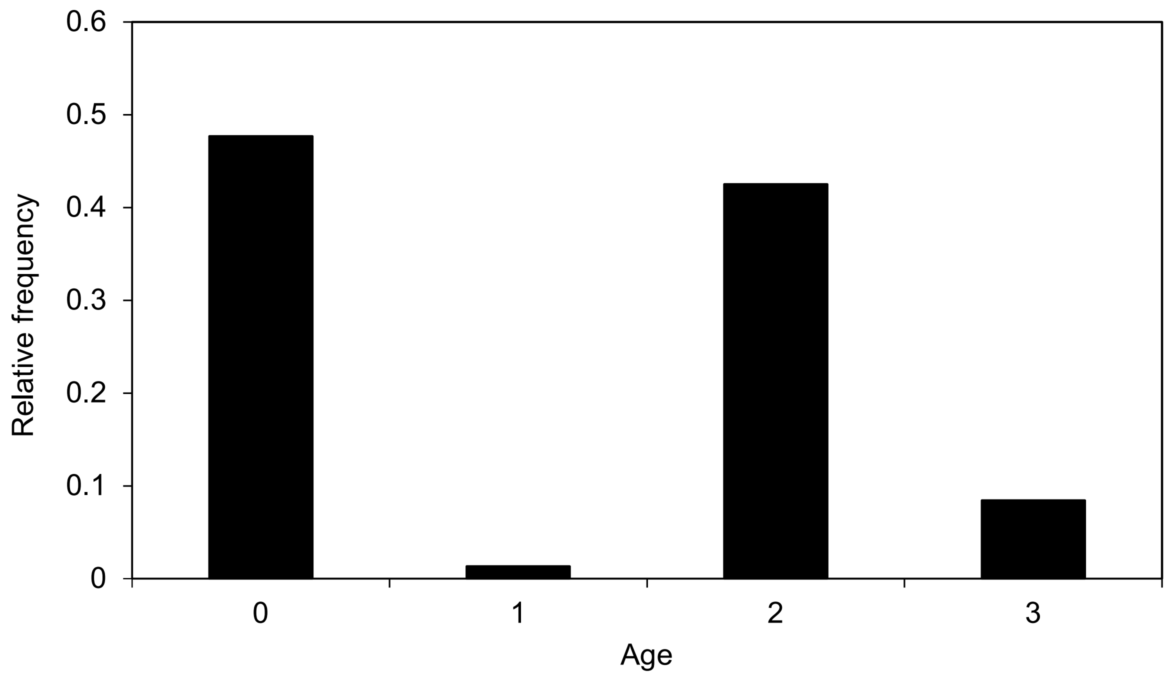

Figure 39. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho during August 25–26, 2017.

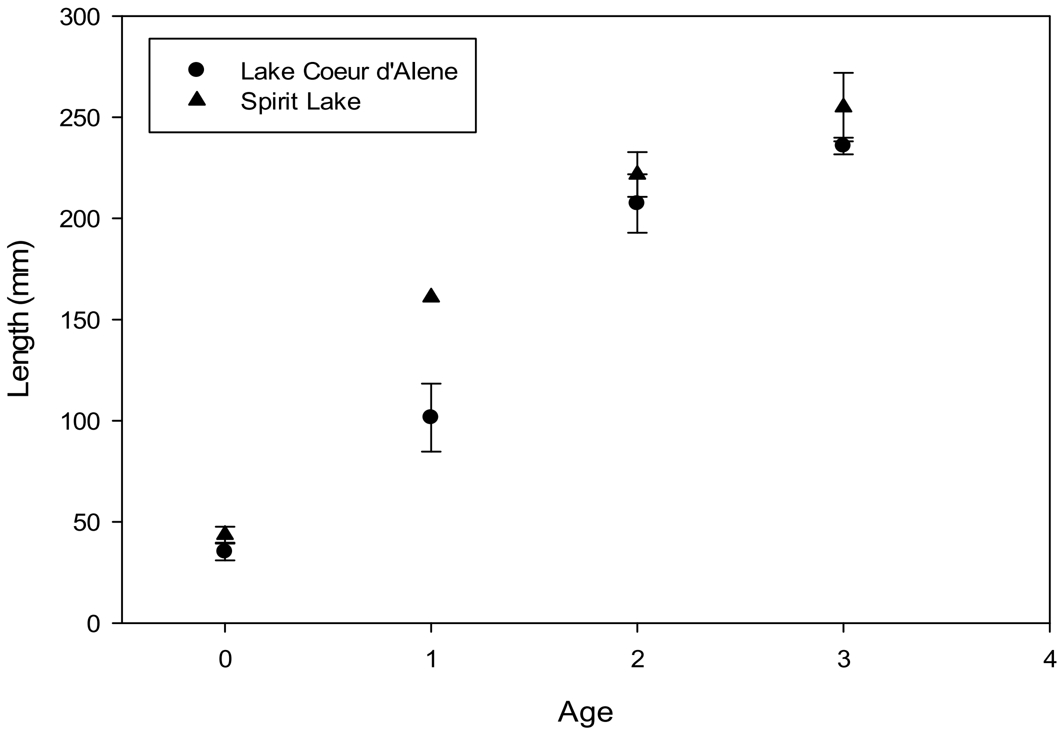

Figure 40. Mean length-at-age of kokanee sampled from Lake Coeur d'Alene and Spirit Lake, Idaho during 2017.

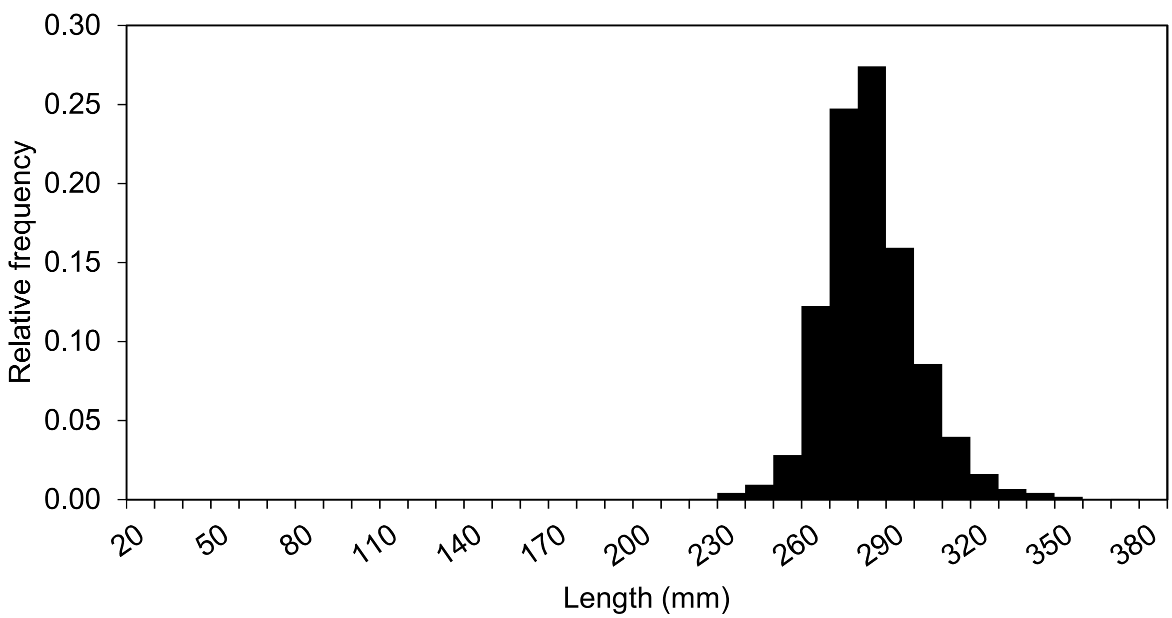

Figure 41. Length-frequency distribution for male and female adult kokanee sampled from Lake Coeur d'Alene, Idaho during October 16–19, 2017.

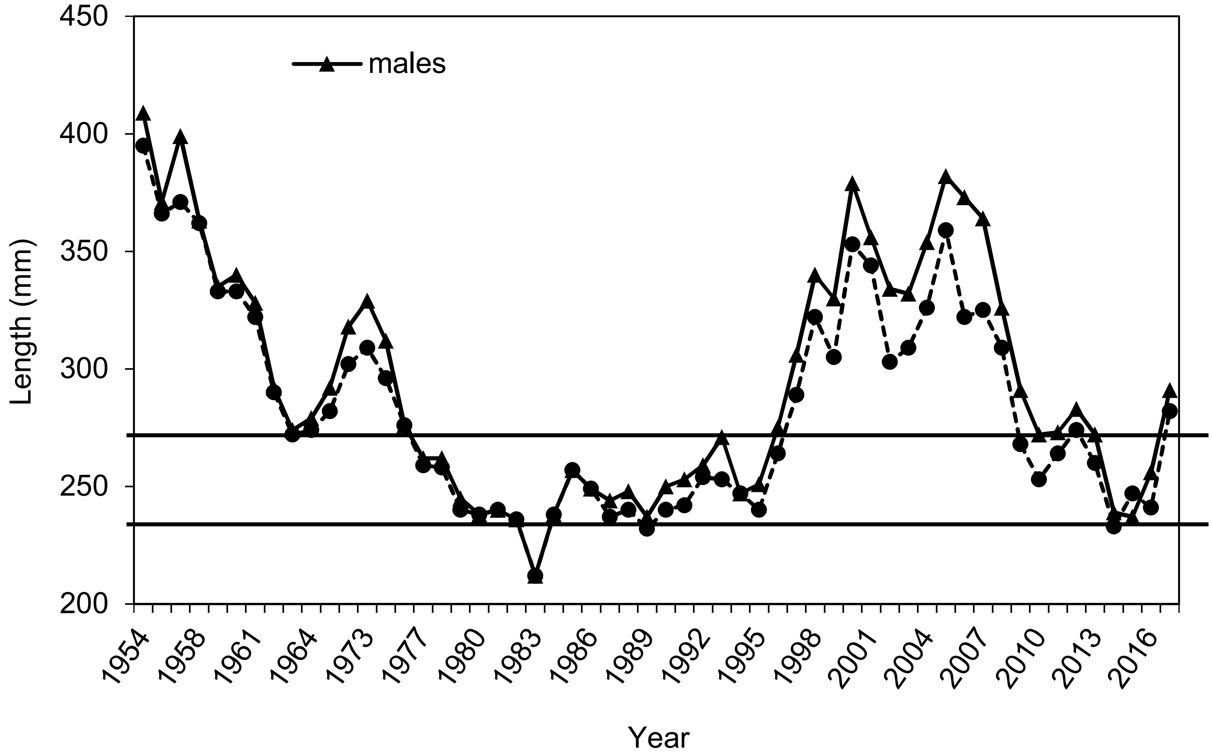

Figure 42. Mean total length of mature male and female kokanee sampled near Higgens Point in Lake Coeur d'Alene, Idaho during 1954–2017. Horizontal lines indicate the upper and lower limit of the adult length management objective (250–280 mm).

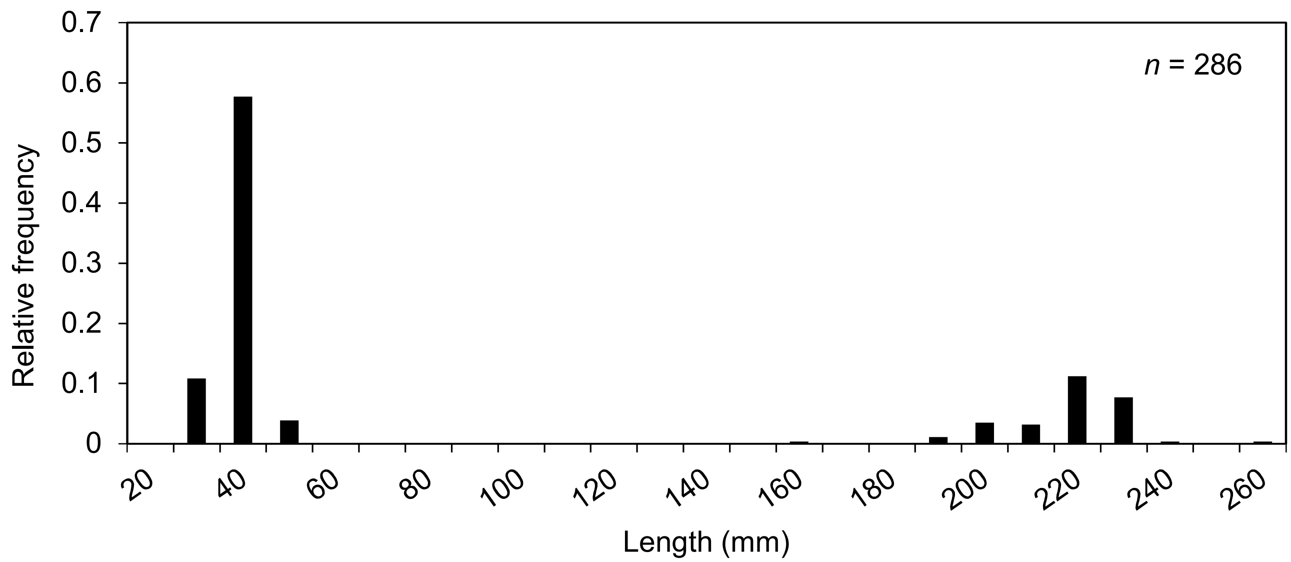

Figure 43. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho on July 24, 2017.

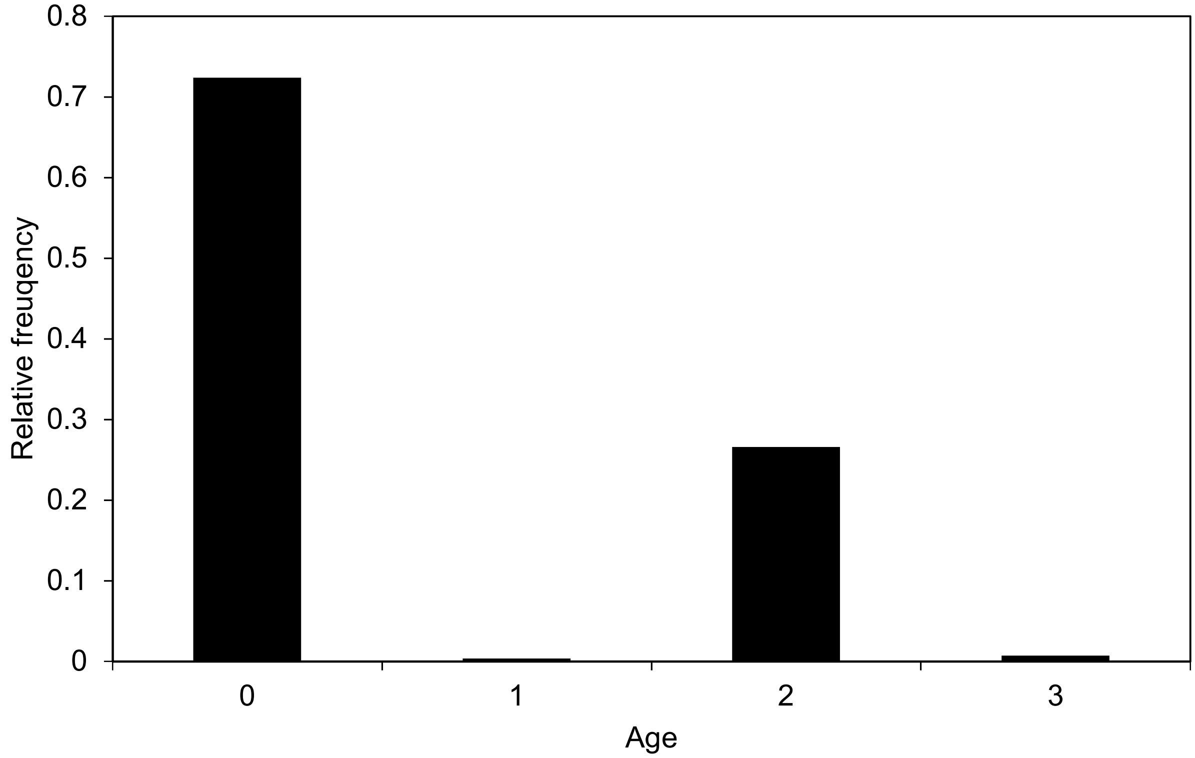

Figure 44. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho on July 24, 2017.

SPOKANE BASIN WILD TROUT MONITORING

ABSTRACT

Long-term data obtained from historical snorkeling transects 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 clarki lewisi* to environmental conditions, habitat rehabilitation, and angling regulations. During July 31–August 4, 2017, we used daytime snorkeling to observe fishes at historical sampling transects in the Coeur d'Alene River (n = 44) and St. Joe River (n = 35) basins. We estimated total Westslope Cutthroat Trout densities of 1.08 fish/100 m^2 in the North Fork Coeur d'Alene River (including Teepee Creek), 0.48 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 1.88 fish/100 m^2 in the St. Joe River. For Westslope Cutthroat Trout ≥ 300 mm in total length, we estimated densities of 0.23 fish/100 m^2 in the North Fork Coeur d'Alene River, 0.15 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 0.61 fish/100 m^2 in the St. Joe River. Densities of Rainbow Trout *O. mykiss* remain at relatively low abundances in both drainages, and our estimates were similar to the past 15–20 years. Size structure remained slightly better in the St. Joe River compared to the Coeur d'Alene River. Overall, trends in abundance and size structure of Westslope Cutthroat Trout in the upper Spokane River Basin have increased substantially over the past decade and abundance continues to be variable, yet relatively high. Future monitoring should continue in order to better inform management of Westslope Cutthroat Trout and to demonstrate progress toward conservation objectives. Current catch-and-release angling regulations for Westslope Cutthroat Trout and liberal harvest regulations for non-native salmonids (i.e., Rainbow Trout, Brook Trout *Salvelinus fontinalis*) appear to be effective methods for maintaining desirable abundance and size structure of Westslope Cutthroat Trout.

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INTRODUCTION

Westslope Cutthroat Trout *Oncorhynchus clarki 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, populations of Westslope Cutthroat Trout have been negatively influenced for a variety of reasons. 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 nonnative 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).

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 sensitive 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 close proximity of the Coeur d'Alene River and St. Joe River to large communities (i.e., Coeur d'Alene, Spokane) makes these waters popular destination trout fisheries, and angling pressure 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 catch-and-release rules (Hardy and Fredericks 2009; Kennedy and Meyer 2015). For example, prior to 2008, the lower portions of the Coeur d'Alene River (Lake Coeur d'Alene to confluence of Yellow Dog Creek) and St. Joe River (Lake Coeur d'Alene to confluence of North Fork St. Joe River) were managed under a two fish daily bag and slot limit (none between 203–406 mm; Hardy and Fredericks 2009). However, currently the entire Spokane River Basin within Idaho is managed under a catch-and-release regulation for Westslope Cutthroat Trout, with the exception of the St. Maries River (two fish daily bag limit). The shift to catch-and-release rules led to improvements in these populations; however, increased education, enforcement of regulations, and habitat rehabilitation have also contributed. Westslope Cutthroat Trout populations responded positively to regulation changes and angler use followed suit. Improvements in the quality of the fishery, combined with the elimination of season restrictions, also increased angler use in the Coeur d'Alene and St. Joe rivers (IDFG 2013). In

fact, an economic survey of angler use estimated that the number of angler trips increased from 35,000 in 2003 to 50,000 in 2011 (IDFG 2013). Long-term monitoring has been tremendously important 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 a 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.

3. Maintain long-term trend data to provide information related to management of Westslope Cutthroat Trout.

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 spring runoff and snowmelt. Approximately 90% of the land area within the drainages is publically-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 = 42; Figure 1; Bowler 1974) and St. Joe River in 1969 (n = 35; Figure 2; Rankel 1971; Davis et al. 1996). Sampling has been conducted on an annual basis for each reach since the beginning of the monitoring program, with the exception of seven reaches added to the St. Joe River in 1996 (Davis et al. 1996). Sampling reaches in the St. Joe River drainage occur only along the mainstem St. Joe River (Figure 2), while reaches within the Coeur d'Alene River drainage occur on the North Fork Coeur d'Alene River, Little North Fork Coeur d'Alene River, and Teepee Creek (Figure 1).

METHODS

Standardized index reaches in the North Fork of the Coeur d'Alene (including Teepee Creek), Little North Fork Coeur d'Alene, and St. Joe rivers were sampled during July 31–August 4, 2017 using daytime snorkeling (DuPont et al. 2009; Thurow 1994). 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; mm) 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 permanently 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 salmonid species (i.e., Westslope Cutthroat Trout, Rainbow Trout, Mountain Whitefish *Prosopium williamsoni*) were separated into 75-mm length groups. Nongame fish species (e.g., *Cottus* spp. and *Catostomus* spp.) were enumerated, but lengths were not estimated.

Reach length and wetted width were measured at each sampling site with a laser rangefinder. 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 were responsible for any changes in fish abundance and assemblage structure. Surface area (m^2) was estimated at each site to provide a measure of sampling effort. The number of salmonids observed was divided by the surface area sampled to provide a standardized relative abundance measure. We calculated a mean relative density that could be compared to previous years (DuPont et al. 2009). Non-target species were enumerated and reported as the total number observed.

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

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

where *a* is the number of fish greater than or equal to the minimum quality length and *b* is the number of fish greater than or equal to 300 mm length (Neumann and Allen 2007; Neumann et al. 2012).

RESULTS

North Fork Coeur d'Alene River

A total of 720 Westslope Cutthroat Trout, 32 Rainbow Trout, and 1,677 Mountain Whitefish was observed among the 44 sampling sites in the North Fork Coeur d'Alene River drainage. In addition, we observed 128 Northern Pikeminnow *Ptychocheilus oregonsis*, and five Brook Trout. Mean total density of Westslope Cutthroat Trout was 1.08 fish/100 m^2 in the North Fork Coeur d'Alene River (including Teepee Creek) and 0.48 fish/100m^2 in the Little North Fork Coeur d'Alene River (Figure 3). Mean density of Westslope Cutthroat Trout ≥ 300 mm was 0.23 fish/100 m^2 in the North Fork Coeur d'Alene River and 0.15 fish/m^2 in the Little North Fork Coeur d'Alene River (Figure 4). For Westslope Cutthroat Trout during 2017, the mean estimates of total density and density of fish ≥ 300 mm were lower than the previous 10-year average (total Westslope Cutthroat Trout = 1.06 fish/100 m^2; Westslope Cutthroat Trout ≥ 300 mm = 0.24 fish/100 m^2) in the combined reaches. Mean total density of Rainbow Trout in the North Fork Coeur d'Alene River was 0.01 fish/ 100 m^2 and 0.10 fish/100m^2 in the Little North Fork Coeur d'Alene River (Figure 5). Mean total density of Mountain Whitefish was 1.38 fish/100 m^2 in the North Fork Coeur d'Alene River and 0.40 fish/100 m^2 in the Little North Fork Coeur d'Alene River (Figure 6). We estimated a RSD-300 of 51 for the Coeur d'Alene River Basin (Figure 11).

