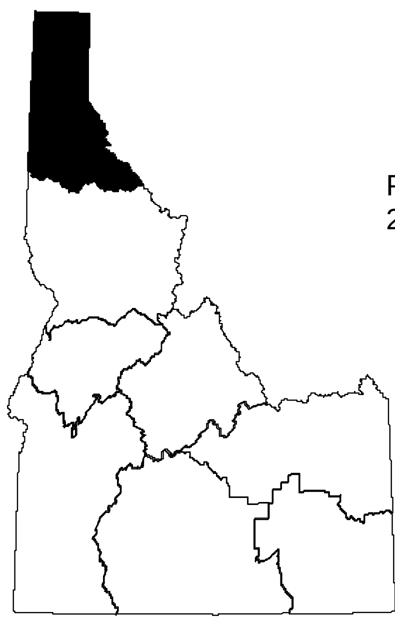
FISHERY MANAGEMENT INVESTIGATIONS

IDAHO DEPARTMENT OF FISH AND GAME
FISHERY MANAGEMENT ANNUAL REPORT

Ed Schriever, Director



PANHANDLE REGION
2016

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UPPER PRIEST LAKE LAKE TROUT MANAGEMENT

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 2016, gill nets were used to remove 1,894 Lake Trout during a two week period from May 16 to May 25. Average daily Lake Trout catch rate from standard mesh sizes was 9.5 fish/box, representing a stable to declining catch rate trend over time. Lake Trout length ranged from 185 mm to 1010 mm. Bull Trout *Salvelinus confluentus* catch rate (0.35/box) was above average for the previous nine-year period.

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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 Lake and Upper Priest Lake fishing (Bjornn 1957). Historically, Bull Trout provided a trophy fishery component (Bjornn 1957). However, harvest opportunities were discontinued in 1984 following declines in Bull Trout abundance. Although fishing mortality was removed, no positive response to the population resulted (Mauser et al. 1988). Today, the Bull Trout population in Upper Priest Lake is considered severely depressed while the population in Priest Lake nearby 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 1950s (Mauser et al. 1988). Westslope Cutthroat Trout harvest opportunities were closed in 1988, also following a decline in abundance. Overharvest, interspecific competition, predation, and degradation of spawning habitat were all believed to contribute to the decline of native fish in this system.

While multiple factors have likely influenced the abundance of native fishes in Priest and Upper Priest lakes, increasing Lake Trout abundance was believed to be the primary cause of population scale changes in native fish communities. Lake Trout *Salvelinus namaycush*, 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 were used annually since 1998 to remove Lake Trout and reduce their abundance in the lake. Management efforts have collected between 150 and 5,000 Lake Trout annually from Upper Priest Lake (Fredericks et al. 2013). In 2016, we continued Lake Trout removal 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 temperature of approximately 21 ˚C. The lake is bathtub shaped with steep walls and a flat bottom. Upper Priest and Priest lakes are held at 743 m elevation from the end of spring run off until mid-October using a small damn located at the outlet of Priest Lake. Upper Priest Lake is connected to Priest Lake by a channel known as the Thorofare. The Thorofare is roughly 3.2 km long, 70 m wide and 1.5-3 m deep at summer pool. At low pool water depth in the Thorofare outlet is < 0.15 m inhibiting boat traffic.

METHODS

We completed the 2016 Upper Priest Lake Lake Trout removal effort between May 17 and May 25. Hickey Brothers Research LLC was contracted to provide equipment and labor for completing 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) and Kalispell Tribe.