St. Joe River

A total of 1,038 Westslope Cutthroat Trout, zero Rainbow Trout, and 760 Mountain Whitefish was observed among the 35 sampling sites in the St. Joe River. In addition, we observed 229 Largescale Sucker, 74 Northern Pikeminnow. Bull Trout *S. confluentus* were not observed during 2017 sampling. Mean total density of Westslope Cutthroat Trout was 1.88 fish/100 m^2 (Figure 7). Mean density of Westlope Cutthroat Trout ≥ 300 mm was 0.62 fish/100 m^2 (Figure 8). The mean estimates of total density was high and density of fish ≥ 300 mm lower during 2017 than the previous 10-year averages of 1.62 fish/100 m^2 and 0.62 fish/100 m^2. Mean total density of Rainbow Trout and Mountain Whitefish was zero fish/100 m^2 and 0.88 fish/100 m^2, respectively (Figures 9 and10). Size structure of Westslope Cutthroat Trout in the St. Joe River (RSD-300 = 52) was slightly better than in the Coeur d'Alene River Basin (Figure 11).

DISCUSSION

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

Westslope Cutthroat Trout densities have increased markedly since the beginning of this monitoring program and continue to show improvement (Maiolie and Fredericks 2014). Although we have documented a considerable amount of variability in annual density estimates, the past decade is characterized by the highest densities in both the North Fork Coeur d'Alene and St. Joe rivers. In particular, increased densities of Westslope Cutthroat Trout ≥ 300 mm reflect substantial improvements in size structure. We continue to see increases in Mountain Whitefish densities in the lower portions of the Coeur d'Alene and St. Joe rivers. Rainbow Trout densities remain at extremely low abundance throughout the St. Joe and North Fork Coeur d'Alene rivers. We continued to document relatively high densities of Rainbow Trout in the Little North Fork Coeur d'Alene River; notwithstanding, Westslope Cutthroat Trout densities also remain high in the Little North Fork Coeur d'Alene River. Rainbow Trout are known to compete and hybridize with Westslope Cutthroat Trout; thus, IDFG manages Rainbow Trout in the Spokane River Basin under a general daily bag limit to encourage angler harvest that may reduce the potential for such interactions. The recent increase in density of Rainbow Trout in the Little North Fork Coeur d'Alene does not correspond to an increase in other portions of the basin, and is not currently a major management concern.

In recent years, a concern among the angling public has been about the effect of summer conditions and its interaction with angling-induced fish mortality. Severe drought conditions during 2015 were followed by low flows again in 2016. Both river systems showed declines in Westslope Cutthroat Trout and Mountain Whitefish density during 2016; however, densities improved during 2017. While low flow conditions in 2015 and 2016 may have negatively influenced salmonid densities in these river systems, their populations have remained strong and appear to be fairly resilient to the observed environmental conditions.

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.

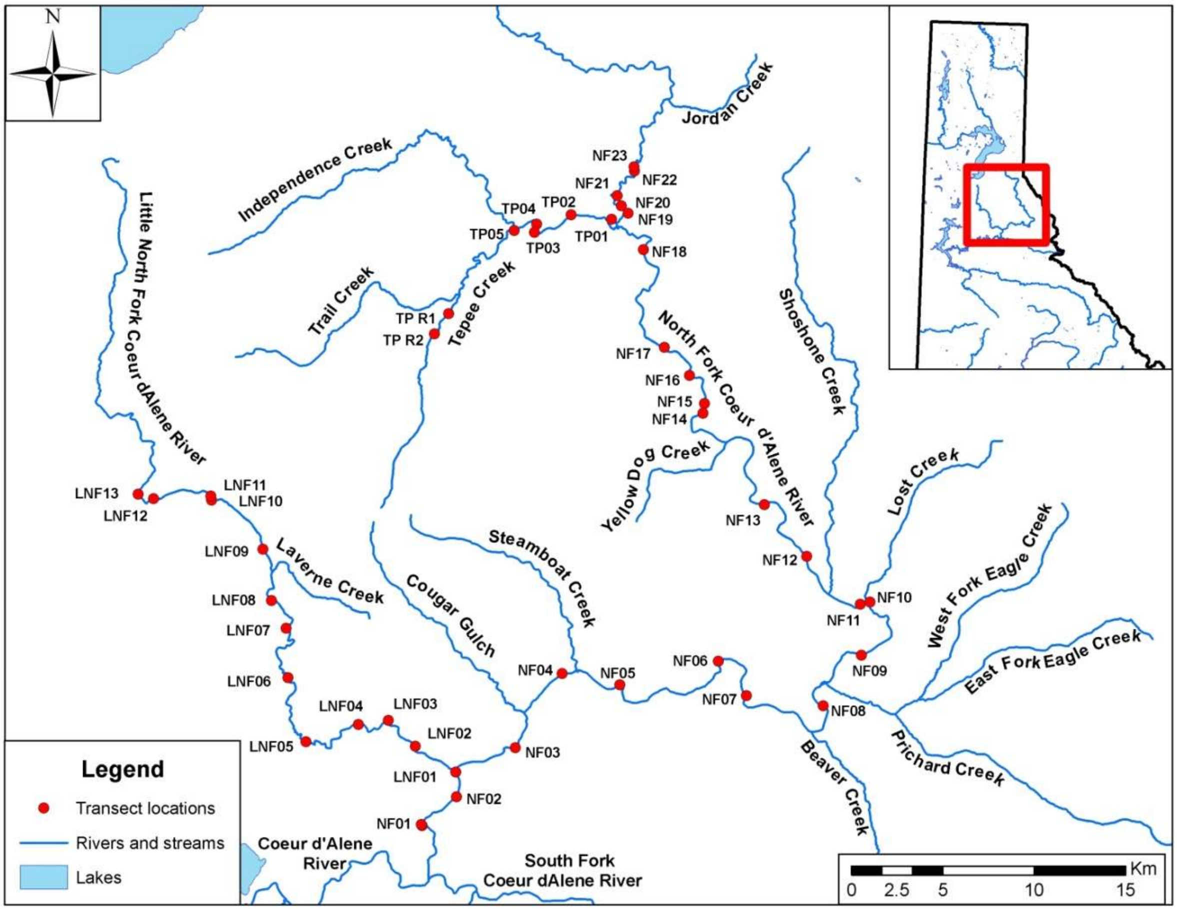

Figure 45. Location of 44 index reaches sampled using snorkeling in the Coeur d'Alene River, Idaho during August 2–4, 2017.

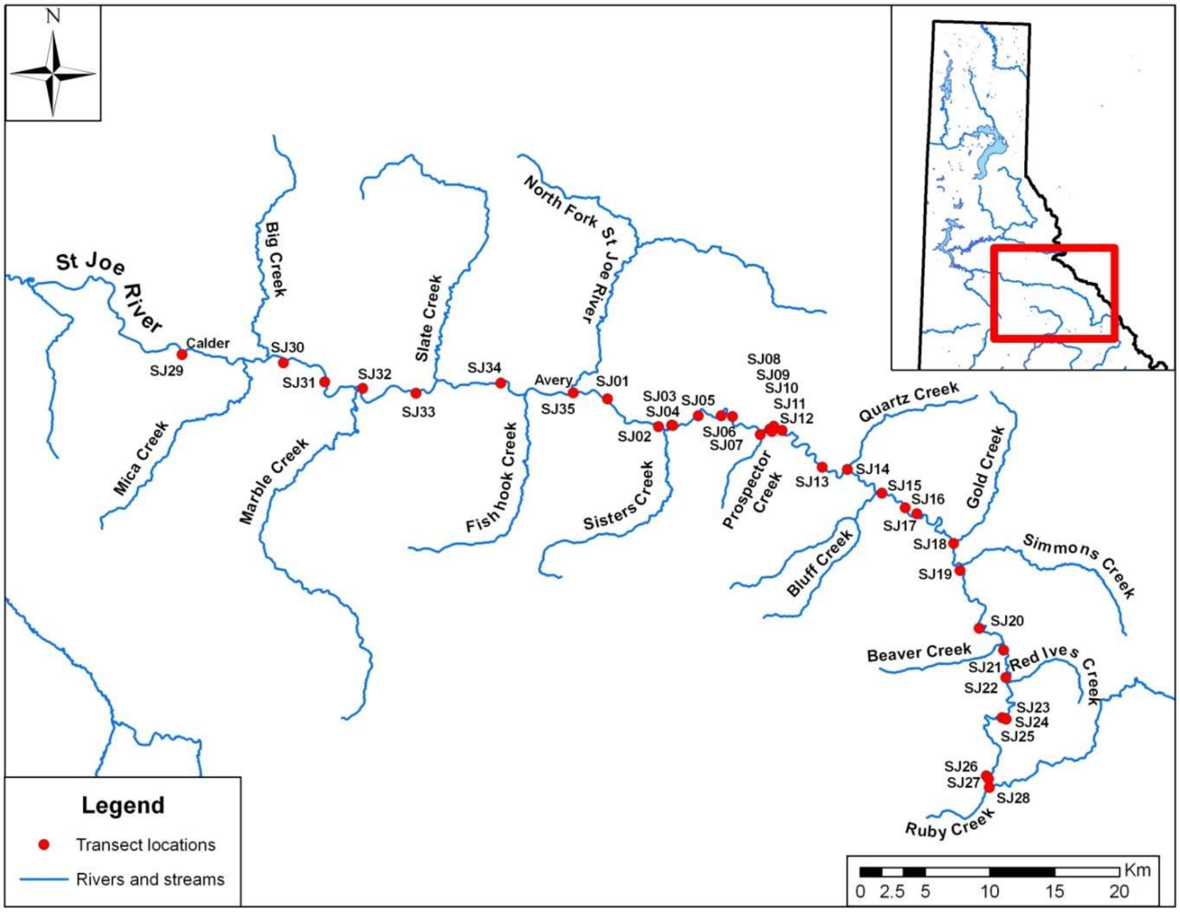

Figure 46. Location of 35 index reaches sampled using snorkeling in the St. Joe River, Idaho during July 31–August 1, 2017.

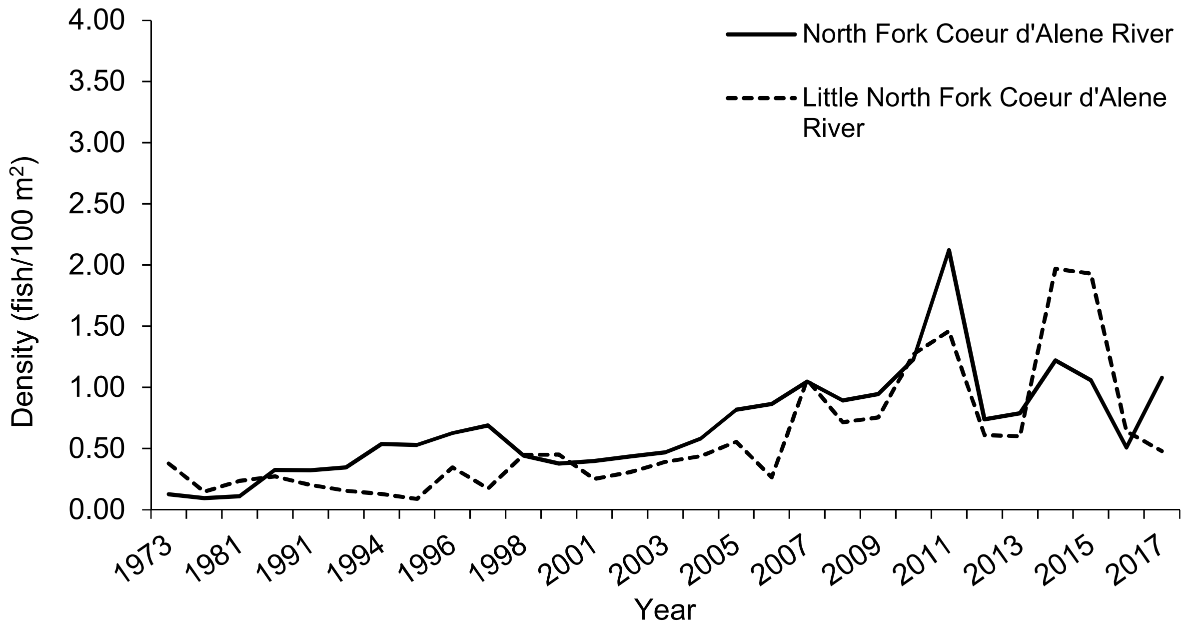

Figure 47. Mean density of Westslope Cutthroat Trout observed during snorkeling in the North Fork of the Coeur d'Alene River and Little North Fork of the Coeur d'Alene River during 1973–2017.

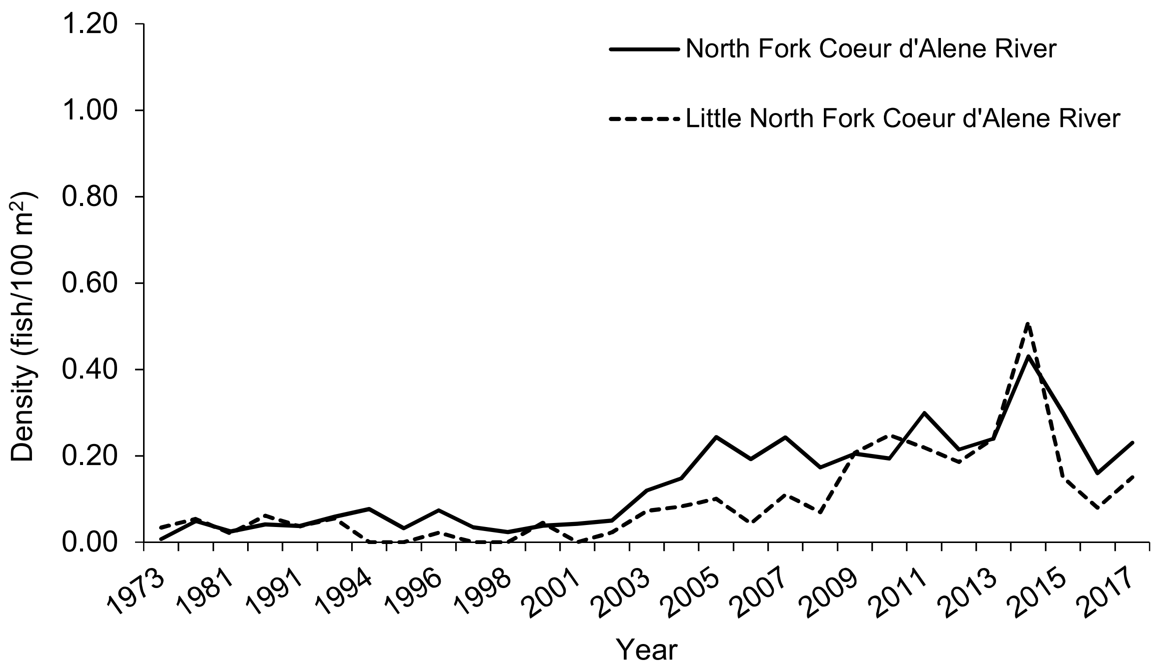

Figure 48. Mean density of Westslope Cutthroat Trout larger than 300 mm TL observed during snorkeling in the North Fork of the Coeur d'Alene River and Little North Fork of the Coeur d'Alene River during 1973–2017.

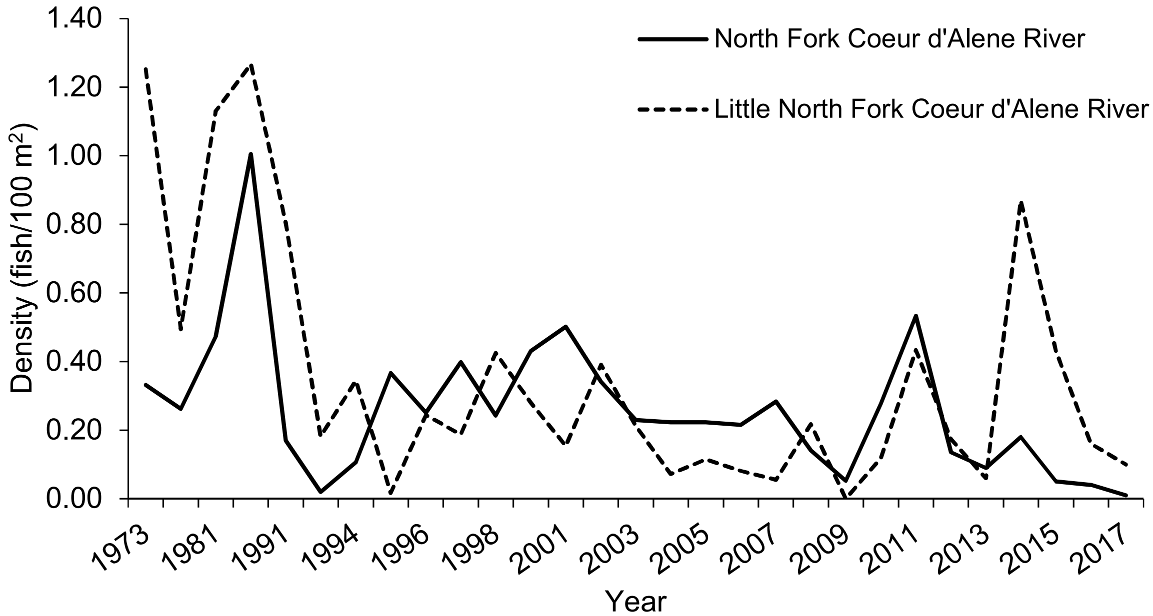

Figure 49. Mean density of Rainbow Trout observed during snorkeling in the North Fork of the Coeur d’Alene River and Little North Fork of the Coeur d’Alene River during 1973–2017.

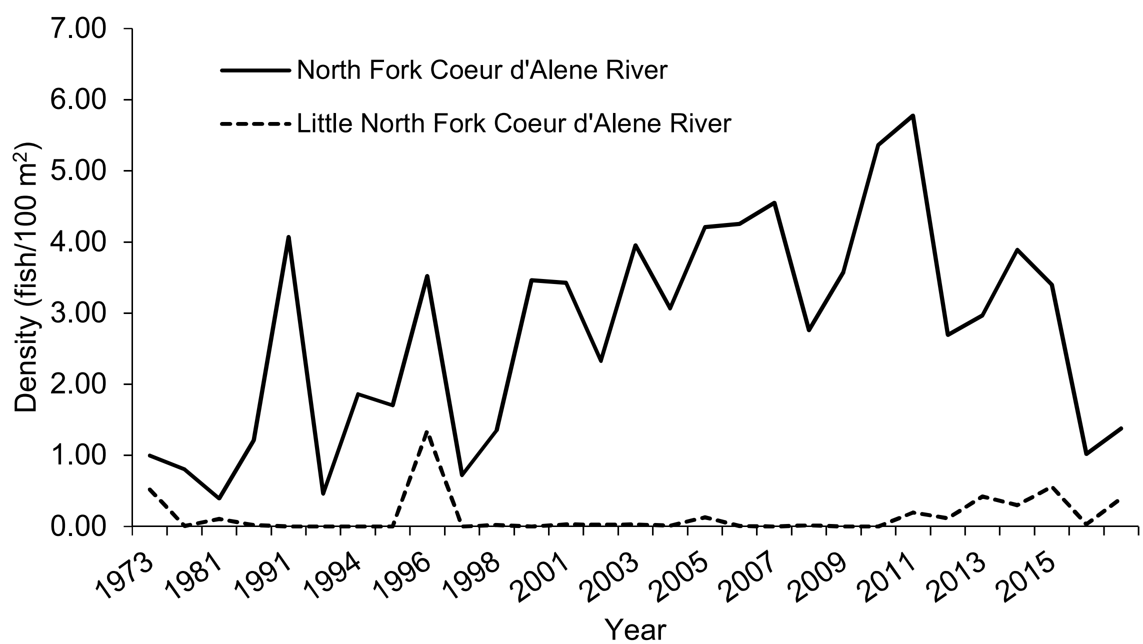

Figure 50. Mean density of Mountain Whitefish observed during snorkeling in the North Fork of the Coeur d’Alene River and Little North Fork of the Coeur d’Alene River during 1973–2017.

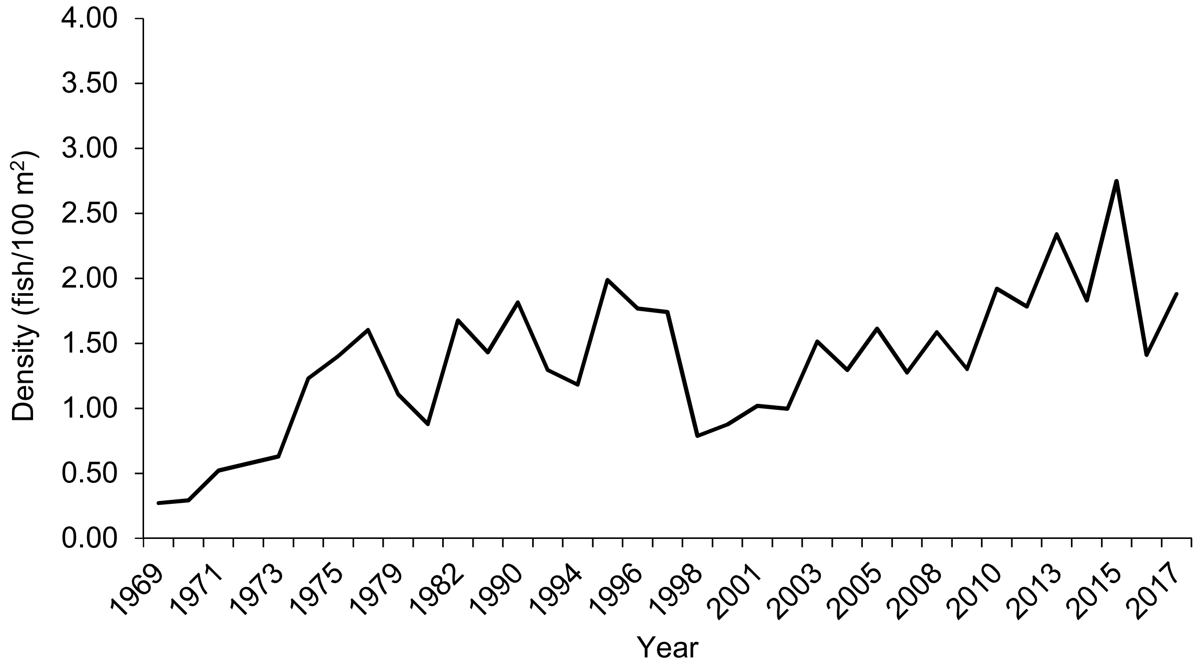

Figure 51. Mean density of Westslope Cutthroat Trout observed during snorkeling in the St. Joe River during 1969–2017.

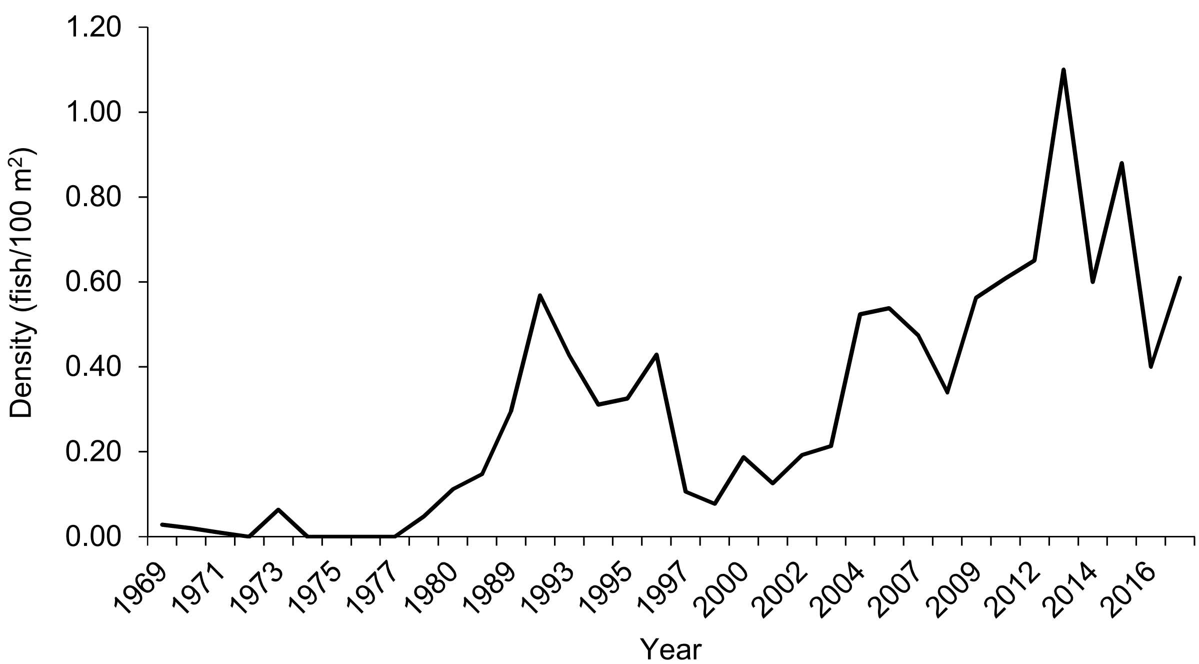

Figure 52. Mean density of Westslope Cutthroat Trout larger than 300 mm TL observed during snorkeling in the St. Joe River during 1969–2017.

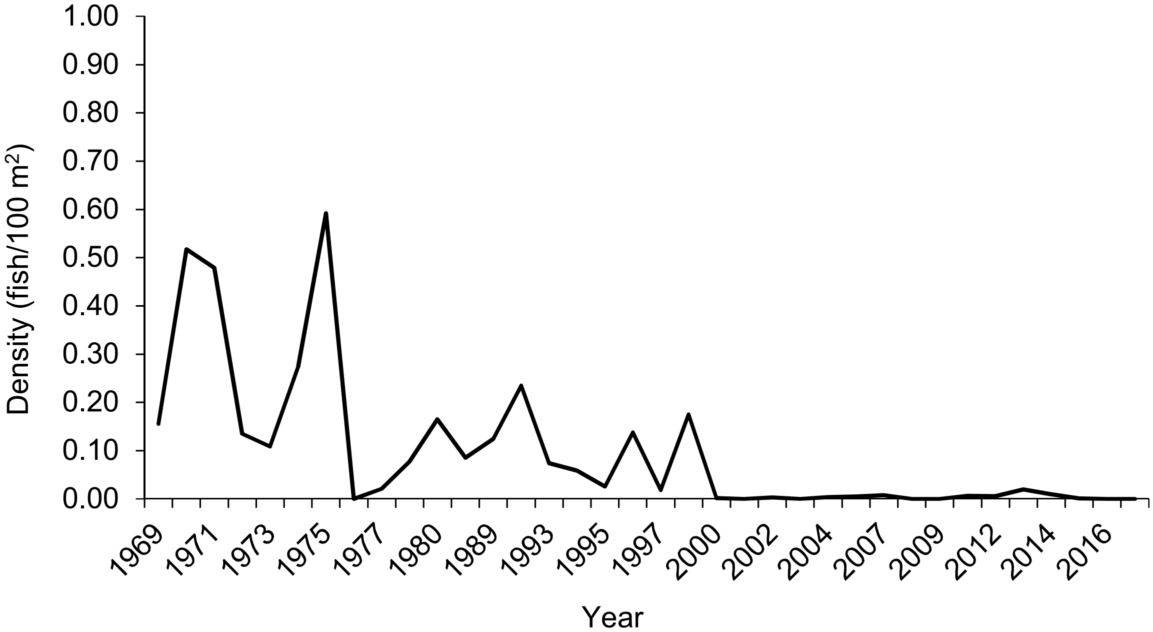

Figure 53. Mean density of Rainbow Trout observed during snorkeling in the St. Joe River during 1969–2017.

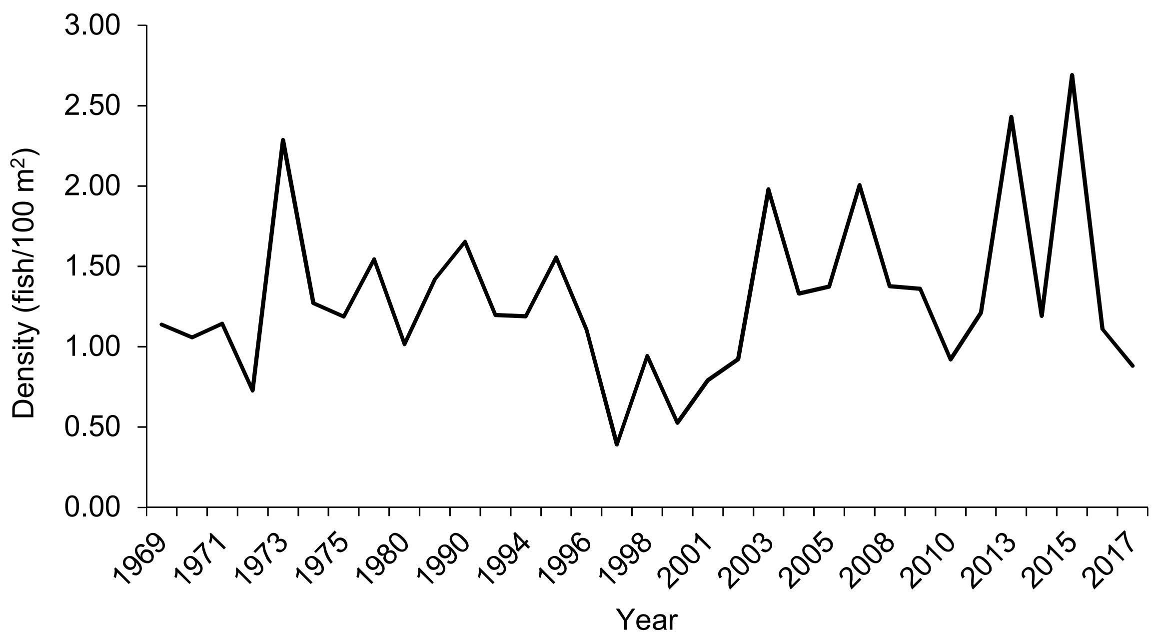

Figure 54. Mean density of Mountain Whitefish observed during snorkeling in the St. Joe River during 1969–2017.

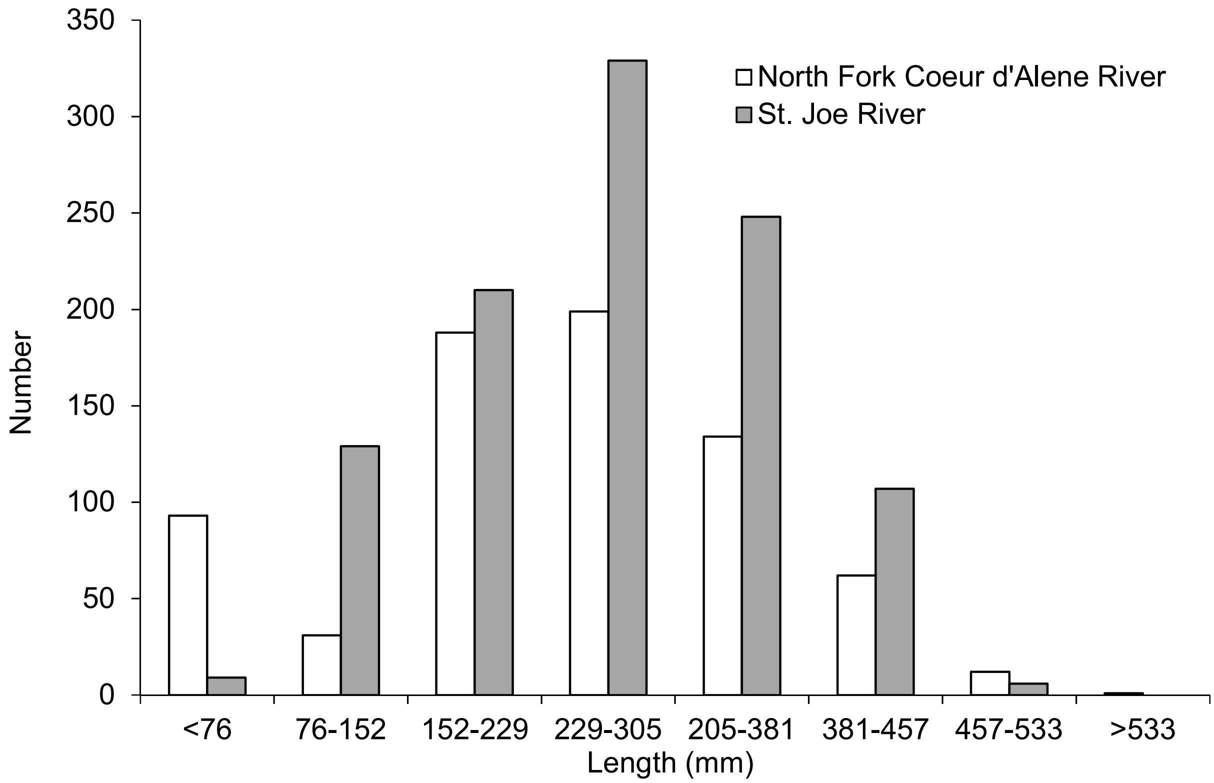

Figure 55. Length-frequency distributions of Westslope Cutthroat Trout observed during snorkeling in the North Fork Coeur d’Alene River (includes Little North Fork Coeur d’Alene River and Teepee Creek) and St. Joe River during 2017.

LAKE COEUR D'ALENE CHINOOK SALMON EVALUATIONS

ABSTRACT

We evaluated escapement of Fall Chinook Salmon *Oncorhynchus tshawytscha* to index trends in adult abundance by enumerating redds at standard index reaches of the Coeur d'Alene and St. Joe rivers. In 2017, we observed a total of 79 redds at all index reaches combined. All redds were observed in the Coeur d'Alene River and none were observed in the St. Joe River. Redd abundance decreased substantially from 2015 across all index reaches. Chinook Salmon support an important recreational fishery in Lake Coeur d'Alene and also have strong potential to alter the pelagic prey (i.e., kokanee *O. nerka*) community, necessitating continued monitoring to understand changes to the fishery.

We continued efforts to improve hatchery Fall Chinook Salmon performance. Similar to the previous three years, experimental fall outplants occurred during 2017 in Wolf Lodge We also sought to collect eggs from locally-adapted wild adults that home to tributaries of Lake Coeur d'Alene. However, too few wild Chinook Salmon eggs were collected to satisfy broodstock requirements. Efforts to improve hatchery Chinook Salmon performance should focus on utilizing locally-adapted adfluvial stocks to avoid post-smolting emigration. We recommend continuing efforts to trap adult Chinook Salmon in Wolf Lodge and other tributaries to Lake Coeur d'Alene to collect locally-adapted broodstock for hatchery supplementation.

In response to growing public interest in the use of special regulations for managing Chinook Salmon, we evaluated the potential effect of minimum length limit increases on total harvest and trophy potential. In addition, we evaluated the population stock-recruitment relationship using historical redd count data to understand the influence of adult escapement on recruitment to the fishery. Population model results indicated that relative decreases in harvest equal to 25, 38, and 55% could be expected for respective increases of 51, 102, and 152 mm in the minimum length limit at conservative levels of exploitation (20%) and conditional natural mortality (50%). In addition, the same respective rule changes have the potential to result in relative increases of 7, 17, and 25% for the number of fish attaining 711 mm. Given the tradeoffs associated with minimum length limit changes, our results show little support for regulation changes under our current understanding of public values relative to the Lake Coeur d'Alene Chinook Salmon fishery.

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INTRODUCTION

Chinook Salmon *Oncorhynchus tshawytscha* is an anadromous Pacific salmon species historically found in much of the Columbia River Basin (Wallace and Zaroban 2013). While anadromy is the natural life history form of Chinook Salmon, they have been successfully stocked into lentic systems outside of their native distribution where they exhibit adlfuvial life histories. 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.

Fall Chinook Salmon were first stocked into Lake Coeur d'Alene in 1982 as a biomanipulation tool to reduce kokanee *O. nerka* 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).

The Idaho Department of Fish and Game (IDFG) continues to utilize Chinook Salmon as one tool for managing the kokanee population in Lake Coeur d'Alene. In addition, stocking supplements the fishery by providing additional harvest opportunity and trophy fishing opportunity. The IDFG's management objective regarding Lake Coeur d'Alene has been to maintain predator stocking at a rate that does not depress the kokanee population, yet helps to achieve kokanee size structure objectives. Combinations of redd excavation and adjusting stocking have been used to regulate abundance for Chinook Salmon. Estimates of wild production have been obtained by coupling redd survey information with known egg-fry survival rates; subsequently, redds have been destroyed during some years to bring estimated production in line with objectives. Historically, Chinook Salmon redd objectives have been 100 total redds among both the Coeur d'Alene and St. Joe Rivers. During years when the objective was exceeded, redds have been excavated, and supplemental stocking has been 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, in recent years the IDFG has not excavated Chinook Salmon redds, but monitors trends in redd abundance and supplemental stocking has been maintained at ~20,000 individuals annually since 2010 to supplement harvest.

One factor that has influenced the IDFG's ability to control adult Chinook Salmon abundance in Lake Coeur d'Alene is related to performance and retention of hatchery fish. Although 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. Maiolie and Fredericks (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 near smoltification. Anglers have reported that hatchery Chinook Salmon (identified by a clipped adipose fin) were more commonly encountered during 2013–2014, suggesting that those individuals are now recruiting to the fishery at higher rates, but perhaps still at lower rates than desired by managers.

Because Chinook Salmon occur naturally with anadromous life histories, it is likely that many are entrained shortly after release. Pacific Salmon demonstrate strong homing behavior and life history fidelity. However, bypassing critical early life stages (i.e., smoltification), imprinting of juveniles, or stocking brood derived from locally-adapted individuals may be used to overcome this tendency. By stocking after smolting occurs and simulating migration from a lotic to lentic environment, managers may be able to impose an adfluvial life history on hatchery stock. Mimicking a migratory life history and imprinting juveniles to a fluvial, "natal" environment is critical for altering the life history of anadromous fishes. For example, Alaska Department of Fish and Game (ADFG) has documented low retention of anadromous fishes stocked directly into freshwater lakes. In contrast, ADFG has obtained higher retention and higher return-to-creel among groups that are held in lake tributaries, imprinted, and allowed to emigrate to the respective lake where they carry out their adult life history (Havens et al. 1987). An additional hypothesis is that smolt-related emigration can be reduced by using locally-adapted adfluvial broodstock. The utilization of locally-adapted brood has been demonstrated in many systems, especially in anadromous fish populations (Taniguchi 2003), and may likely increase retention of hatchery Chinook Salmon in Lake Coeur d'Alene.

Both kokanee and Chinook Salmon provide popular angling opportunities in Lake Coeur d'Alene. The IDFG's objective for Lake Coeur d'Alene is to manage for a kokanee yield fishery (15 fish daily bag limit) and trophy Chinook Salmon fishery (2 fish daily bag; none under 508 mm). Prior to the introduction of Chinook Salmon, nearly all (~99%) of the angling effort in Lake Coeur d'Alene has 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). Chinook Salmon are highly-desired by anglers because they often grow to trophy sizes and have very palatable flesh. As such, monitoring the Chinook Salmon population and understanding factors that regulate it is critical for providing quality angling opportunities.

OBJECTIVES

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

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

3. Evaluate alternative management scenarios for improving size structure and abundance of Chinook Salmon to address public concern about the influence of angling on the population.

STUDY AREA

Lake Coeur d'Alene is a natural mesotrophic water body located in the Panhandle of northern Idaho (Figure 1). 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 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 of 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 close 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.

METHODS

Spawner abundance

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 1) have been sampled annually sometime during late September–early October to estimate relative redd abundance. Early surveys were done via helicopter, but since 2012 surveys have been conducted by watercraft (Maiolie and Fredericks 2014). Two individuals floated the Coeur d'Alene River index reaches during October 5–6, 2017 and the St. Joe index reach during October 4, 2017 using a driftboat. 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. We compared among previous years' surveys to provide insight on trends in abundance.

Performance of supplemental Chinook Salmon

Eggs from Tule Fall Chinook Salmon were purchased from Big Creek Fish Hatchery located near Astoria, Oregon, and were hatched and reared at Cabinet Gorge Hatchery in Clark Fork, Idaho. The adipose fin was completely removed from all individuals (n = 24,070), but they were not tagged as in previous years. Hatchery individuals were stocked into Wolf Lodge Creek (Figure 1) on September 21, 2017. Hatchery Chinook Salmon were stocked post-smoltification and in an upstream location along Wolf Lodge Creek to improve homing behavior and survival. All individuals were thermal marked by Cabinet Gorge Fish Hatchery staff; marks may be used to assign sampled adults back to brood year and to differentiate among stocking strategies.

Population modeling

We used historical fishery-dependent and -independent data to understand the influence of various angling regulations on population recruitment, size structure, and total harvest. This exercise was motivated by recent public interest in evaluating the utility of special rules on population characteristics. However, due to the difficulty of sampling Chinook Salmon, we relied on past estimates of population rate functions and angler exploitation to inform models. Specifically, we drew from fishery-dependent age data collected during 2014 (Watkins et al. 2019) to estimate growth and used an estimate of angler exploitation from Fredericks et al. (2003). Fishery derived age data tends to be highly biased toward large fish (Walters 1985), and as such is not useful for estimating total annual mortality. Therefore, we relied on our knowledge of Chinook Salmon ecology to model various management scenarios over an assumed range of mortalities that we considered plausible given the characteristics of the fishery.

We used a modeling approach similar to Allen and Miranda (1995) and Isermann et al. (2002) to evaluate the effects of different minimum length limits on harvest and the number of fish reaching 711 mm total length (TL). A Beverton-Holt equilibrium yield per recruit model (Ricker 1975) was used to simulate the relative change in Chinook Salmon harvest and size structure per 1,000 recruits under different length limits. Models were constructed using the Fishery Analysis and Modeling Simulator v. 1.64 (FAMS; Slipke and Maceina 2014). Models incorporated parameters of growth, mortality, longevity, and the species specific length-weight relationship. Angler exploitation was set at 20% based on a previous evaluation (Fredericks et al. 2003) and conditional natural mortality (*cm*) was varied from 0.40–0.60. We were also interested in simulating population trajectories under the same *cm* if angler exploitation was reduced to 15%. We then compared relative differences in total harvest and the number of fish reaching 711 mm TL under minimum length limits of 559, 610, and 660 mm to the current minimum length limit (508 mm TL).

The influence of adult escapement on recruitment was also evaluated to provide insight on the influence of special regulations that may be used to improve adult abundance (Ricker 1975). Specifically, we were interested in understanding if the abundance of mature adults documented at redd count index reaches was related to adult returns from that brood year. As such, we developed a stock-recruitment relationship between the number of redds in a given year and the five-year lagged number of redds. We assumed constant rates of fishing and natural mortality in relation to abundance. We attempted to fit a Ricker stock-recruitment function to these data; however, the model would not converge, and was therefore not useful.

RESULTS

We summarized redd abundance to provide insight on adult escapement and to monitor trends in natural production. We observed a total of 105 redds at index reaches in the Coeur d'Alene River basin. Of these, we observed 76 redds in the mainstem Coeur d'Alene River between Cataldo and the confluence of the South Fork Coeur d'Alene River, and 29 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 (Table 1). We did not sample the South Fork Coeur d'Alene River during 2017 due to logistical constraints associated with low flow conditions. No redds were observed in the St. Joe River between St. Joe City and the Calder Bridge (Table 1). Chinook Salmon redd abundance decreased around three-fold between 2015 and 2017 (Figure 2).

Our modeling of minimum length limits suggested that total harvest in the Chinook fishery decreased while the number of fish reaching 711 mm increased as the minimum length limit was increased. Relative differences in both metrics increased as a function of exploitation. At μ = 20% and *cm* = 0.50, simulations resulted in relative changes in harvest equal to 25, 38, and 55% for 51, 102, and 152 mm increases in the minimum length limit (Figure 3). In addition, the same respective rule changes could result in relative increases of 7, 17, and 25% for the number of fish attaining 711 mm (Figure 4). Again, relative changes in trophy potential were less substantial when μ was decreased to 15% (Figure 4).

DISCUSSION

The wild Chinook Salmon fishery has increased in abundance over the past decade, although 2017 produced somewhat marginal angling by anecdotal assessment. The combination of several factors (i.e., stable environmental conditions, abundant kokanee forage) has likely allowed the population to rebound from the low abundances observed in the late-1990s (Watkins et al. *in review*). The most recent redd survey (fall 2017) showed that adult escapement was slightly below the long-term average (mean = 82 redds).

The Chinook Salmon fishery in Lake Coeur d'Alene has historically been supported almost entirely by naturally-produced individuals. Anecdotal evidence from anglers suggests that age-1 and age-2 adipose-clipped individuals have been more common in the fishery in recent history. The IDFG has made the following advances in Chinook Salmon rearing and stocking which may be contributing to improved performance of hatchery individuals: 1) Fall Chinook Salmon rearing has been moved from Nampa Hatchery to Cabinet Gorge Hatchery where rearing temperatures are colder and the transport distance to Lake Coeur d'Alene is shorter, and 2) size-at-release has been improved by switching from spring to fall stocking. The combination of changes in rearing and release timing are expected to improve survival of hatchery fish; however, we will be unable to fully-quantify the effect of these management actions until 2014 outplants recruit to the fishery. While the direct results of these actions are difficult to substantiate, we cannot attribute this change in occurrence of hatchery individuals to any other major management changes. This is consistent with previous studies showing that performance of hatchery fish is often directly related to length-at-release where larger individuals typically exhibit higher survival and return-to-creel than their smaller counterparts (Henderson and Cass 2011).

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 and Fredericks 2013; Maiolie and Fredericks

2014), but no work has sought to understand retention of hatchery-origin Chinook Salmon and whether post-release emigration may be a limiting factor. Future work will be aimed at evaluating relative return-to-creel by comparing stocking strategies that are hypothesized to improve retention. Anglers often catch adipose-clipped Chinook Salmon in Lake Roosevelt which have presumably emigrated from Lake Coeur d'Alene and become entrained in that reservoir (William Baker, Washington Department of Fish and Wildlife, personal communication). These occasional reports 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 (Koenig et al. 2015). This raises serious concern about post-release retention of hatchery stock and its effect on return-to-creel. 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. Improving retention will likely require the use of a method that imposes an adfluvial life history on hatchery individuals, or require the use of a landlocked, adfluvial stock (i.e., Lake Coeur d'Alene) for hatchery production.

A segment of anglers interested in Lake Coeur d'Alene Chinook management has recently expressed concern about the current status of the fishery and the prospect of angling regulation changes that may be used to increase abundance and size structure of Chinook. Although redd count data suggests that wild fish abundance is near the long-term mean, the dearth of hatchery fish contributing to the fishery in recent years (i.e., 2011–present) has almost certainly resulted in lower angler catch rates and reduced angler satisfaction. As such, public interest has focused on management mechanisms that address the wild rather than hatchery component of the fishery. While this is an understandable concern given the performance of hatchery salmon in the last decade, the rule changes addressing harvest of wild fish would be futile. Indeed, at levels of expected angler exploitation, an appreciable increase in size structure could be realized by Chinook anglers, but only with drastic changes in the minimum length limit. Because *cm* is thought to be very high and μ is moderate, the natural mortality rate is more important than harvest, thus negating the benefit of protecting fish for longer periods of time. Annually, around 80% of Chinook Salmon in Lake Coeur d'Alene mature at age-4 and are typically between 550–905 mm (mean = 731 mm) at that time (Watkins et al. 2020). As such, a minimum length limit increase of 152 mm from the current regulation would protect the majority of fish in the population from harvest. Theoretically, only late-maturing and fast growing individuals would be available for harvest under that scenario and such individuals would recruit to the harvest portion of the fishery within less than one year of maturity. Currently, the vast majority of harvest focuses on age-3+, but also fast-growing age-2 fish. Under assumed natural mortality of Chinook Salmon, protecting fish for another year would substantially compromise total harvest for limited size structure gains, and reasonable size restriction changes (i.e., 51 or 102 mm increase) would result in relative differences in fish reaching 711 mm that may not even be realized by anglers.

Our analysis of stock-recruitment dynamics resulted in little support for implementing adult Chinook protections or otherwise increasing escapement. Although stock-recruitment models did not converge, even the linear relationship between spawner stock and the five year lagged spawner stock showed no relationship. Because recruitment tends to decline past threshold spawner stock sizes in most fish populations (Ricker 1954), a linear relationship can often be reasonably expected. However, *post hoc* analyses of our stock-recruitment data showed that even at low to moderate spawner stock abundances, concomitant increases in recruitment would

not be expected. Overall, the stock-recruitment relationship appears to be completely random whereby very low spawner stock abundance may result in robust year classes and vice versa (Figure 5). While this phenomenon is not uncommon in salmon populations, it is perceived as inconceivable to many anglers. A variety of environmental factors may limit recruitment in the Lake Coeur d'Alene system, and those factors are poorly understood by fishery managers. It is hypothesized that winter flow conditions in spawning tributaries, spawning habitat quality, and entrainment may be important factors influencing recruitment to the fishery; however, the relative importance of those factors is currently unknown. We recommend that future assessments focus on using historical stock-recruitment data to understand relationships with environmental conditions. While management actions relative to such conditions may be limited, the benefit to the public could be great. A more holistic understanding of Chinook Salmon population dynamics will likely help to redirect public energy toward management actions (e.g., hatchery stock performance) that will result in appreciable differences to angling.

RECOMMENDATIONS

1. Continue evaluation of hatchery Chinook Salmon performance; specifically, the influence 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.

3. Maintain current angling regulations (i.e., 2 fish daily bag, none under 508 mm TL) for Chinook Salmon on all water bodies in the Panhandle Region.

4. Update estimates of natural and fishing mortality in the Chinook Salmon population to better reflect current biological and social conditions.

Table 29. 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. Only reaches with a long time series of information used to index Chinook Salmon redd abundance are included.

		Year				
Reach	Description	2017	2016	2015	2014	2013
	Coeur d'Alene River					
CDA 1	Cataldo to S.F. Coeur d'Alene River confluence	61	76	210	104	108
CDA 2	S.F. to L.N.F Coeur d'Alene River confluence	18	29	68	62	2
CDA 3	S.F. Coeur d'Alene River	--	--	10	4	14
	St. Joe River					
SJR 1	St. Joe City to Calder bridge	0	0	15	9	4

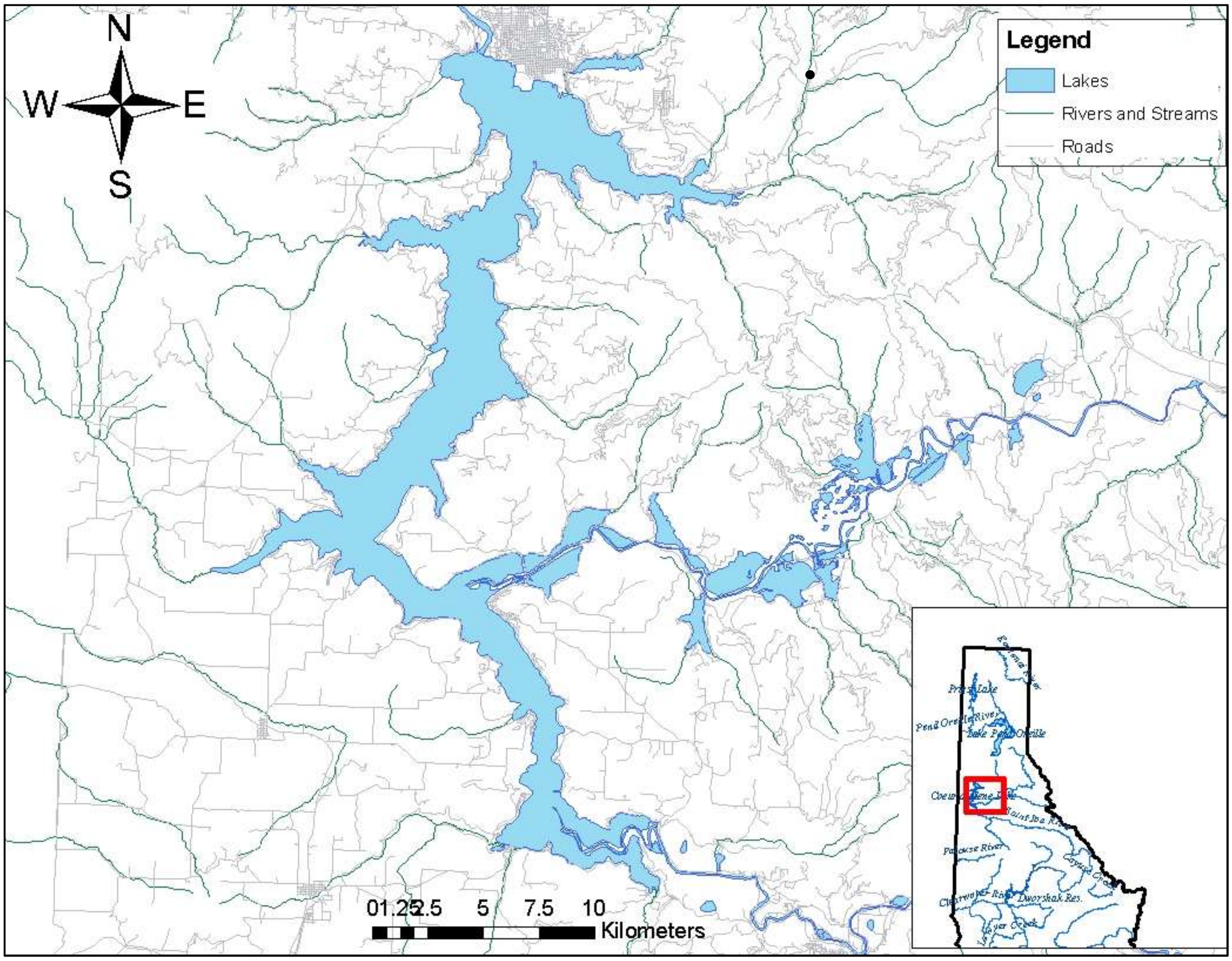

Figure 56. Location of Lake Coeur d'Alene, Idaho. The black dot on Wolf Lodge Creek represents the location of where juvenile hatchery Chinook Salmon were released.

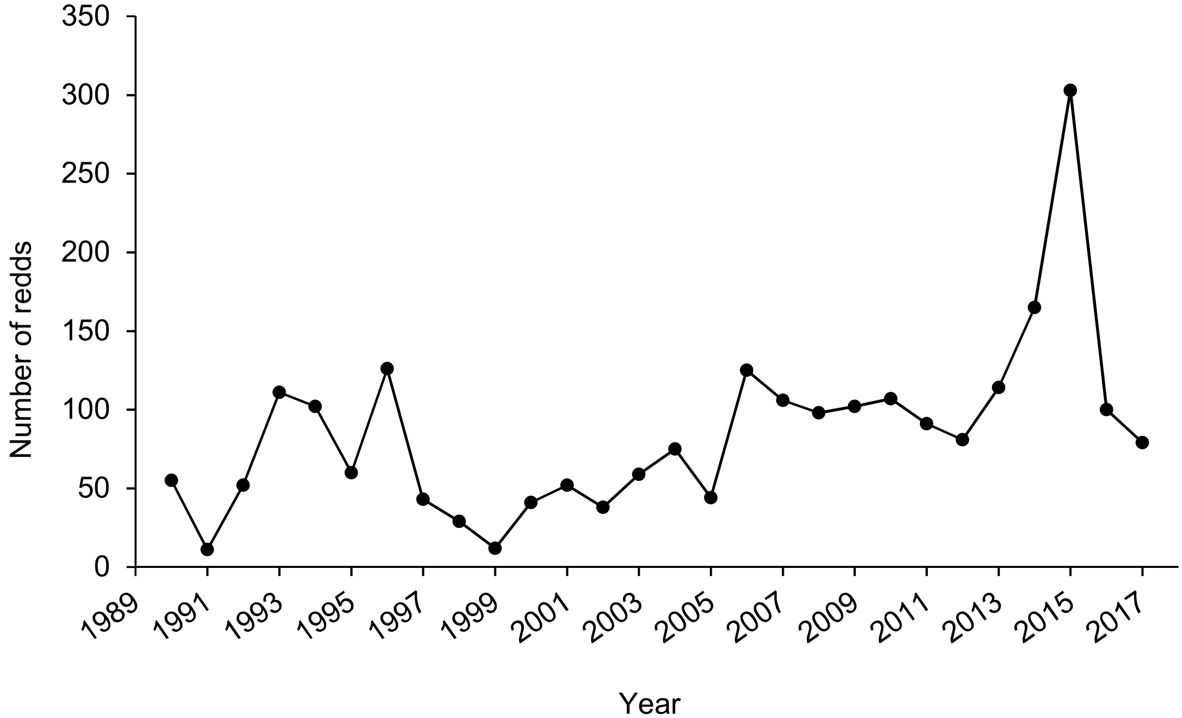

Figure 57. Number of Chinook Salmon redds counted during sampling of index reaches in the Coeur d'Alene River and St. Joe River from 1990–2017.

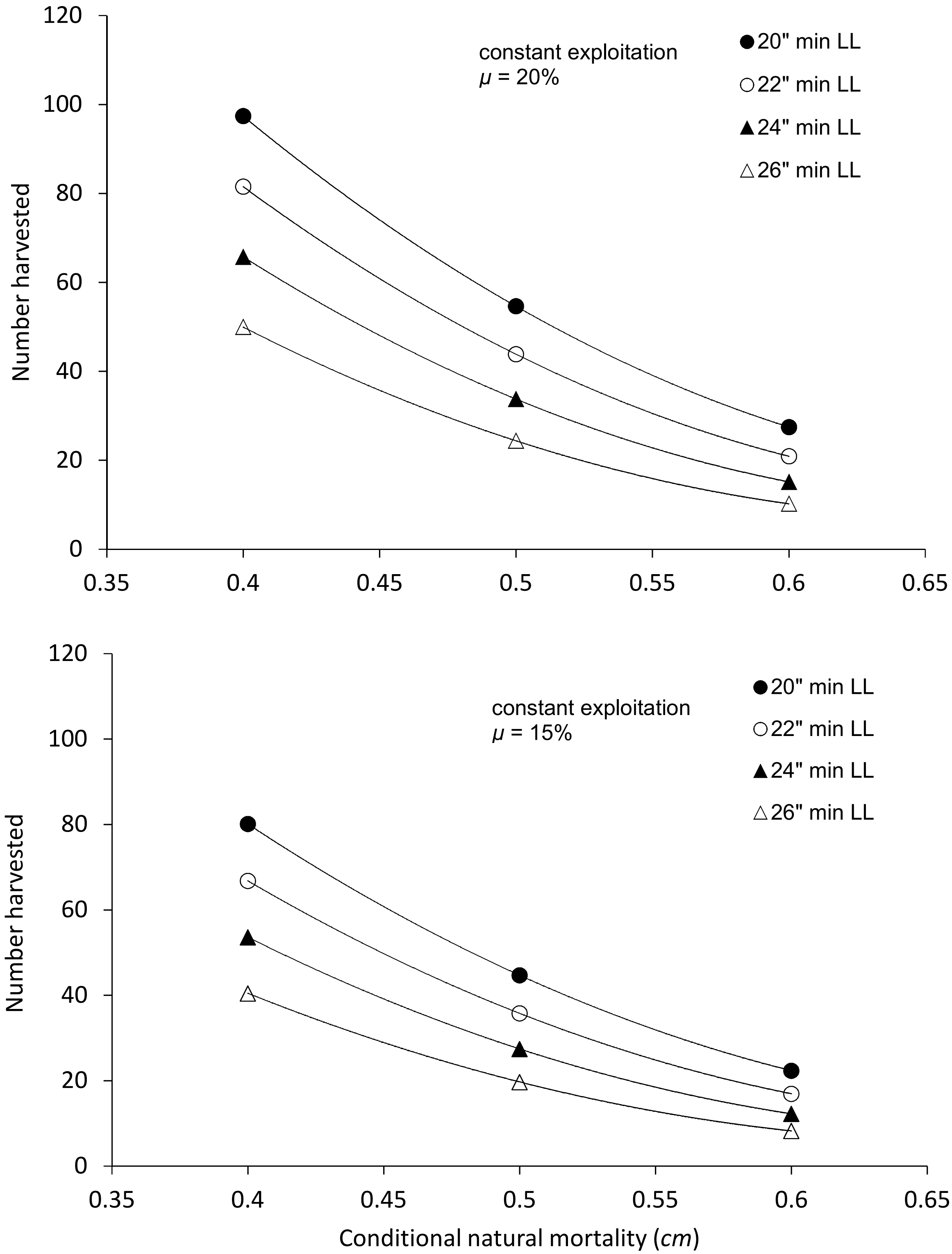

Figure 58. The simulated effect of alternative minimum length limit scenarios on the number of Chinook Salmon harvested by anglers in Lake Coeur d'Alene under constant rates of 20% (top panel) and 15% (bottom panel) angler exploitation.

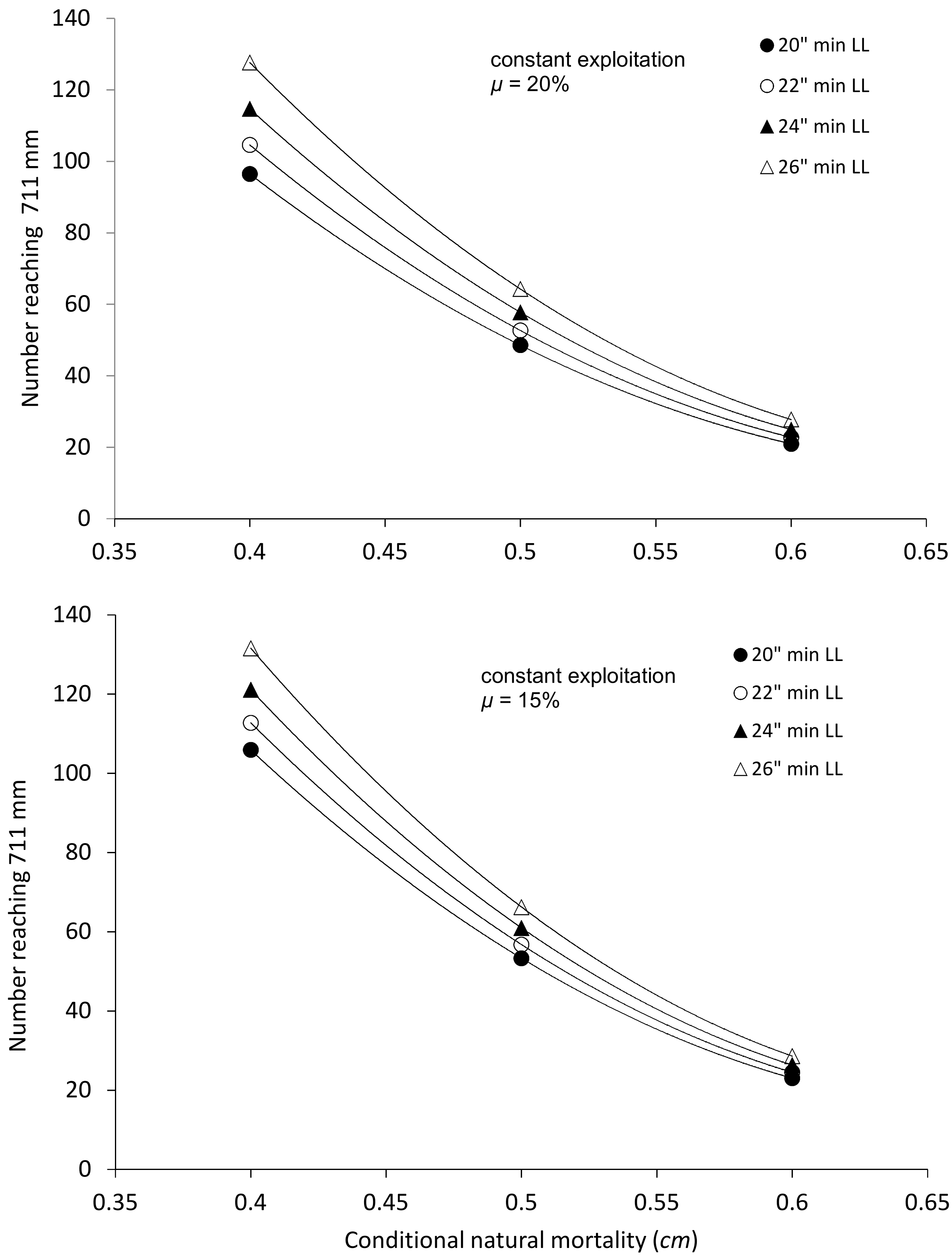

Figure 59. The simulated effect of alternative minimum length limit scenarios on the number of Chinook Salmon reaching 711 mm TL in Lake Coeur d'Alene under constant rates of 20% (top panel) and 15% (bottom panel) angler exploitation.

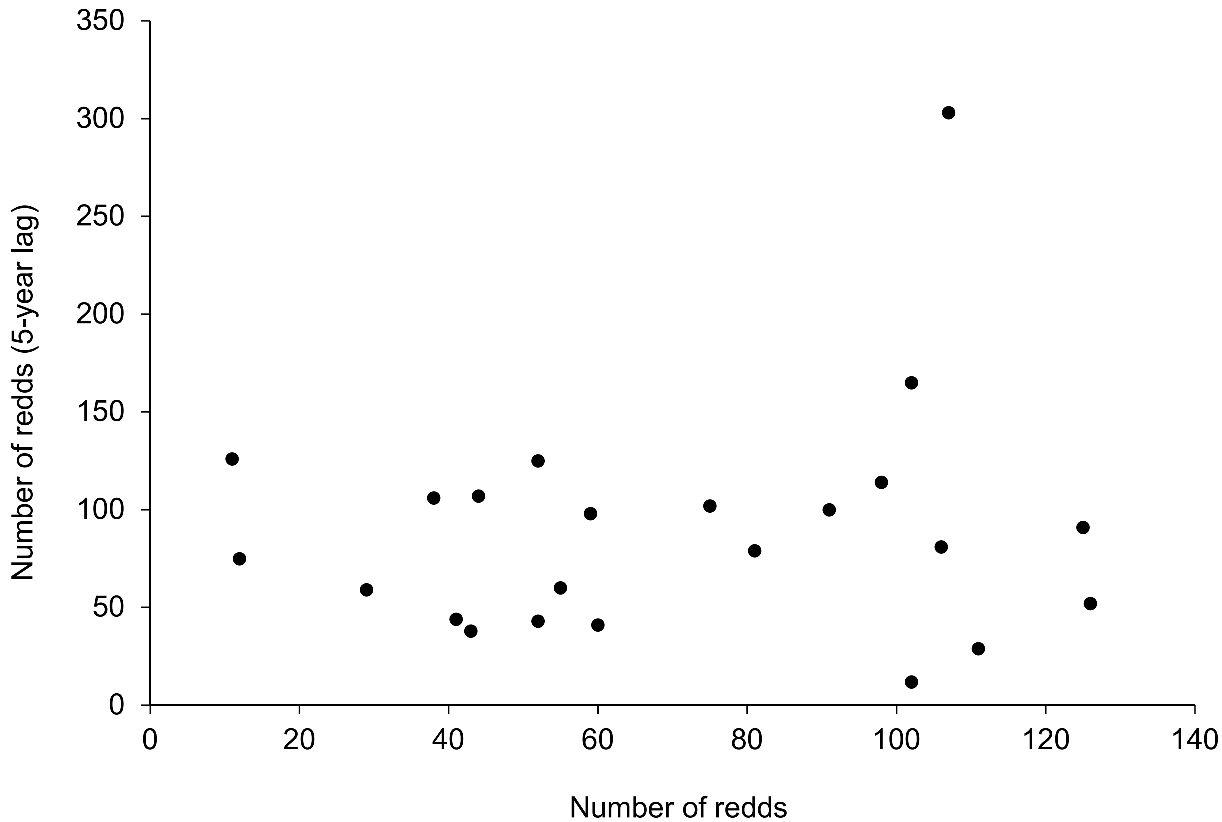

Figure 60. Stock-recruitment relationship for Chinook Salmon as indexed by total redd count plotted against the 5-year lagged total redd count.

COEUR D'ALENE LAKE TRIBUTARY INVENTORY

ABSTRACT

We sampled direct 2nd–4th order tributaries to Lake Coeur d'Alene during the summer of 2017 to assess fish assemblage structure and species distribution. Sampling transects were established at 3-km intervals along each stream and backpack electrofishing was used to capture fishes. Habitat information was collected to characterize the physical properties of the study streams, and also to understand interactions within the fish-habitat-landscape system. We sampled a total of 28 sites throughout the ten streams included in the study. We sampled a total of 1,086 fishes representing three species and two families. Westslope Cutthroat Trout were detected at all sites and were the most abundant species. Mean density of Westslope Cutthroat Trout varied from 0.3–19.0 fish/100 m^2. Size structure of Westslope Cutthroat Trout was also variable among streams, suggesting that a diversity of life history strategies (e.g., adfluvial, fluvial migrant) exist in small direct tributaries to Lake Coeur d'Alene. Cedar Sculpin were the second most abundant species and were detected in all streams except Beauty, Blue, Carlin, and Turner creeks. Brook Trout were only detected in the Wolf Lodge Creek drainage (i.e., Wolf Lodge, Marie, and Cedar creeks). Brook Trout were not detected in the South Fork Mica and Cougar creek drainages where they have historically been found or known to occur. In general, our findings suggest that Westslope Cutthroat Trout still occupy much of the same distribution throughout direct tributaries to Lake Coeur d'Alene, and their abundance has likely increased in some tributaries. Brook Trout distribution has not increased and their abundance remains relatively low in the Wolf Lodge Creek basin. Patterns in habitat characteristics were generally consistent among streams, except with respect to instream and terrestrial cover, and substrate. Cougar and South Fork Mica creeks exhibited the most variation from other streams in that those systems tended to have more cover and higher proportions of fine substrates at our sampling sites. The high relative proportion of fine substrate suggested that sedimentation was occurring from upland areas in the drainages. Substrate composition did not associate with canopy cover nor land use in areas adjacent to our sampling sites, suggesting that direct sediment sources were likely diffuse and widespread. Westslope Cutthroat Trout densities tended to be lowest in drainages with high residential development, but high or stable (from previous surveys) in other drainages, including those with extensive timber harvest. We postulate that rural residential development and resource use likely have a strong negative influence on native fishes in the Lake Coeur d'Alene basin because of its diffuse and permanent disturbance on the landscape. Future monitoring should focus on assessing changes in fish communities in drainages with high rates of development. Further, management may seek to identify opportunities to work with land and infrastructure managers to identify fish conservation measures and mitigation techniques to minimize human disturbance to fishes in the basin.

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INTRODUCTION

Lake Coeur d'Alene is the second largest natural lake in the Idaho Panhandle and it supports a uniquely diverse and popular sport fishery. The Lake Coeur d'Alene system provides important habitat for native Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* that exhibit both fluvial and adfluvial life histories (Behnke 1992; Wallace and Zaroban 2013). Westslope Cutthroat Trout populations have declined in recent history due to a variety of factors related to human activity on the landscape (Brown and Krygier 1970; Corn and Bury 1989) and changes to fish assemblage structure (Walrath et al. 2015). In the small, direct tributaries to Lake Coeur d'Alene, the primary sources of disturbance to native fish populations often derive from logging and residential and infrastructure development. In this study, we sought to assess populations of native fishes in small tributaries to Lake Coeur d'Alene, and also to understand fish community structure. Documenting the presence of nonnative Brook Trout *Salvelinus fontinalis* was of particular importance because the species is known to compete with native salmonids in western North America (Marnell 1988). An additional component of this study was to understand the role of habitat in structuring fish assemblages and providing suitable habitat for Westslope Cutthroat Trout. Kootenai County and the area surrounding Lake Coeur d'Alene has seen a dramatic increase in urban and rural residential development, and disturbance and associated land and water use have strong potential to negatively influence stream habitat and native fishes. As such, human development necessitates resource monitoring to inform decisions about planning and management.

OBJECTIVES

1. Assess fish community structure in tributaries to Lake Coeur d'Alene.

2. Evaluate Westslope Cutthroat Trout distribution within Lake Coeur d'Alene tributaries.

3. Describe habitat in Lake Coeur d'Alene tributaries

4. Investigate the influence of land-use activities on fish community structure in Lake Coeur d'Alene tributaries.

METHODS

Fishes were sampled from ten tributaries to Lake Coeur d'Alene (Figure 1) during July–August of 2017 when water discharge permitted safe wading. Tributaries within the boundaries of the Coeur d'Alene Indian Reservation were not sampled. The mainstem length of each stream was measured and sample locations were then selected systematically at 3-km intervals between the inlet and headwater origin. Near the location of each site, reaches were identified based on major macrohabitat transitions between riffles extending between 100–200 m in length. Backpack electrofishing was used to capture fishes. Electrofishing equipment consisted of a Smith-Root model LR-24 electrofisher (Smith-Root, Inc., Vancouver, Washington, USA) using pulsed-DC current set to 600–800 v and 40–50 hz depending on water conductivity and temperature (Miranda 2009). During sampling, one person operated the electrofishing equipment and two netters collected immobilized fish adjacent to the operator. Sampling consisted of a single upstream electrofishing pass, beginning and ending at transitions to riffle macrohabitats. Upon completion of each reach, all fishes were identified to species and measured for total length (TL).

Surface area (m^2) was estimated at each site to provide a measure of sampling effort. The number of each species observed was divided by the surface area sampled to provide a standardized relative abundance measure (DuPont et al. 2009).

Habitat information was collected to understand the influence of abiotic factors on fish assemblage structure and species relative abundance. Depth, wetted width, substrate composition, bank type, and woody debris were measured within each reach following fish sampling. Habitat sampling transects were established at 10-m intervals along each reach and instream variables were measured at 1-m^2 areas around five equidistant points along each transect. Depth was measured to the nearest 0.1 m and substrate was visually estimated as the proportion belonging to one of five categories: silt–sand (< 0.0004–0.2 mm), gravel (0.2–64.0 mm), cobble (64.0–256.0 mm), boulder (> 256.0 mm), and bedrock (modified from Orth and Maughan 1982). The proportion of both banks belonging to the following four categories was also visually estimated: eroding, vegetated, silt–sand (0.2 mm), and cobble–boulder (i.e., riprap structure; 64.0 mm). The amount of woody debris was calculated as the total surface area of woody instream cover that was greater than 0.2 m in diameter and greater than 0.5 m in length (Watkins et al. 2015).

RESULTS

A total of 1,085 fish was collected among the 28 sites and was comprised of 580 Westslope Cutthroat Trout, 444 *Cottus* Spp., and 61 Brook Trout. Westslope Cutthroat Trout were present at every sample site and had a mean TL of 92 mm (range = 199 mm; Table 1). Westslope Cutthroat Trout were the only species whose presence was detected in Beauty, Blue, Carlin, and Turner creeks. Relative abundance of Westslope Cutthroat Trout increased significantly in North Fork Mica Creek and decreased insignificantly in South Fork Mica Creek between our survey and a 2002 survey (Liter et al. 2007). Presence of Brook Trout was detected in Cedar, Marie, and Wolf Lodge creeks, which all drain into the Wolf Lodge subbasin (Figure 1; Table 1). Carlin, Blue, and Turner creeks exhibited the three highest densities of Westslope Cutthroat Trout among all tributaries, while Cougar, Marie, and Wolf Lodge creeks exhibited the lowest densities (Table 1). Summarized size structure information on each species can be found in Table 1 and Figures 2–4.

Habitat variables (Table 2) were estimated in each stream to provide insight on the variability in physical characteristics. The study streams showed some patterns of congruence in terms of habitat structure and longitudinal variability. Mean wetted stream width was similar amongst most streams, with the exception of North Fork Mica, Marie, and Wolf Lodge creeks which had high (i.e., mean = 5.0 m) stream width (Table 3). The streams with high mean width also exhibited high variability in width across sites. Mean water depth and its associated variance was similar among all streams. The most substantial differences in habitat were for instream and terrestrial cover and substrate metrics. Nearly all streams exhibited moderate to high proportions of coarse substrate and low proportions of fine substrate, except Cougar and South Fork Mica creeks. The proportion of fine substrate in both of these streams was more the twice that of any other study stream (Table 3). Estimates of instream and terrestrial cover were higher for these streams as well. The proportion of fine substrate did not associate with estimated proportion of instream nor riparian canopy cover. In general, riparian vegetation provided more cover for fish than instream structure among most streams.

DISCUSSION

This study was largely motivated by a need to acquire baseline fish population and habitat data that could be used to inform current and future land and water use and development projects in the basin. The drainages surrounding Lake Coeur d'Alene have changed substantially over the past century, largely due to increased incidence of land use (primarily timber harvest) and development in rural and urban portions of the watershed. Rural residential development and the associated infrastructure needs are of particular concern from a fish habitat perspective because it represents permanent and diffuse disturbance across the landscape (Theobald et al. 1997; Gude et al. 2006). Urban development tends to be concentrated in space, resulting in local impacts with well-defined environmental effects. Often, those impacts are easily measured and mitigation systems are sometimes in place to address such impacts. However, the consequences of rural residential development to fishery resources are less predictable and often difficult to quantify (Lewis et al. 2009). While human population growth, in and of itself, negatively influences fishery resources largely because of land disturbance and water use, diffuse development relative to population growth is often more important because it represents widespread, rather than local, landscape disturbance. The area surrounding Lake Coeur d'Alene has been subject to high human population growth, particularly during the past three decades. Although much of the associated residential development to support that population has centered in urban and suburban portions of the region, rural growth throughout Kootenai County has increased at an unusually high relative proportion, similar to many areas in the West (Gude et al. 2006). As such, the use of best management practices associated with development and land use, and basic fish habitat conservation, are more important than ever. Thoughtful implementation of habitat projects and consultation of development relative to fish and wildlife impacts will hinge on the availability of current data.

The streams that we surveyed in this study exhibited habitat composition suitable for supporting native salmonids. Accordingly, all streams were occupied by Westslope Cutthroat Trout which likely derive from a combination of fluvial and adfluvial production. Westslope Cutthroat Trout occurred in all drainages, although not detected at every sampling site. Our sampling detected Brook Trout in only the Wolf Lodge Creek basin, but Brook Trout have historically occupied the Mica (Liter et al. 2007) and Cougar creek basins. It is likely that Brook Trout still occupy the Mica Creek Basin, and that our sampling failed to detect its presence. However, from anecdotal observations of the Mica Creek drainage, it appears that very little Brook Trout (Behnke 1992) habitat is available, thus potentially limiting abundance. On the other hand, Cougar Creek appears to possess more of the physical habitat characteristics consistent with Brook Trout presence (i.e., low flow velocity, high abundance of pool macrohabitats), particularly throughout the lower one-third of the drainage.

Densities of Westslope Cutthroat Trout tended to exhibit similar patterns with respect to development, whereby sites subject to intensive nearby development supported the lowest Westslope Cutthroat Trout densities. For example, Cougar, Marie, and Wolf Lodge creeks had some of the lowest mean Westslope Cutthroat Trout densities. Cougar and Wolf Lodge creeks, in particular, exhibited low proportions of instream and terrestrial cover, and tended to be warmer on average. In these two systems, habitat alterations consistent with residential development were common—banks were typically stabilized with manmade structure and riparian areas were largely transformed and lacked woody perennial vegetation. Contrary to patterns observed in areas of intense residential development, patterns associated with land use (primarily timber harvest) were not evident. In fact, the highest Westslope Cutthroat Trout densities were observed in drainages where land ownership was largely private and(or) state-owned, where forests were intensively managed for harvest. We observed relatively high densities of Westslope Cutthroat

Trout in Carlin and Turner creeks where recent large-scale timber harvest activities had occurred. In most cases, sites located near clear-cut areas had instream and riparian habitat characteristics uncommon of streams in intensively logged watersheds. This patterns was almost certainly an outcome of adherence to Idaho Forest Practices Act guidelines (IDL 1974) because we found that riparian buffers were present in nearly all areas along streams where the associated uplands were logged. Instream habitat near logged areas did not exhibit signs of excessive sedimentation or unusual hydrography (i.e., absence of instream roughness barriers, bank erosion).

It is likely that instream and riparian area stability support habitat characteristics important for supporting Westslope Cutthroat Trout in the Lake Coeur d'Alene system. Watersheds having actively managed timber resources exhibited moderate to high relative abundance of Westslope Cutthroat Trout, and that pattern can likely be attributed to favorable land use practices. In general, our results suggest that broad-scale disturbance may be relatively unimportant for influencing Westslope Cutthroat Trout under land use actions that support and safeguard instream and riparian habitat. These circumstances are almost never consistent with residential development because it is associated with persistent human activity and functions in complete contrast to timber management. Developed areas were almost always characterized by armored banks, denuded riparian areas, and noxious vegetation. In addition, livestock were commonly associated with developed areas and contributed to bank destabilization and upland erosion (Kauffman and Krueger 1984).

Because residential development represents a permanent change in the landscape, it is a local conservation issue to many fish and wildlife populations (Theobald et al. 1997; Gude et al. 2006). With respect to aquatic animal populations, development is of particular concern because the associated human activity causes disruptions to habitat because of both land and water use. The changes to terrestrial areas that either directly or indirectly affect aquatic systems are well-recognized by fishery scientists and are often cited for alterations to salmonid habitat (Shepard et al. 2005). However, because rural residences typically utilize groundwater for domestic and agricultural purposes, the hydrography of streams can be directly altered by mechanisms related to water extraction and transformation (Van Sickle et al. 2004).

From our understanding of previous research and the study herein, it appears that rural development in the Lake Coeur d'Alene basin will be an important factor influencing native fish conservation into the future, especially as it relates to land and water use. We recommend continued monitoring on 10 year intervals to reassess fish assemblage structure and habitat condition in the same study streams. Follow-up sampling should apply a similar design and approach in order to draw meaningful temporal and spatial comparisons. Quantitative measures of land and water development and trends in use may also be warranted to assess relationships between human activity and native fish persistence.

RECOMMENDATIONS

1. Where appropriate, collaborate with private landowners and governmental agencies to identify opportunities to improve salmonid habitat, primarily in South Fork Mica, Marie, Wolf Lodge, and Cougar creeks.

2. Conduct follow-up monitoring during 2027 to reassess fish community assembly and habitat.

Table 30. Sample size (*n*), total length (mm; Minimum–Maximum [Min–Max]) statistics, and density (fish/100 m^2) for fish populations sampled from tributaries to Lake Coeur d'Alene (2017). Numbers in parentheses represent one standard error about the mean.

		Total length		
Species	*n*	Mean	Min–Max	Density
Beauty Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	0	--	--	0.0 (0.0)
Westslope Cutthroat Trout	42	106.8 (5.3)	36–180	5.3 (1.5)
Blue Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	0	--	--	0.0 (0.0)
Westslope Cutthroat Trout	66	53.0 (3.0)	30–137	15.9 (7.7)
Carlin Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	0	--	--	0.0 (0.0)
Westslope Cutthroat Trout	159	88.5 (2.9)	33–215	19.0 (6.2)
Cedar Creek				
Brook Trout	4	202.8 (43.3)	78–275	0.6 (0.5)
Cedar Sculpin	92	61.5 (1.6)	32–105	15.6 (2.9)
Westslope Cutthroat Trout	54	70.5 (5.6)	31–183	7.4 (2.5)
Cougar Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	2	57.5 (1.5)	56–59	0.3 (0.2)
Westslope Cutthroat Trout	27	142.9 (7.1)	101–228	3.3 (1.3)
Marie Creek				
Brook Trout	27	129.0 (9.1)	51–229	1.9 (0.9)
Cedar Sculpin	123	57.3 (1.1)	27–93	8.7 (1.6)
Westslope Cutthroat Trout	20	114.6 (7.6)	43–197	1.4 (0.6)
North Fork Mica Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	46	74.2 (2.7)	16–116	3.6 (1.8)
Westslope Cutthroat Trout	115	104.7 (3.8)	40–202	9.1 (3.4)

Table 30 (continued)

Species	*n*	Total length		Density
		Mean	Min–Max	
South Fork Mica Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	21	52.2 (4.9)	19–90	3.1 (1.5)
Westslope Cutthroat Trout	48	91.2 (5.2)	29–181	7.0 (4.9)
Turner Creek				
Brook Trout	0	--	--	0.0 (0.0)
Cedar Sculpin	0	--	--	0.0 (0.0)
Westslope Cutthroat Trout	60	97.8 (5.1)	38–168	17.3 (10.0)
Wolf Lodge Creek				
Brook Trout	30	143.7 (12.0)	52–330	1.8 (2.3)
Cedar Sculpin	160	65.3 (1.5)	36–117	9.4 (2.9)
Westslope Cutthroat Trout	5	83.6 (31.4)	33–200	0.3 (0.3)

Table 31. Descriptions of habitat variables summarized to assess abiotic conditions in tributaries to Lake Coeur d'Alene (2017).

Variable	Description
Width	Mean wetted width (m)
Depth	Mean water column depth (m)
$Substrate_{Fine}$	Proportion of substrate (%) consisting of fine particles (≤2 mm diameter)
$Substrate_{Coarse}$	Proportion of substrate (%) consisting of coarse particles (≥64 mm diameter)
$Cover_{Instream}$	Proportion of overhead submerged cover (%) provided by large substrate or woody debris
$Cover_{Canopy}$	Proportion of wetted transect width with overhanging vegetation

Table 32. Mean estimates (SEs in parentheses) of the habitat variables measured at sampling sites in tributaries to Lake Coeur d'Alene (2017).

	Variable					
Stream	Width (m)	Depth (m)	$Substrate_{Fine}$ (%)	$Substrate_{Coarse}$ (%)	$Cover_{Instream}$ (%)	$Cover_{Canopy}$ (%)
Beauty Creek	2.7 (0.2)	0.3 (0.2)	2.2 (0.8)	47.4 (4.2)	13.5 (2.1)	9.0 (1.6)
Blue Creek	2.1 (0.2)	0.1 (0.01)	3.5 (1.8)	73.0 (3.0)	10.0 (4.2)	32.0 (5.2)
Carlin Creek	2.6 (0.2)	0.1 (0.02)	10.0 (4.9)	47.1 (5.6)	19.3 (2.6)	32.8 (4.5)
Cedar Creek	2.5 (0.2)	0.1 (0.01)	17.0 (2.6)	52.3 (3.9)	6.3 (2.0)	31.8 (5.0)
Cougar Creek	2.6 (0.1)	0.2 (0.01)	39.0 (7.5)	30.0 (6.1)	7.9 (1.0)	17.1 (2.9)
Marie Creek	5.2 (0.3)	0.2 (0.01)	2.0 (0.9)	74.7 (1.4)	12.7 (2.9)	40.0 (4.6)
North Fork Mica Creek	4.7 (0.6)	0.2 (0.01)	16.3 (1.8)	67.3 (2.0)	14.3 (2.7)	29.8 (3.7)
South Fork Mica Creek	2.4 (0.1)	0.2 (0.01)	56.0 (7.1)	20.0 (5.6)	25.3 (3.3)	39.3 (5.3)
Turner Creek	1.5 (0.1)	0.1 (0.01)	0.0 (0.0)	67.5 (3.7)	19.5 (5.9)	17.5 (4.2)
Wolf Lodge Creek	5.1 (0.4)	0.2 (0.01)	6.2 (1.7)	69.5 (2.4)	10.3 (2.9)	10.8 (2.2)

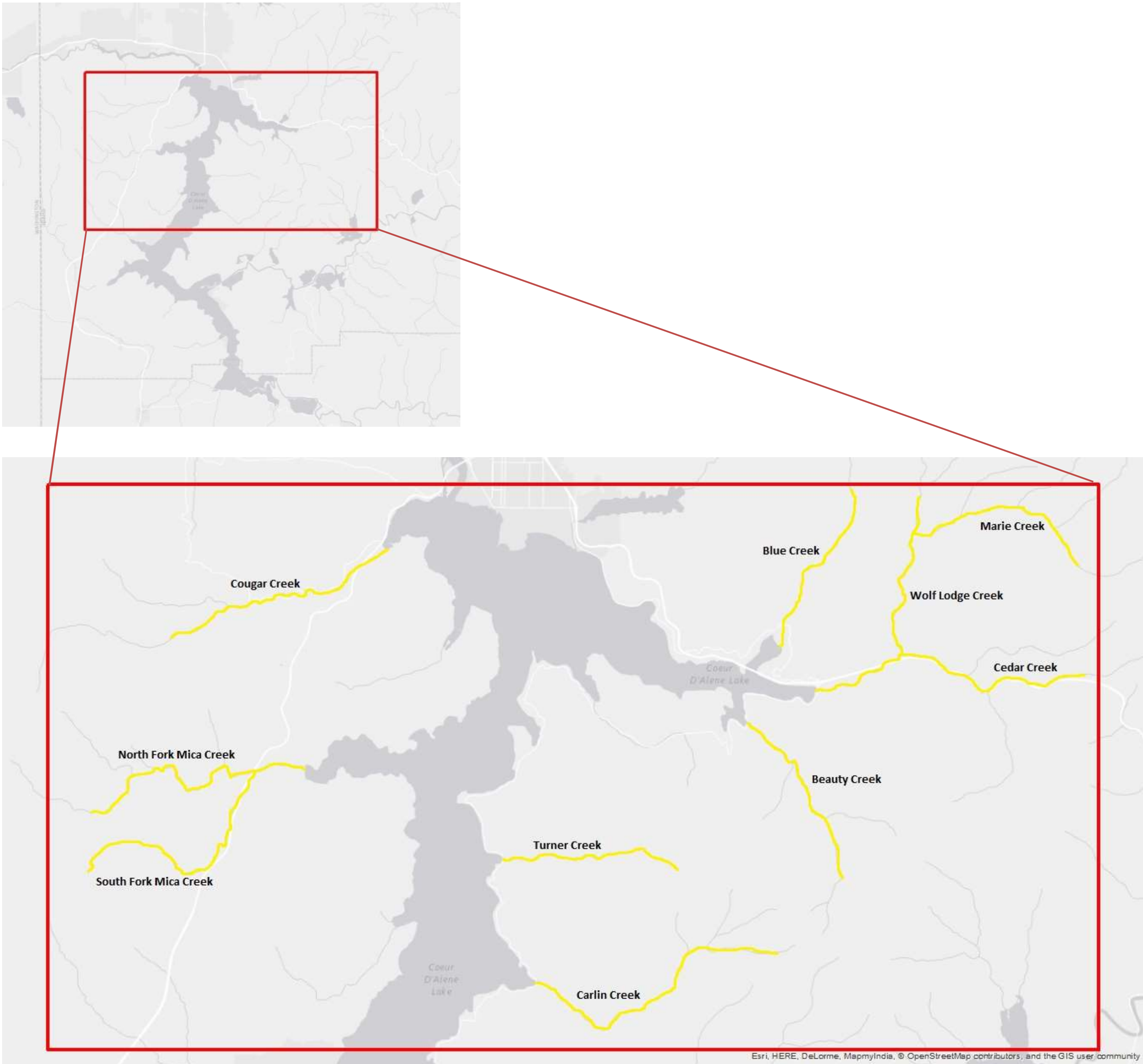

Figure 61. Map of Lake Coeur d'Alene tributaries sampled during July 2017.

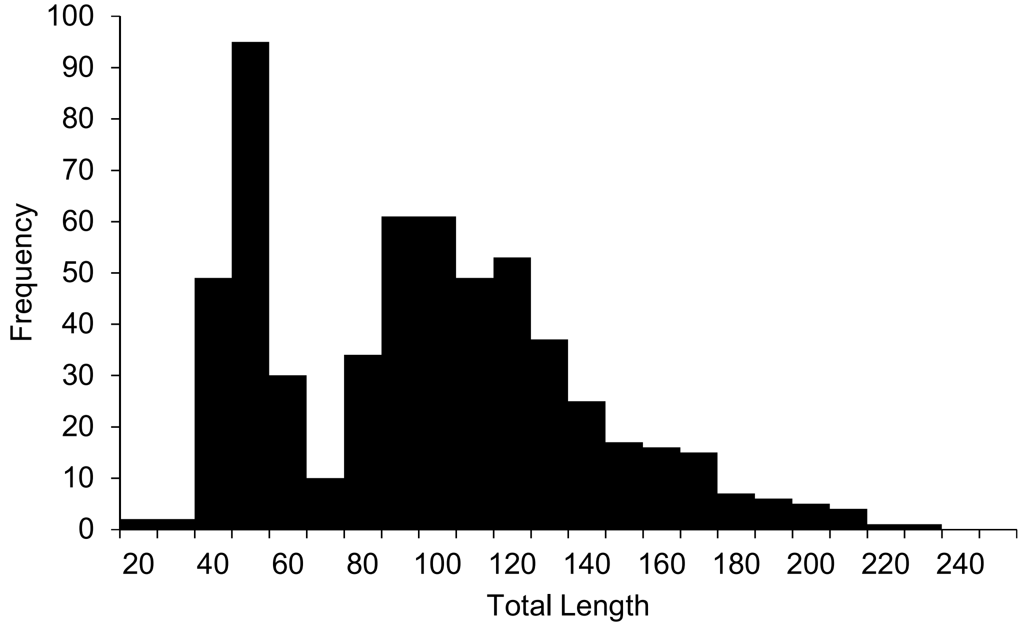

Figure 62. Length frequency distribution for Westslope Cutthroat Trout sampled from tributaries to Lake Coeur d'Alene (2017).

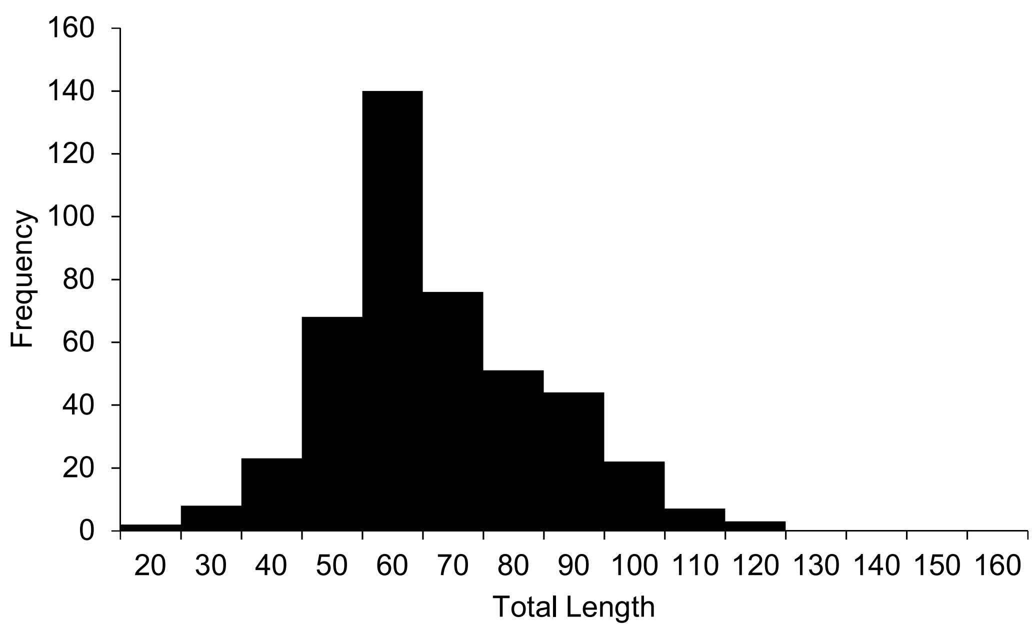

Figure 63. Length frequency distribution of Cedar Sculpin sampled from tributaries to Lake Coeur d'Alene (2017).

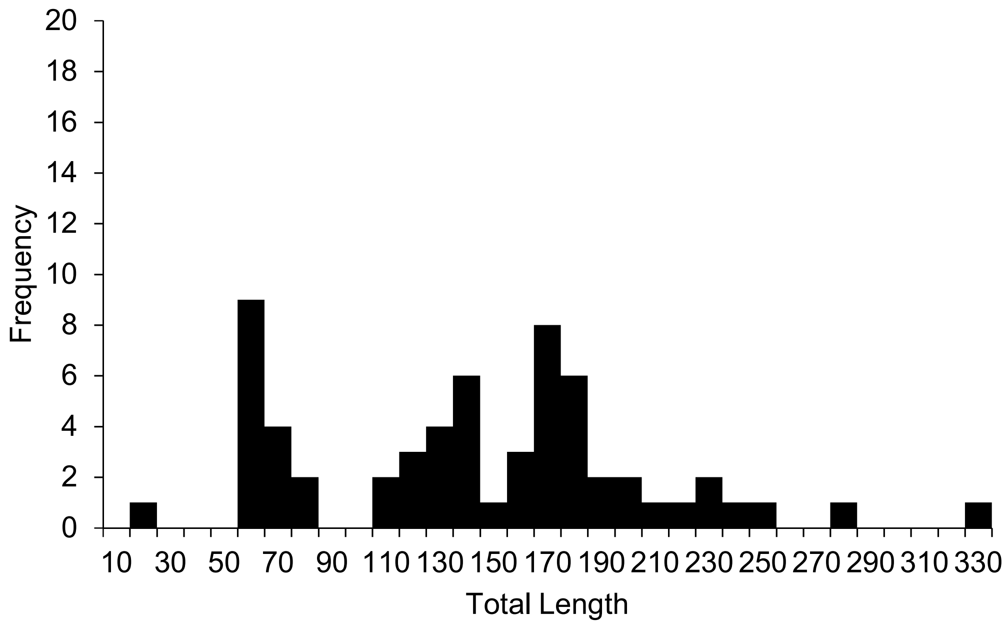

Figure 64. Length frequency distribution of Brook Trout sampled from tributaries to Lake Coeur d’Alene (2017).

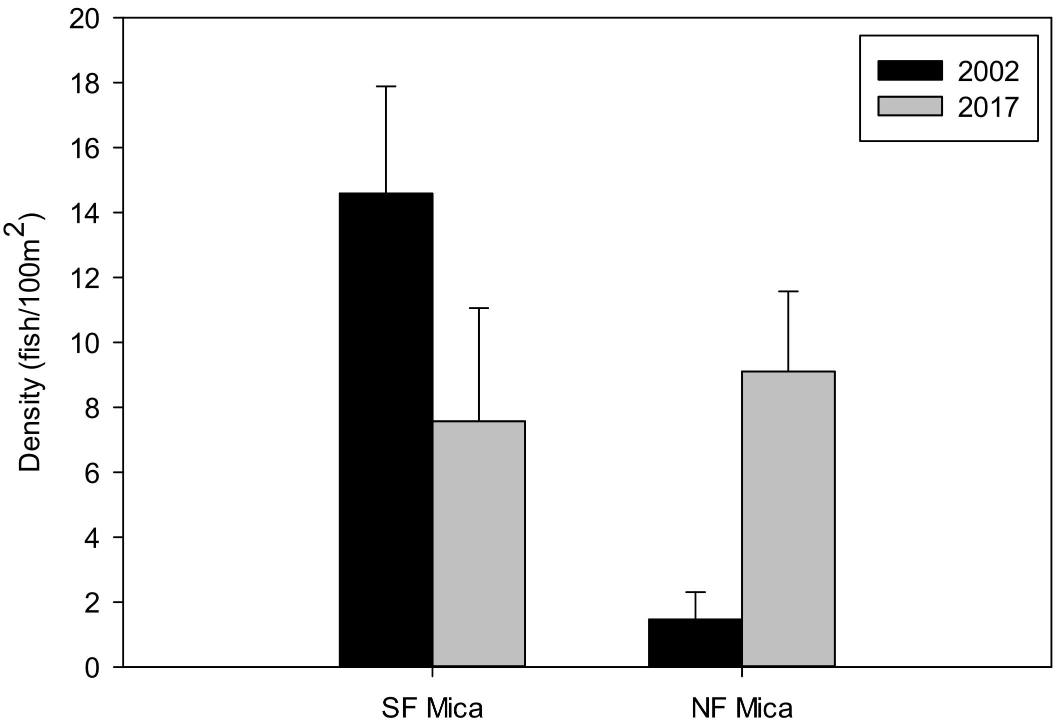

Figure 65. Comparison of Westslope Cutthroat Trout density estimates to Liter et al. (2007).

WINDY BAY NORTHERN PIKE MANAGEMENT

ABSTRACT

Competing values often lie at the interface of native-nonnative fish management issues. In Lake Coeur d'Alene, certain subpopulations of adfluvial Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* have declined in abundance and their recovery is thought to be inhibited by nonnative Northern Pike *Esox lucius* predation. We collaborated with the Coeur d'Alene Tribe to implement a novel removal-translocation Northern Pike management approach designed to alleviate localized predation risk to migrating Westslope Cutthroat Trout while not adversely affecting the popular Northern Pike fishery. During the springs of 2015–2017 we removed 580 Northern Pike from Windy Bay around the inlet of Lake Creek in Lake Coeur d'Alene using gillnets. Northern Pike were translocated to the northern portion of Lake Coeur d'Alene (~22.9 km from Windy Bay) where the risk to native fishes is lower and where they were subject to higher angler harvest. During the three-year study, we reduced total subpopulation abundance by 67% and were able to reach acceptable depletion for a subpopulation of ≤162 fish following 9–13 days of spring gillnetting effort that constituted 1,528–1,825 total net/h. We observed a right-skewed shift in Northern Pike size structure over time, suggesting that recruitment was limited by the removal of mature, pre-spawn adults. Recolonization between years appears largely influenced by immigration of adult Northern Pike from nearby bays. Gillnetting survival of Northern Pike was 71% and annual angler exploitation of translocated fish varied from 19.6–35.4% (mean = 30.0%). Fidelity of translocated fish to the release location was high with 83% of tag returns being from locations within one km of the release point, and fewer than 1% of marked individuals immigrated back to Windy Bay. Here we provide information on a creative management approach to balance incongruent public interests and insight for fishery managers on its applicability in other systems.

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INTRODUCTION

Worldwide, fish species have been introduced to waters outside of their native distribution for centuries (Gozlan et al. 2010). As a result, various ecosystems have experienced increased species richness (Horak 1995) and fish assemblages are becoming increasingly homogenized (Rahel 2000). In western North America, fish introductions by both legal (e.g., biomanipulation; fishery supplementation) and illegal (e.g., release of live baits; release of aquarium pets; anglers introduce desired fish species) means have occurred since the late 19th century. However, the rate of nonnative species spread has increased substantially since the early 1900s, mostly due to deliberate movement of desirable sportfishes. Regardless of the cause by which nonnative species are introduced, their establishment and proliferation can result in the decline of native species with significant social, economic, and ecological importance. The change to native fish assemblages from species introductions increases biotic interactions and creates the potential to precipitate negative ecological effects. Native species are often influenced by nonnative fishes through either direct (e.g., predation; Ruzycki et al. 2003) or indirect (e.g., competition for food and space; Thompson and Rahel 1996; Gido and Brown 1999) mechanisms. Effects resulting from the former are manifested in the interactions between nonnative top-level predators and native prey species. Additive mortality from predation can hamper recruitment and lead to declines in abundance of native fishes over time.

Examples of the negative effects of predation on native fishes have been widely demonstrated in the literature. For instance, Ruzycki et al. (2003) reported declines in Yellowstone Cutthroat Trout *Oncorhynchus clarki bouvieri* abundance in Yellowstone Lake following the introduction of nonnative Lake Trout *Salvelinus namaycush*. Similarly, introductions of Northern Pike *Esox lucius* in western North America have been highly prolific and altered the dynamics of native prey species. Muhlfeld et al. (2008) documented the predation effects of Northern Pike on native salmonids (i.e., Westslope Cutthroat Trout *O. clarki lewisi* and Bull Trout *S. confluentus*) in the Flathead River system, Montana. Similarly, Johnson et al. (2008) reported that Northern Pike predation ranked as a top threat to native *cyrprinus* and *catostomus* spp. recovery in the Yampa River basin, Colorado.

The Northern Pike is a top-level predator that prefers warm, slow-moving water around vegetated rivers or lake bays (Scott and Crossman 1973). Northern Pike have a circumpolar distribution, but their native distribution with in the lower 48 states is limited to the upper Mississippi River basin (Pflieger 1975). Northern Pike were illegally introduced to the state of Idaho around the early 1970s in the Lake Coeur d'Alene system (Rich 1992).

The Lake Coeur d'Alene system has the longest history of Northern Pike occupancy among all Idaho waters. The lake also serves as important habitat for adult adfluvial Westslope Cutthroat Trout *O. clarki lewisi*, which have been in decline in some tributaries (Vitale et al. 2004). Adfluvial Westslope Cutthroat Trout in the system have been negatively affected by a variety of anthropogenic factors, including land use, water development, and over-exploitation (Rankel 1971; DuPont and Horner 2009). However, until recently, the extent to which predation from nonnative fishes may be limiting Westslope Cutthroat Trout stocks was poorly understood. Over the past 20 years, the Coeur d'Alene Tribe has been engaged in active restoration of adlfuvial Westslope Cutthroat Trout populations within tribally-managed waters. The Coeur d'Alene Tribe's work has documented low (~1.7%) juvenile-to-adult return rates of adfluvial Westslope Cutthroat Trout in Lake Creek over a 6-year period (Firehammer et al. 2012). Low adult returns were hypothesized to result from predation-induced mortality during migration. Walrath (2013) complimented this baseline work, demonstrating that total consumption of Westslope Cutthroat Trout by Northern Pike was high (N = 5,564; 95% CI = 3,311–10,979) throughout Lake Coeur

d’Alene, but that impacts were site-dependent. Predation was highest during spring when adult Westlsope Cutthroat Trout are returning to spawning tributaries and juveniles are immigrating to Lake Coeur d’Alene (Walrath 2013; Walrath et al. 2015a). These springtime migrations for Westslope Cutthroat Trout coincide with high Northern Pike activity (i.e., spawning). The spring freshet in tributaries to Lake Coeur d’Alene triggers migration of Westslope Cutthroat Trout and inundates areas around tributary inlets which provide ideal spawning habitat for adult Northern Pike (Firehammer et al. 2012; Scott and Crossman 1973). Thus, the ecology of both species leads to substantial spatiotemporal overlap in occurrence near tributary inlets, creating a critical bottleneck for vulnerable Westslope Cutthroat Trout. Moreover, given the reported consumption demand of Northern Pike, predation is sufficient to substantially influence recruitment potential of individual Westslope Cutthroat Trout subpopulations.

Predator-induced declines of native fishes necessitate interferential management to reduce interactions between native and nonnative fishes, and management usually involves predator removal of some sort (Mueller 2005). The challenge to fishery managers is that introduced predators are often highly valued by the public. Angling clienteles develop around introduced sport fishes and those groups lobby to conserve the species. Ruzycki et al. (2003) cautioned that fishery managers must demonstrate the effects of predation on native fishes before controversial management actions are taken. The authors also caution that fishery managers can avoid the development of an angling clientele by demonstrating those effects before serious declines occur in native populations, and before the introduced predator population can provide a fishery. However, this is nearly impossible in most cases, and a clientele will almost certainly develop before effects can be adequately evaluated. As such, fishery managers often require management alternatives that address the values of several competing public interests. Here, we present a removal-translocation program designed to mitigate for nonnative Northern Pike predation on Westslope Cutthroat Trout. Overall, our management objective was to develop a strategy that could minimize the impact to the popular Lake Coeur d’Alene Northern Pike fishery and also alleviate predation risk to native fishes. We worked cooperatively with the Coeur d’Alene Tribe to remove Northern Pike from a localized area of Lake Coeur d’Alene where predation was significantly limiting Westslope Cutthroat Trout abundance. Our strategy involved translocation of a problematic subpopulation to a portion of the lake where they pose a reduced threat and are readily available to more anglers. Our objectives were to 1) evaluate if localized Northern Pike abundance could be suppressed in Windy Bay during the spring, 2) estimate the effort required to substantially reduce abundance, and 3) minimize impacts on the popular Northern Pike fishery at-large.

STUDY AREA

Lake Coeur d’Alene is a mesotrophic natural lake located in the Panhandle of northern Idaho (Figure 1). 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 water level approximately 2.5 m, creating more littoral habitat and shallow-water areas around the lake’s periphery.

Lake Creek is a third-order perennial tributary to Lake Coeur d’Alene that flows into the lake at Windy Bay (Figure 1). Lake Creek has an interstate and interjurisdictional watershed

encompassing portions of eastern Washington and Idaho. The lower portion of the Lake Creek watershed lies within the Coeur d'Alene Tribe Indian Reservation and has been the focus of long-term habitat enhancement aimed at restoring adfluvial Westslope Cutthroat Trout. Although the Coeur d'Alene Tribe manages fishery resources in lower Lake Creek, the Windy Bay area where the stream enters Lake Coeur d'Alene is owned and managed by the state of Idaho.

METHODS

Staff from the Coeur d'Alene Tribe and IDFG sampled Northern Pike daily (Monday–Friday only) during mid-March through early-April (2015–2017) following ice-out. Our approach was adaptive, whereby the sampling design and gear configuration evolved over the course of the project to address inefficiencies as information became available. During 2015, fish were captured using 45 × 1.8 m experimental sinking gill nets (five panels with 50, 64, 76, 88, and 100-mm stretch-measure mesh), and sampling consisted of a single gill net deployed at each of 6–8 randomly selected sites during each day following the design described by Walrath et al. (2015a). In consecutive years, fish were sampled using modified 45 × 1.8 m sinking gill nets (two panels of 76.2 and 101.6-mm stretch-measure mesh) and effort was assigned following a stratified-random design with strata designated by catch-per-unit-effort (CPUE) using Neyman allocation (Cuff and Coleman 2011). The gear and design changes in 2016 were informed by an analysis of Northern Pike catch data from 2015 and findings of Walrath (2013); specifically, we reallocated effort to focus on areas known to have higher Northern Pike abundance. In addition, one of our goals was to minimize capture mortality of Northern Pike. Thus, during 2015, gill nets were soaked for 3–4 hours before retrieval (i.e., daytime sets) and also fished overnight to understand the effect of soak time on survival. Mortality from overnight gill net sets was only slightly (i.e., 12.6%) higher, and that difference was deemed acceptable by managers given the additional time and resource needs associated with multiple daytime gill net deployment-retrievals. As such, overnight gill net sets were used in all subsequent capture years. Catch-per-unit-effort was estimated as the number of Northern Pike captured per net/h. We used the Leslie-DeLury depletion method to estimate the population size of Northern Pike in Windy Bay (Leslie and Davis 1939; DeLury 1947):

$$C_t / f_t = q(N_0 - \Sigma C)$$

where C_t / f_t is the response variable (catch divided by fishing effort at time t), ΣC is the explanatory variable (cumulative catch prior to the t^{th} removal), q is the catchability coefficient (i.e., proportion of population removed by fishing effort), and N_0 is the starting population size. Depletion models were also used to understand efficiency. We assumed that 1) the population was closed, 2) removal resulted in significant population size reduction, 3) constant q, and 4) fishing effort expenditure was known (Omand 1951; Ricker 1975). We modeled the relationship between mean weekly CPUE and cumulative catch, and estimated the extrapolation point where CPUE is zero (i.e., initial population size; Ricker 1975). Cumulative catch and the subpopulation proportion removed over time were also compared among years to better understand efficiency in removal rates.

The post-capture condition of each Northern Pike was assessed after gill net retrieval; individuals determined to be in good (i.e., actively swimming in an upright fashion) condition were tagged with non-reward FD-94 T-bar anchor tags (76 mm; Floy Tag Inc., Seattle, WA, USA). Each tag was uniquely numbered and inserted near the posterior end of the dorsal fin of each Northern Pike. All tags also possessed the telephone number and website for IDFG's "Tag! You're It!" reporting hotline. Tags were used as a mark to evaluate site fidelity and angler exploitation of

Northern Pike. Angler exploitation was estimated using the non-reward tag reporting estimator described by Meyer et al. (2012), namely,

$$\mu' = \mu / [\lambda (1–Tag_l)(1–Tag_m)]$$

where μ' is the adjusted angler exploitation rate, μ is the unadjusted exploitation rate (i.e., number of fish reported divided by the number of fish tagged), λ is the species-specific angler reporting rate (53.0%), Tag_l is the tag loss rate (10.2%), and Tag_m is the tagging mortality rate (3.0%).

Total length (TL; mm) was measured from all fish captured during this study. Proportional size distribution (PSD) was estimated to summarize length-frequency information for Northern Pike (Neumann et al. 2012). Length data were summarized for all fish removed from Windy Bay, translocated fish, and translocated fish caught by anglers. Length distributions were compared among years within and between the various dispositions using a Kolmogorov-Smirnov test to assess differences in median length and distribution shape. When multiple comparisons were made, the *p*-values were adjusted for increasing error and then evaluated to asses which pairs of distributions significantly differed. Length data from all fish captured in Windy Bay during each year were compared to the previous year's estimated distribution. Length distributions of translocated and harvested fish were compared to distributions of all fish in the associated year to understand size-related patterns in survival and harvest. Analyses were conducted in Program R (R Development Team 2012) and a Type I error rate of $\alpha = 0.05$ was used to determine statistical significance.

Northern Pike were transported by vehicle to Cougar Bay near the north end of Lake Coeur d'Alene (Figure 1), approximately 22.9 air km from the capture site. Condition of Northern Pike was again assessed after they had been transported to the release location; individuals in poor condition (i.e., likely to expire by subjective measure) were killed and all others were released back into Lake Coeur d'Alene. Cougar Bay was chosen as the release location based on 1) its close proximity to a major population center (i.e., higher fishing pressure), 2) the low risk that Northern Pike would present to native species, 3) good fishing access available to boat and shore-based anglers and 4) the prospectively high exploitation of Northern Pike (Walrath 2013).

RESULTS

A total of 580 Northern Pike was removed from Windy Bay over the course of the three-year project. Of those, 412 were translocated to Cougar Bay. Gill net bycatch was minimal; the most common species comprising the bycatch were Largescale Sucker *Catostomous macrocheilus*, Brown Bullhead *Ameiurus nebulosus*, and Northern Pikeminnow *Ptychocheilus oregonesis*. Higher mortality resulted from longer gill net soak time, and gill net entanglement time was thought to be the most influential factor on mortality; nonetheless, 71% of captured Northern Pike survived and were successfully translocated to Cougar Bay.

Catch rates of Northern Pike declined substantially through time, both within and across years. Catch rates varied from 0.44 fish/net h during the first week of removal in 2015 to < 0.01 fish/net h during the latter part of removal in 2016 (Table 1). In general, the highest CPUE was observed during the beginning of the project and the lowest CPUE was observed toward the latter portion of the project. The relationship between CPUE and cumulative catch was negative in all years. In 2015, initial subpopulation abundance in Windy bay was estimated at 328 fish (Figure 2), and subpopulation abundance had declined to 108 fish in 2017. Proportional reduction in subpopulation abundance slowed through time, and we observed a decrease of 51% from 2015

to 2016 and 33% from 2016 to 2017 (Figure 2). After gear and sampling design alterations, 50% of the initial subpopulation was removed after three (2017) to four days (2016) of overnight gillnetting effort, and the effort required to remove 90% of the subpopulation had decreased to nine days by the end of the study (Figure 3).

Mean total length was 596 mm (range = 766 mm; SE = 5.0) for all Northern Pike captured in Windy Bay (Figure 4), 590 mm (range = 704 mm; SE = 5.6) for Northern Pike translocated to Cougar Bay, and 601 mm (range = 540 mm; SE = 12.6) for translocated Northern Pike caught by anglers (Figures 4–6). Mean length of all fish increased slightly throughout the course of the study, and the pattern was largely influenced by the paucity of fish ≤400 mm and ≤500 mm in 2016 and 2017, respectively (Figure 4). Length distributions became increasing right-skewed through time and all differed significantly from the previous year. The PSD of Northern Pike in Windy Bay increased through time and the subpopulation was comprised almost entirely by quality-length and larger individuals by 2017 (Figure 4). Size structure of translocated and angler harvested fish followed a similar pattern by which smaller fish became rarer and PSD increased through time, yet not differing in shape from that of the corresponding population during each year (Figures 5 and 6).

Angler exploitation of translocated Northern Pike varied from 19.5–35.4% after one year at-large. The estimate of annual exploitation was lowest in 2016, but similarly high during 2015 and 2017. Tag returns were clustered near Cougar Bay suggesting that Northern Pike had high fidelity to their release location. Although tag return information did not reveal immigration of translocated fish to Windy Bay, five immigrants were documented by subsequent removal efforts. Of these, 50% were from the same year's removal effort (Table 1). Ninety one percent of tag returns were from fish reportedly caught within 8 km of the release location in Cougar Bay, and 83% of tag returns were reported from locations within one km of Cougar Bay.

DISCUSSION

The management strategy that we implemented in conjunction with the Coeur d'Alene Tribe was developed following a comprehensive evaluation of the effects of Northern Pike predation on Westslope Cutthroat Trout (Walrath 2013; Walrath 2015a) and extensive public input. Our strategy focused on small-scale, localized removal that would not adversely affect the fishery at-large. Over the course of this effort, we removed 580 Northern Pike from Windy Bay around the vicinity of the Lake Creek inlet and the subpopulation size declined substantially through time. Our study suggests that we can maintain low local Northern Pike abundance during the spring and also force local long-term abundance down, thus reducing the effort expended over the course of a multi-year project. Within two years following adaptive measures to the project we were able to reach critical population depletion with three weeks, or approximately nine work days, of effort and maintained low catch rates following that point. Assuming our 2016–2017 data reflect peak efficiency, we found that 90% depletion of a subpopulation of ≤162 Northern Pike could be achieved in 9–13 days consisting of ~1,530–1,825 net/h of gillnetting effort in Windy Bay. Although true subpopulation size in Windy Bay is unknown, our estimate during 2015 is congruent with 2012 and 2013 estimates obtained using multiple mark-recapture techniques (N = 332; Walrath 2013). Thus, we had high confidence in population estimates derived from depletion models and our ability to remove the majority of Northern Pike occupying Windy Bay.

Effective allocation of resources was contingent on the use of a flexible approach that allowed necessary adjustments to both gear and design. A common theme among fish removal programs is that some baseline information about the characteristics (e.g., size structure,

distribution, habitat use) of the target fish population is required to develop an effective protocol (Casselman and Lewis 1996; Harding et al. 2001; Peterson et al. 2008; Dux et al. 2005). This is consistent with many nonnative fish suppression programs in western North America that have creatively utilized common sampling gears to achieve specific management objectives (Syslo et al. 2011). Previous studies have provided a foundational understanding of the effectiveness of gill nets for sampling and suppressing Northern Pike (Jolley et al. 2008; Kuzmenko et al. 2010); however, population size structure is an important determinant of removal effectiveness relative to gear design. In the case of this study, 3.0 and 4.0 stretch-measure gill net mesh were suitable for all sizes of Northern Pike encountered in Windy Bay, and those dimensions likely improved removal efficiency as smaller fish became increasingly rare throughout our study. More importantly, effort reallocation resulted in rapid subpopulation depletion and more efficiently utilized material resources. The first year's data from this study highlighted insightful patterns in Northern Pike catch rates in Windy Bay that were presumably driven by distributional differences in habitat quality and quantity (Grimm 1989; Casselman and Lewis 1996). Consistent with previous work related to Northern Pike ecology, we observed the highest catch rates in areas close to the stream inlet where inundated vegetation had resulted in abundant spawning habitat (Casselman and Lewis 1996; Craig 2008; Mingelbier et al. 2008). As such, we focused a greater proportion of effort in areas close to good spawning habitat without ignoring adjacent areas clearly occupied by fewer immature or otherwise non-spawning Northern Pike (Pope at al. 2010).

Our analysis of size structure illuminated some important aspects of this project relative to population recruitment and translocation. The most notable difference in size structure of total annual catch was the absence of Northern Pike ≤400 mm in 2016 and ≤500 mm in 2017, which suggested that recruitment was being limited. Similar to other studies where mature fishes are suppressed prior to spawning (Mueller 2005), size structure shifts can be indicative of recruitment inhibition. Because recruitment was likely not a major contributor to recolonization in Windy Bay, we drew on historical information from Rich (1992) and Walrath (2013) to better understand apparent re-population. Both authors reported limited movement of Northern Pike in the Lake Coeur d'Alene system from mark-recapture and angler tag return data. The insight provided by these studies, combined with our understanding of habitat in Lake Coeur d'Alene (Bennett and Rich 1990; Rich 1992), suggests that metapopulation dynamics (Levins 1970) likely govern Northern Pike distribution and mixing in the system. Much of the littoral habitat in Lake Coeur d'Alene is not suitable for Northern Pike (i.e., steep shoreline; Bennett and Rich 1990; Casselman and Lewis 1996), with the exception of its many bays, and lakewide fish assemblage surveys substantiate the notion that Northern Pike occurrence is strongly associated with bays and that movement between bays is limited. The shift in Northern Pike length distribution suggests that the recolonization we observed was probably influenced by adult immigration from nearby Bays following removal each year. Overall, we assume that movement of Northern Pike is minimal and that they have a high affinity for particular locations that provide appropriate habitat. We documented immigration of four Northern Pike back to Windy Bay from the translocation area, further supporting the notion that distant emigration does not significantly affect recolonization of Windy Bay. The large majority of translocated Northern Pike reported by anglers were also caught in the general vicinity of Cougar Bay.

Animal translocations are a commonly used to manage wildlife species (Griffith et al. 1989; Singer et al. 2000), but are less common in fisheries management. Where translocation management is applied, it is most often used to supplement imperiled fish populations (Minckley 1995; Vrijenhoek 1998). To our knowledge, nonnative fish suppression efforts have not used translocation in combination with suppression to minimize fishery-level consequences.

During our study, we did not observe size structure differences between translocated fish suggesting that mortality from gillnetting and handling was not size related. Angler exploitation of translocated Northern Pike was similar to estimates from other studies in the Lake Coeur d'Alene system (Rich 1992; Walrath et al. 2015). Current rates of fishing mortality are hypothesized to stabilize Northern Pike population growth (i.e., $\lambda = 1.0$) where angler exploitation rates exceed 30% in Lake Coeur d'Alene (Pierce et al. 1995; Nelson et al. 1996). Cougar Bay typically receives high angler use due to its close proximity to the city of Coeur d'Alene and its good access for both boat and bank anglers. As such, exploitation rates of Northern Pike in Cougar Bay are typically the highest in Lake Coeur d'Alene (Nelson et al. 1996). The translocation of Northern Pike to Cougar Bay maximizes their susceptibility to angler harvest and likely improves the fishery near a major population center.

Biological invasions are the leading cause of native species declines, second only to habitat degradation (Simberloff 2001), and the effects of introduced predators are well-understood by ecologists (Rahel 2000). On a global scale, resource managers have undertaken aggressive conservation measures to maintain native fish assemblages and ensure the persistence of the benefits they provide. Of such measures, controlling introduced species is one of the most common, yet publically contentious, strategies. As such, developing socially-acceptable management plans to accomplish conservation goals is something that has long vexed resource managers. Strong socioeconomic and cultural values lie at the interface of native-nonnative fishery management issues, and passionate beneficiaries of the resource are on both sides. To facilitate public support of contentious fishery management actions, it is critical to justify the control action by demonstrating the negative impacts of the introduced species. In addition, managers must acknowledge the benefits and values associated with fisheries formed by nonnative fishes, and develop management strategies within that constraint. Minimizing the net loss in terms of both native species conservation and angling opportunity is critical when developing control action plans.

We demonstrated the use of a relatively benign control method for a nonnative species to alleviate predation risk to a native species. Our approach has been met with broad public support and has minimally affected angling opportunity for Northern Pike in Lake Coeur d'Alene (CDAT 2017). Overall, we effectively suppressed adult Northern Pike abundance during the springs of 2015–2017 and complimented the objectives of the Coeur d'Alene Tribe with respect to Westslope Cutthroat Trout restoration in the Lake Creek drainage. Oftentimes, fishery managers desire to reduce predation impacts of socially-important species that have developed passionate clienteles. Our study details one method by which local predation mitigation can be achieved while simultaneously addressing public interests. The scale and complexity of Lake Coeur d'Alene, coupled with the ecological characteristics of Northern Pike, facilitated the success of this novel approach, but the appropriateness of this approach will be case specific. Lake Coeur d'Alene is a large dendritic system where Northern Pike habitat is highly isolated and distant translocations are feasible; however, resource managers working in simpler systems likely will not have similar luxuries. Nonetheless, the prospect of angling opportunity loss without guarantee of replacement is an important consideration for fishery managers approaching native-nonnative fish conflicts.

Table 33. Weekly catch information for Northern Pike suppression in Windy Bay including sampling time period, sample sizes, recaptures, catch-per-unit-effort (CPUE; fish/net h), and length statistics. Recapture information includes the year of during which recaptured Northern Pike were initially translocated in parentheses; all other parenthetical values represent one standard error about its associated mean.

						Total length (mm)	
Week	Period	*n* (captured)	*n* (translocated)	Recaptures	CPUE	Mean	Min–Max
				2017			
1	3.27–3.31	76	49	--	0.12	705.8 (8.4)	554–920
2	4.3–4.8	21	14	2 (2017)	0.02	715.8 (17.5)	520–825
3	4.10–4.14	11	4	--	0.02	707.9 (21.2)	583–810
				2016			
1	3.14–3.18	50	32	--	0.01	614.7 (13.3)	465–941
2	3.21–3.25	64	45	--	< 0.01	534.8 (10.1)	415–778
3	3.28–4.1	21	15	1 (2015)	< 0.01	614.9 (17.9)	458–771
4	4.4–4.8	7	5	--	< 0.01	661.7 (69.3)	417–883
5	4.11–4.15	19	14	1 (2015)	< 0.01	594.4 (23.7)	472–802
				2015			
1	3.12–3.20	113	93	--	0.44	564.2 (9.7)	288–1,000
2	3.23–3.27	47	43	--	0.24	587.6 (15.0)	420–850
3	3.30–4.3	59	40	--	0.10	571.6 (18.3)	329–1,020
4	4.6–4.10	33	19	--	0.04	460.8 (20.6)	254–795
5	4.13–4.16	11	10	--	0.07	591.9 (43.4)	480–947
6	4.20–4.24	30	22	--	0.11	582.4 (15.4)	410–825
7	4.27–4.30	18	7	1 (2015)	0.04	615.6 (25.8)	494–870

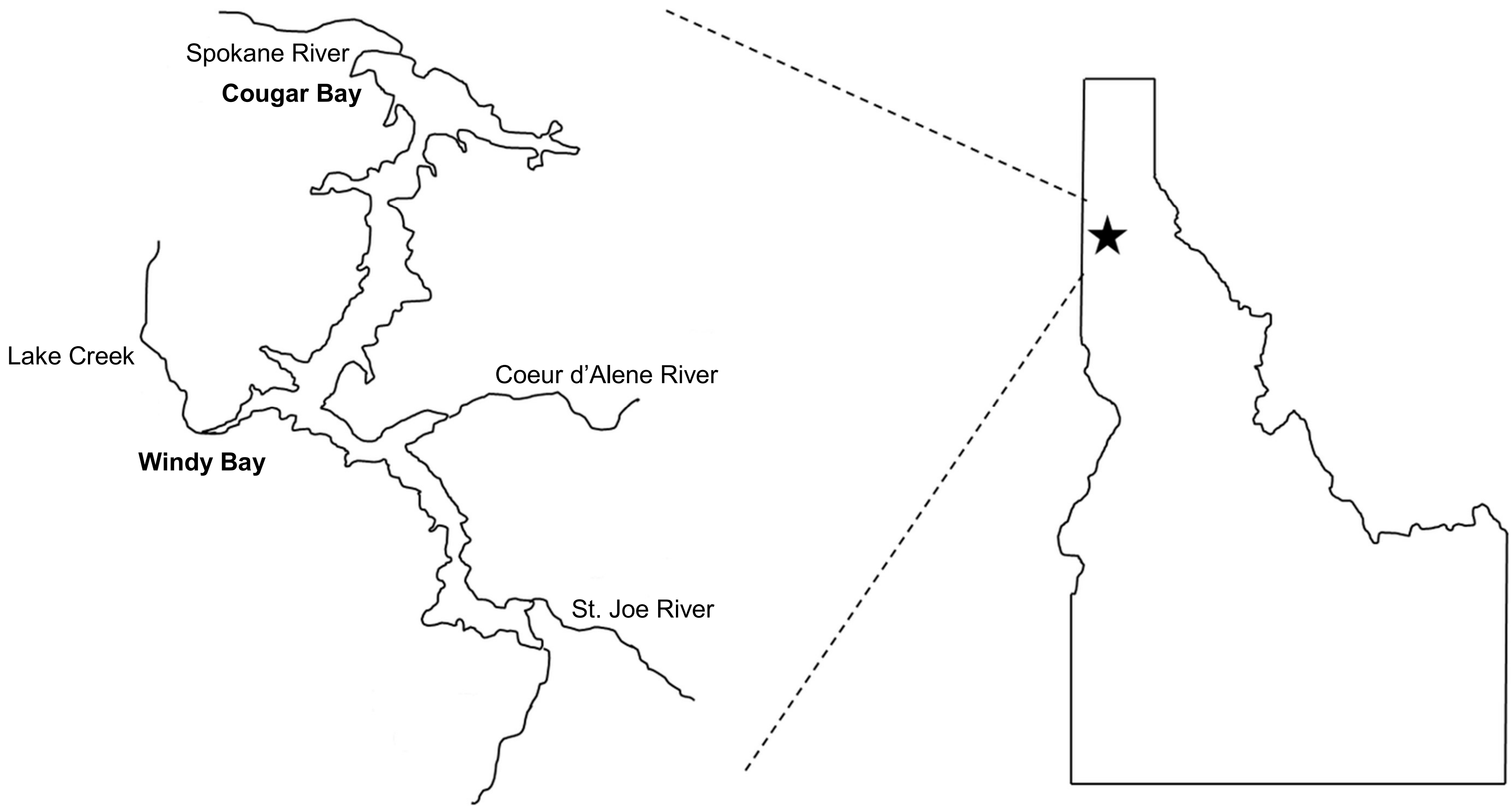

Figure 66. Map of Lake Coeur d'Alene, Idaho and major tributaries. Capture and translocation areas are indicated by bold text.

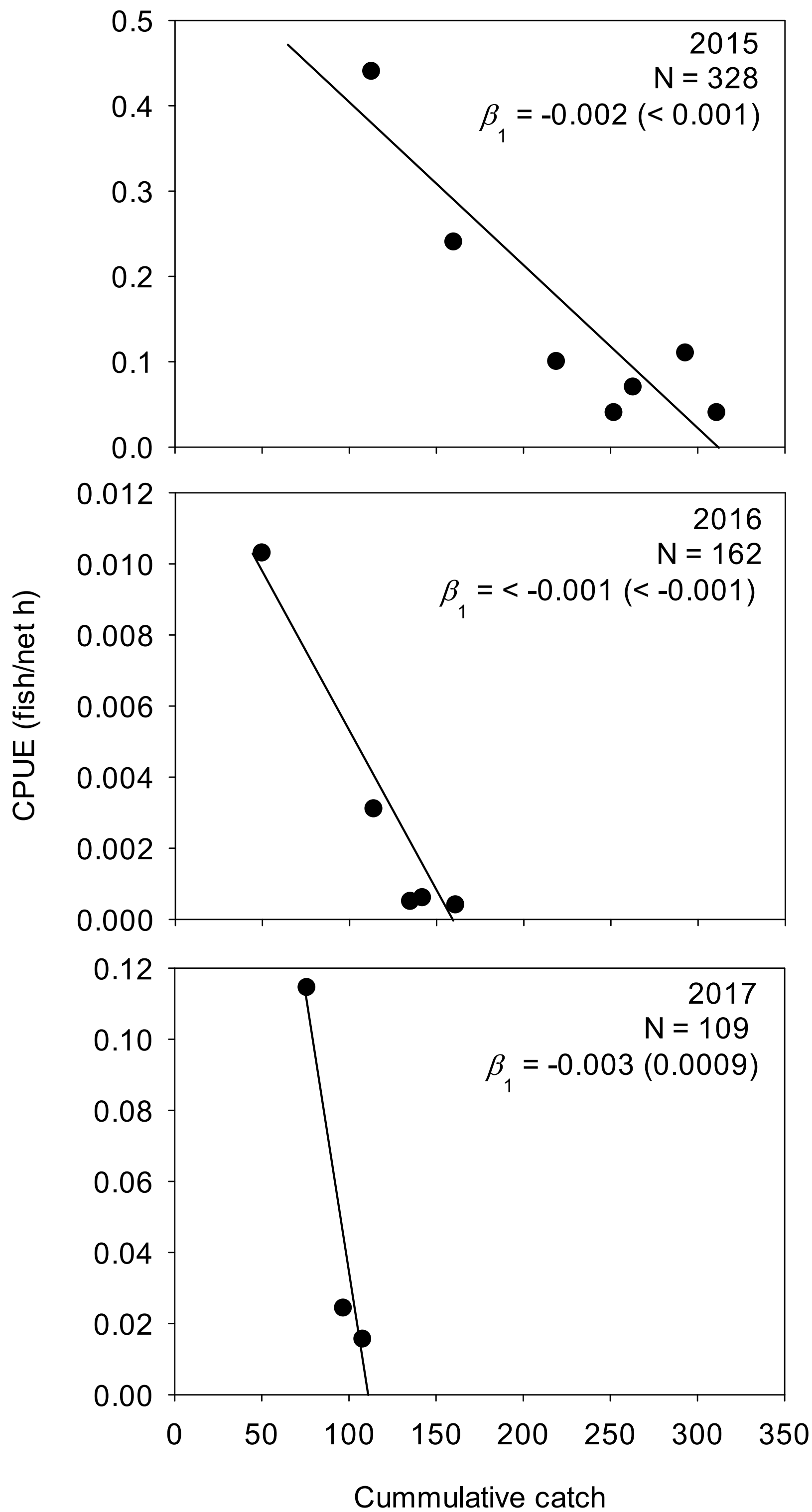

Figure 67. Relationship between catch-per-unit-effort (CPUE) and cumulative catch of Northern Pike sampled in Windy Bay, Lake Coeur d'Alene during spring removal in 2015, 2016, and 2017. Estimated abundance of Northern Pike in Windy Bay during each year is indicated.

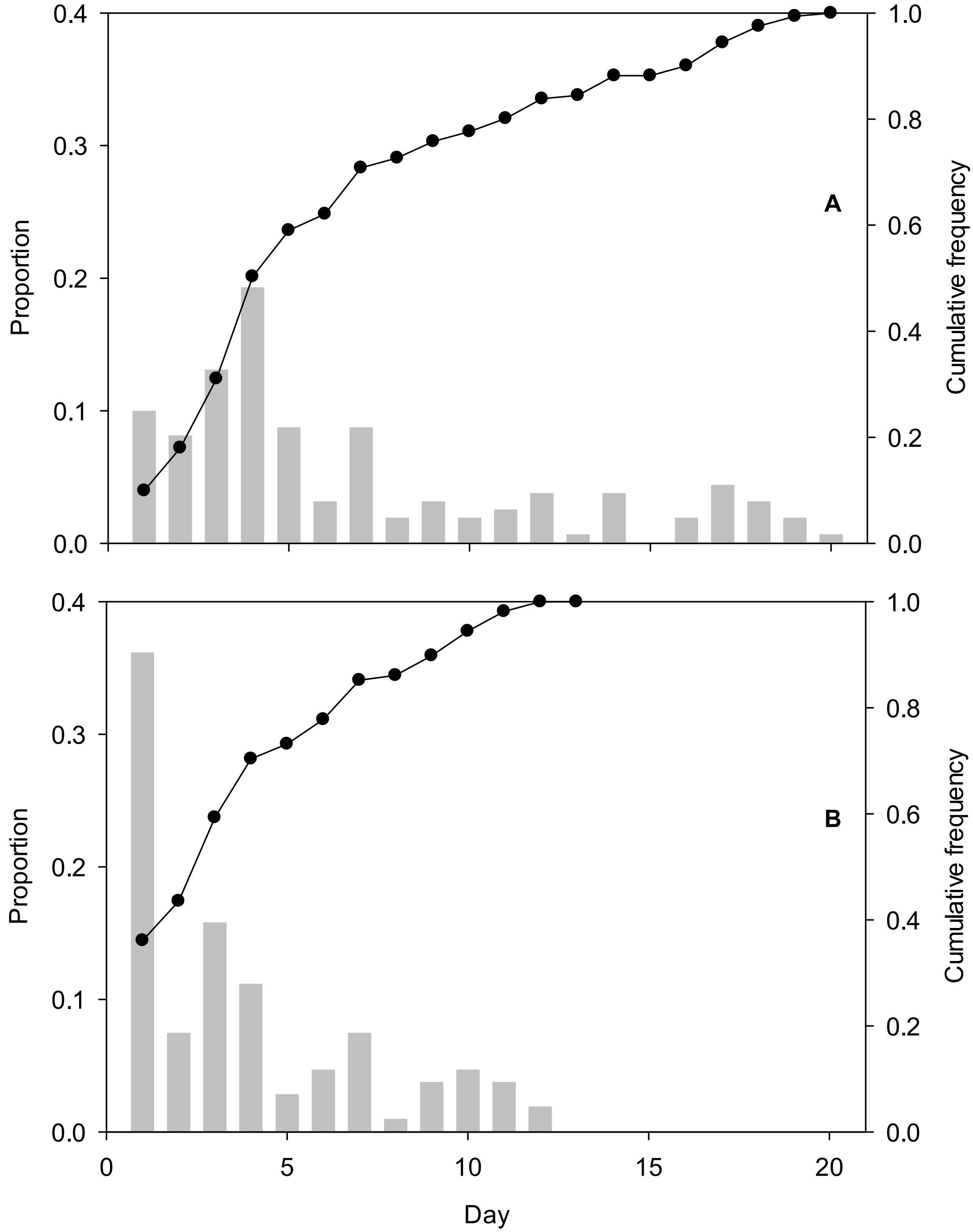

Figure 68. Proportion of initial Northern Pike subpopulation removed during each project day and cummulative frequency of abundance in 2016 (panel A) and 2015 (panel B) following design and gear reconfigurations.

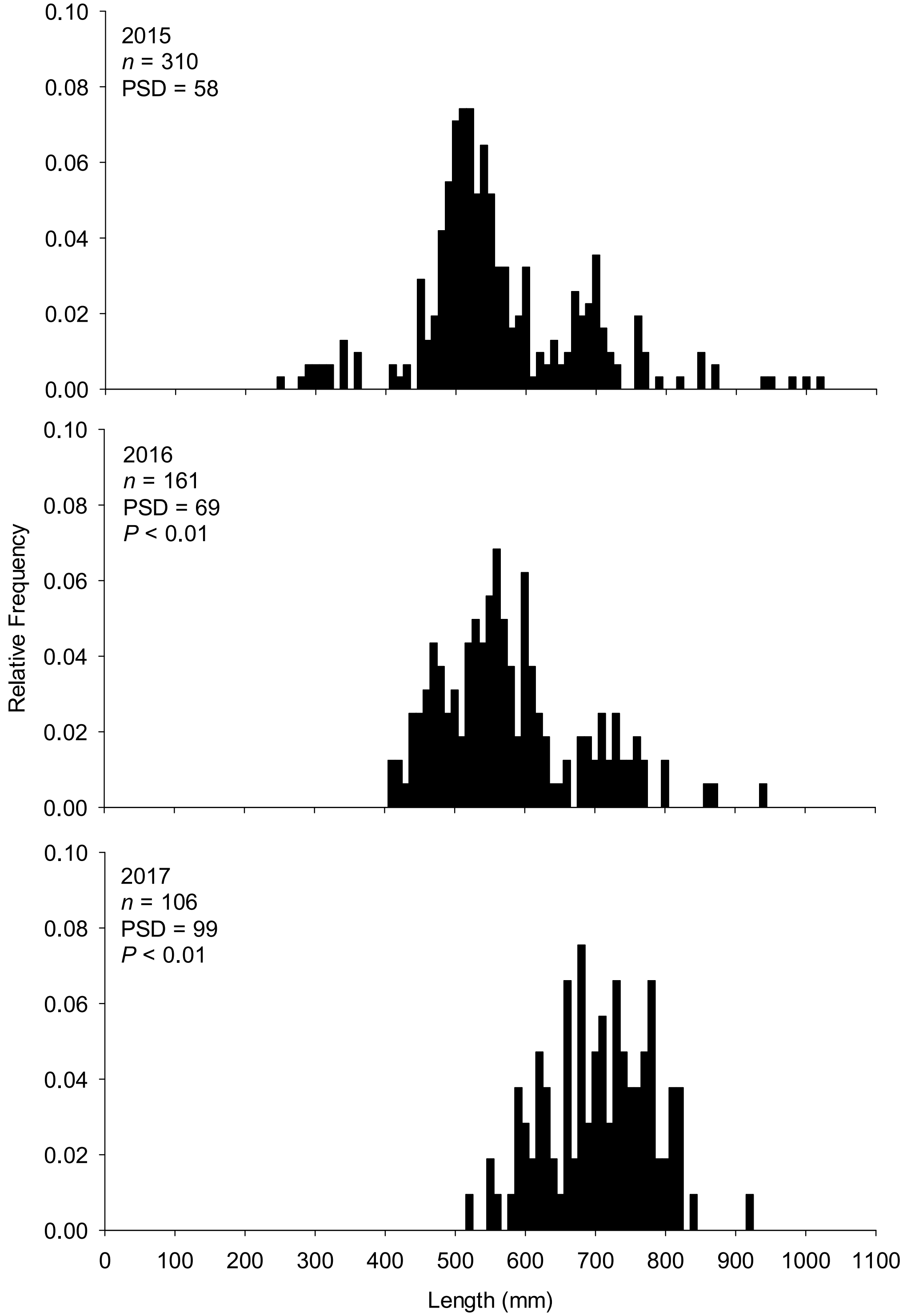

Figure 69. Length-frequency distributions for all Northern Pike sampled during 2015, 2016, and 2017.

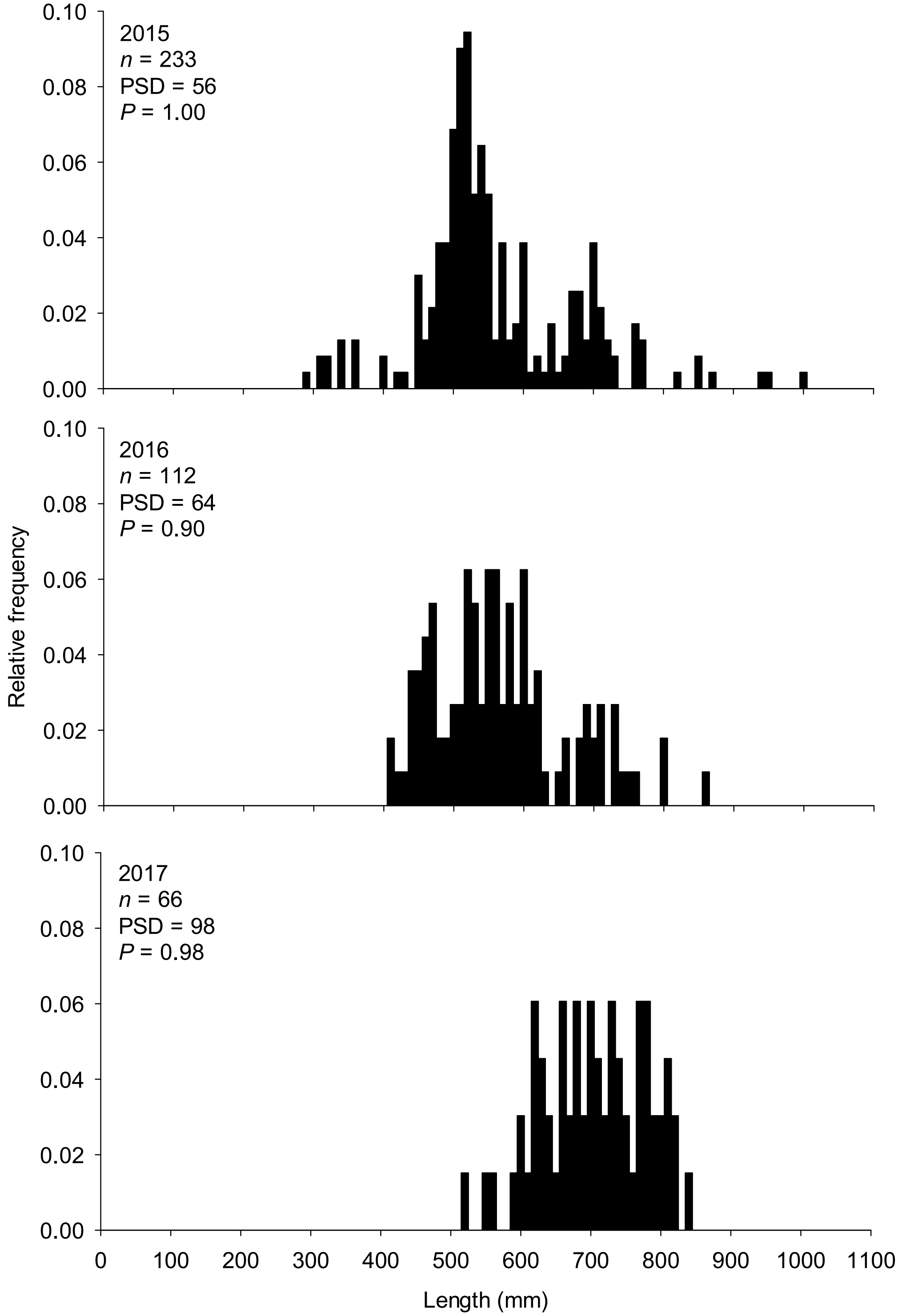

Figure 70. Length-frequency distributions for Northern Pike translocated during 2015, 2016, and 2017.

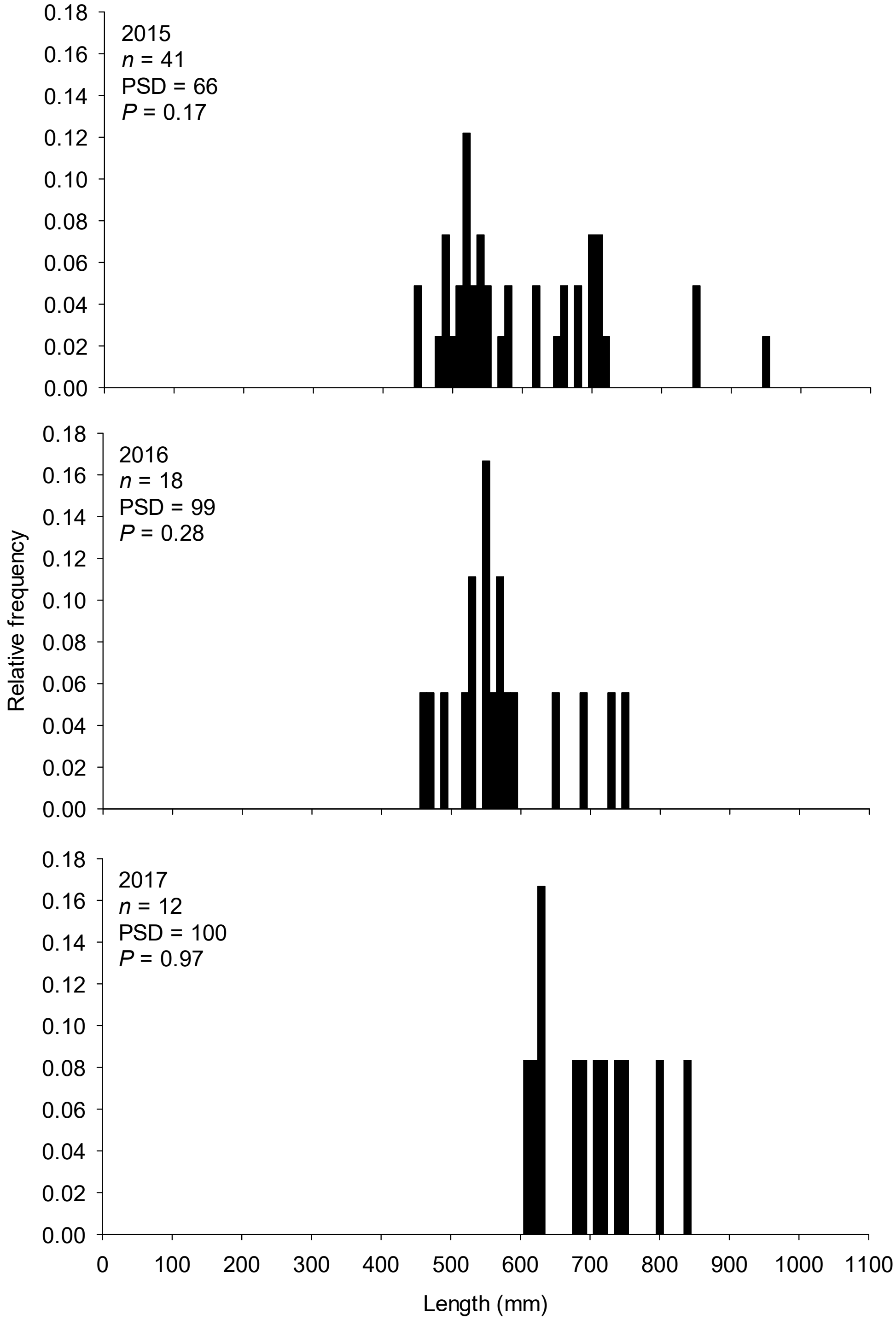

Figure 71. Length-frequency distributions for Northern Pike caught by anglers during 2015, 2016, and 2017.

BULL TROUT REDD COUNTS

ABSTRACT

In 2017, we counted Bull Trout *Salvenlinus confluentus* redds as an index of adult abundance in three of the major drainages in northern Idaho's Panhandle Region. A total of 110 redds were counted, including 98 redds in the Upper Priest Lake drainage, four in the St. Joe River drainage, and eight in the Kootenai River drainage. Redd count totals from 2017 were variable relative to average counts from the previous ten-year period for the Upper Pries Lake and Kootenai drainages, but did not suggest dramatic shifts in Bull Trout abundance at the core area scale. Conversely, counts continued to decline and have reached an exceptionally low level in the St. Joe River drainage.

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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 has management importance. 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. Redd counts allow for evaluation of the status of the 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 (Jakubowski et al. 2017).

METHODS

We counted Bull Trout redds in selected 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. 2014; Table 1; Table 2; Table 3). Surveys were conducted by experienced redd counters or an experienced counter paired with an unexperienced counter in most cases. Unexperienced redd counters were provided basic training in identifying redds prior to a survey. 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 a standardized time periods (late–September to mid-October). In some surveys, redd locations were recorded on maps and/or recorded by global positioning system (GPS). We summarized counts by major drainage areas. We 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.

RESULTS AND DISCUSSION

Priest Lake Core Area

We completed Priest Lake core area redd counts on September 28, 2017. We counted 98 Bull Trout redds combined across seven standard (Ryan et al. 2014) stream reaches surveyed in the core area (Table 4). Overall counts increased from the previous year and were above the previous 10-year average for combined counts of 44 redds. The results of this survey represented the greatest number of redds counted in the history of surveying this core area.

St. Joe Core Area

St. Joe River core area redd counts were completed on September 25–26, 2017. We surveyed standardized reaches of three index streams (i.e., Wisdom Creek, Medicine Creek, and the mainstem St. Joe River between Heller Creek and St. Joe Lake). We counted a total of four

Bull Trout redds among four index reaches in the core area (Table 5). We counted three redds in Medicine Creek and one redds in the St. Joe River between Medicine Creek and St. Joe Lake.

Redd count trends in the St. Joe core area suggest Bull Trout populations are continuing to decline to very low levels. Total redds observed in 2017 represented a continued decline over the past six years. Similar to previous years, Medicine Creek continues to account for the vast majority of Bull Trout redds counted in the St. Joe drainage, highlighting the importance of this spawning tributary. In 2017, Medicine Creek accounted for 3 of the 4 total redds we observed in index streams, while total counts continue a precipitous decline. In Wisdom Creek (one of three index streams), 2017 marked the fourth year in a row of no redds observed, suggesting this population is either at very low densities, or may have been extirpated.

Kootenai River Core Area

Redd counts in the Idaho portion of the Kootenai River core area were completed in mid-October. A total of eight redds were observed, including six in North Callahan Creek and two in South Callahan Creek. Redd counts in Kootenai River tributaries continue to be highly variable. Overall counts increased from the previous year and were above the previous 10-year average for combined counts of 6.4 redds (Table 6).

RECOMMENDATIONS

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

Table 34. Bull Trout redd survey stream reaches for Upper Priest River surveys.

Stream	Reach description	Length (km)	Downstream location		Upstream location	
			latitude	longitude	latitude	longitude
Upper Priest River	Falls to Rock Cr.*	12.5	48.99319	116.94072	48.90649	116.97141
	Rock Cr. to Lime Cr.*	1.6	48.90649	116.97141	48.89405	116.96553
	Lime Cr. to Snow Cr.*	4.2	48.89405	116.96553	48.86251	116.96475
	Snow Cr. to Hughes Cr.*	11.0	48.86251	116.96475	48.80538	116.92413
	Hughes Cr. to Priest Lake	2.3	48.80538	116.92413	48.79896	116.91209
Rock Cr.	Mouth to F.S. trail 308	0.8	48.90649	116.97141	48.91306	116.97272
Lime Cr.	Mouth upstream 1.2 km	1.2	48.89405	116.96553	48.90279	116.95837
Cedar Cr.	Mouth upstream 3.4 km	3.4	48.87966	116.95992	48.8937	116.92136
Ruby Cr.	Mouth to waterfall	3.4	48.82299	116.93245	48.85184	116.93866
Hughes Cr.	Trail 311 to trail 312	2.5	48.86051	117.00519	48.88580	117.99710
	F.S. road 622 to Trail 311	4.0	48.82938	116.98207	48.86051	117.00519
	F.S. road 622 to mouth*	7.1	48.82938	116.98207	48.80538	116.92413
Bench Cr.	Mouth upstream 1.1 km	1.1	48.86874	117.00305	48.87566	117.01203
Jackson Cr.	Mouth to F.S. trail 311	1.8	48.85584	117.00154	48.85458	117.02524
Gold Cr.	Mouth to Culvert*	3.7	48.82122	116.97364	48.80705	117.01592
Boulder Cr.	Mouth to waterfall	2.3	48.81748	116.94952	48.80135	116.96759
Trapper Cr.	Mouth upstream 5.0 km	5.0	48.79591	116.89670	48.83439	116.88697
Caribou Cr.	Mouth to old road crossing	2.6	48.74816	116.86321	48.75853	116.85053

*Annual index survey reaches

Table 35. Bull Trout redd survey stream reaches for St. Joe River surveys in 2017.

Stream	Reach description	Downstream location latitude	Downstream location longitude	Upstream location latitude	Upstream location longitude
Medicine Cr.	Mouth to RM 2.4*	47.0282	-115.1497	47.0538	-115.1276
St. Joe R.	Heller Cr. to St Joe R. Falls *	47.0608	-115.2208	47.0038	-115.1211
Wisdom Cr.	Mouth to RM 1.25*	47.0090	-115.1330	47.0347	-115.1064

*Annual index survey reaches

Table 36. Bull Trout redd survey stream reaches for Kootenai River surveys in 2017.

Stream	Reach	Length (km)	Downstream location latitude	Downstream location longitude	Upstream location Latitude	Upstream location longitude
Boulder Cr	Mouth to waterfall	1.8	48.6246	116.0521	48.6146	116.0687
N. Callahan Cr.	Jill Cr. to waterfall	3.3	48.4372	116.0429	48.4483	116.0775
S. Callahan Cr.	Rd 4556 bridge to Rd 414 bridge	4.3	48.4137	116.0459	48.3969	-1160902

Table 37. Bull Trout redd counts by year from the Upper Priest River, Idaho and selected tributaries between 1993 and 2017. Redd surveys were not completed on all stream reaches in all years between 1993 and 2004. As such, averaged redd counts for surveys completed between these years may include fewer completed counts.

Stream	Transect Description	Length (km)	Avg. 1993 -2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Upper Priest River	Falls to Rock Cr.	12.5	13	14	5	17	10	36	34	58	25	17	21
	Rock Cr. to Lime Cr.	1.6	1	0	2	4	1	0	7	8	12	34	36
	Lime Cr. to Snow Cr.	4.2	6	5	10	3	1	3	6	9	13	11	24
	Snow Cr. to Hughes Cr.	11.0	4	2	4	0	7	2	2	0	1	0	4
	Hughes Cr. to Priest Lk	2.3	0	--	--	0	0	0	--	--	--	--	--
Rock Cr.	Mouth to F.S. trail 308	0.8	0.4	0	0	1	0	0	--	--	--	--	--
Lime Cr.	Mouth upstream 1.2 km	1.2	0.2	0	0	0	0	0	--	--	--	--	--
Cedar Cr.	Mouth upstream 3.4 km	3.4	0.3	0	0	0	0	0	--	--	--	--	--
Ruby Cr.	Mouth to waterfall	3.4	0	0	0	0	--	--	--	--	--	--	--
Hughes Cr.	Trail 311 to trail 312	2.5	1	0	0	0	0	0	--	--	--	--	--
	F.S. road 622 to Trail 311	4.0	1	0	5	0	7	5	0	3	0	0	0
	F.S. road 622 to mouth	7.1	1	0	3	11	3	2	1	2	3	1	11
Bench Cr.	Mouth upstream 1.1 km	1.1	0.3	0	0	0	0	0	--	--	--	--	--
Jackson Cr.	Mouth to F.S. trail 311	1.8	0	0	0	0	0	0	--	--	--	--	--
Gold Cr.	Mouth to Culvert	3.7	2	1	5	6	2	4	3	1	0	0	2
Boulder Cr.	Mouth to waterfall	2.3	0	0	0	0	--	0	--	--	--	--	--
Trapper Cr.	Mouth upstream 5.0 km upstream from East Fork	5.0	2	0	0	0	--	0	--	--	--	--	--
Caribou Cr.	Mouth to old road crossing	2.6	0.2	--	--	0	--	--	--	--	--	--	--
All stream reaches combined		70.5	29	22	34	42	31	52	53	81	54	63	98

Table 38. Bull Trout redd counts by year from the St. Joe River, Idaho and selected tributaries. Redd surveys were not completed on all stream reaches in all years between 1992 and 2003. As such, averaged redd counts for surveys completed between these years may include fewer completed counts.

Stream Name	Average 1992 - 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Aspen Cr.	0	--	--	--	--	--	--	--	--	--	--
Bacon Cr.	0	--	0	--	--	0	--	0	--	--	--
Bad Bear Cr.	0	--	--	--	--	--	--	--	--	--	--
Bean Cr.	7	--	1	--	--	1	0	--	--	--	--
North Fork Bean Creek	--	--	--	--	--	19	8	0	--	--	--
Unnamed tributary to N.Fk. Bean	--	--	--	--	--		3	--	--	--	--
Beaver Cr.	0	0	0	3	--	0	--	--	--	--	--
Bluff Cr.- East Fork	0	--	--	--	--	--	--	--	--	--	--
California Cr.	1	0	2	--	--	0	--	--	0	--	--
Cascade Creek	--	--	--	--	--	2	--	--	--	--	--
Copper Cr.	0	0	--	--	--	--	--	--	--	--	--
Entente Cr.	0	--	--	--	--	--	--	--	--	--	--
Fly Cr.	0	2	1	0	--	0	--	--	3	--	--
Gold Cr. Lower mile	0	--	--	--	--	--	--	--	--	--	--
Gold Cr. Middle	0	--	--	--	--	--	--	--	--	--	--
Gold Cr. Upper	1	--	--	--	--	--	--	--	--	--	--
Gold Cr. All	0	--	--	--	--	--	--	--	--	--	--
Heller Cr.	1	0	3	9	5	5	--	0	11	--	5
Indian Cr.	0	--	--	--	--	--	--	--	--	--	--
Medicine Cr.	36	71	41	48	35	20	20	17	4	11	3
Mill Cr.	--	--	--	--	--	9	6	--	--	--	--
Mosquito Cr.	1	--	--	--	--	--	--	--	--	--	--
My Cr.	--	--	--	--	--	0	--	--	--	--	--
Pole	--	--	--	--	--	0	--	--	--	--	--
Quartz Cr.	0	--	--	--	--	--	--	--	--	--	--
Red Ives Cr.	0	1	--	2	4	0	--	0	0	--	0
Ruby Cr.	3	--	--	--	--	0	--	--	--	--	--
Sherlock Cr.	1	3	--	1	--	2	--	0	0	--	--
Simmons Cr. - Lower	0	1	0	--	--	--	--	--	--	--	--
Simmons Cr. - NF to Three Lakes	2	--	0	--	--	--	--	--	--	--	--
Simmons Cr. - Three Lakes to Rd 1278	2	--	0	--	--	--	--	--	--	--	--
Simmons Cr. - Rd 1278 to Washout	0	--	0	--	--	--	--	--	--	--	--

Table 38 (continued)

Stream Name	Average 1992 - 2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Simmons Cr. - Upstream of Washout	0	--	0	--	--	--	--	--	--	--	--
Simmons Cr. - East Fork	0	--	0	--	--	--	--	--	--	--	--
St. Joe River - below Tento Creek	0	--	--	--	--	--	--	--	--	--	--
St. Joe River - Spruce Tree CG to St. J. Lodge	0	--	--	--	--	--	--	--	--	--	--
St. Joe River - St. Joe Lodge to Broken Leg	4	--	--	--	--	--	--	--	--	--	--
St. Joe River - Broken Leg Cr upstream	0	--	--	--	--	--	--	--	--	--	--
St. Joe River - Bean to Heller Cr.	0	--	--	--	--	--	--	--	--	--	--
St. Joe River - Heller to St. Joe Lake	8	8	1	5	7	4	1	0	7	2	1
Three Lakes Creek	0	--	--	--	--	--	--	--	--	--	--
Timber Cr.	0	--	--	--	--	--	--	--	--	--	--
Tinear Cr.	--	--	--	--	--	2	5	--	--	--	--
Wampus cr	0	--	--	--	--	--	--	--	--	--	--
Washout Cr.	1	--	--	--	--	--	--	--	--	--	--
Wisdom Cr	8	27	8	1	1	5	1	0	0	0	0
Yankee Bar	0	0	--	--	--	--	--	--	1	--	--
Total - index streams	52	106	50	54	43	29	22	17	11	13	4
Total - all streams	59	113	57	69	52	69	44	17	26	13	9
Number of streams counted	14	12	15	8	5	18	8	8	9	3	5

Table 39. Bull Trout redd counts by year from selected tributaries of the Kootenai River in Idaho.

Stream	Length (km)	Avg 2002-2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Boulder Creek	1.8	1	0	0	0	0	0	0	0	0	0	0
North Callahan Creek	3.3	17	17	10	9	2	6	9	7	1	0	6
South Callahan Creek	4.3	5	0	0	1	0	0	2	0	0	0	2
Total		23	17	10	10	2	6	11	7	1	0	8

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