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. Nets were tied together end to end to create a single long net string. Each net string or combination of boxes contained a standardized range of stretched mesh sizes including 45 mm, 51 mm, 64 mm, 76 mm, 89 mm, 102 mm, 114 mm, and 127 mm (Table 1). Effort units were measured as net boxes. 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 AM and 12 boxes of net were set in the PM. The combined effort by mesh size was consistent within AM and PM sets, respectively. The time between net placement and initiating net lifting ranged between two to five hours for all sets. Gill nets were set throughout Upper Priest Lake over the course of the sampling period at depths ranging from 10 m to 31 m. Placement of nets in and around the primary inlets and outlet of Upper Priest Lake was avoided to reduce by-catch 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 mm, 64 mm, 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 2016 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 2016. Prior to 2014 no standard set of mesh sizes was used, limiting 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. A portion of the catch was also used for ongoing research on Lake Trout movements in the system (Personal communication, Derek Entz, Eastern Washington University).

Bycatch associated with the removal effort was generally noted and released, though not all individuals were recorded. However, total length and condition were collected from all Bull Trout. We reported bull trout catch rate as total catch divided by total effort among all mesh sizes and compare catch rate between 2007 and 2016.

RESULTS

We collected 1,894 Lake Trout during the ten-day effort. Average daily catch rate from 51 mm, 64 mm, and 76 mm mesh sizes was 9.5 fish/box (± 4.7, 80% C.I.; Figure 1). Mesh specific catch rates demonstrated increased catches in 2016 were primarily observed in 45 mm and 51 mm mesh sizes (Figure 2).

Total length of Lake Trout varied from 185 mm to 1010 mm (Table 1). In general, fish length increased with increased gill net mesh size. Small mesh sizes (45mm, 51 mm, and 64 mm) represented the highest catch rates and accounted for 81% of the total catch. These mesh sizes also represented 60% of total effort expended.

Bycatch included Bull Trout, Kokanee *Oncorhynchus nerka*, Longnose Sucker *Catostomus catostomus*, Largescale Sucker *C. macrocheilus*, Northern Pikeminnow *Ptychocheilus oregonensis*, and Peamouth *Mylocheilus caurinus*. We caught 84 Bull Trout among all netting efforts representing a catch rate of 0.35 Bull Trout per box of net. Observed catch rate represented more than twice the average rate observed over the previous nine years (0.14 Bull Trout per box, Figure 4). Mean TL of Bull Trout was 373 mm, and ranged from 227 to 765 mm.

DISCUSSION

Patterns in Lake Trout catch rate suggested our Upper Priest Lake management program, aimed at controlling Lake Trout abundance within Upper Priest Lake to benefit native fish species, was successful. We believe catch rates reflect relative abundance Lake Trout. We observed stable to decreasing daily catch rates over the period from 2010 to 2016, suggesting the abundance of Lake Trout in Upper Priest Lake was declining.

We continued to see evidence that the abundance of Bull Trout in Upper Priest Lake is increasing. Bull Trout catch rates associated with Lake Trout netting efforts in Upper Priest Lake were the highest observed since 2007 and continued a positive trend over time. These results suggested conditions in Upper Priest Lake promoted positive population growth. Results also indirectly suggested annual Lake Trout removal efforts benefit Bull Trout. As such, we recommend to continue removing Lake Trout from Upper Priest Lake as a tool for conserving native fishes.

MANAGEMENT RECOMMENDATIONS

1. Continue annual gillnetting to remove Lake Trout from Upper Priest Lake in support of native fish.

Table 1. Upper Priest Lake 2016 gill net effort and Lake Trout (LKT) catch by gill net mesh size. Total length ranges of Lake Trout caught were reported by associated gill net mesh sizes.

Mesh	Effort (m)	% of Effort	LKT Caught	LKT/Box	Min TL	Max TL
45 mm	13,167	20%	543	11.3	196	595
51 mm	13,167	20%	615	12.8	185	753
64 mm	13,167	20%	380	7.9	208	755
76 mm	4,389	7%	82	5.1	297	888
89 mm	4,389	7%	85	5.3	420	895
102 mm	8,778	13%	124	3.9	371	885
114 mm	4,389	7%	37	2.3	494	801
127 mm	4,389	7%	28	1.8	260	1010

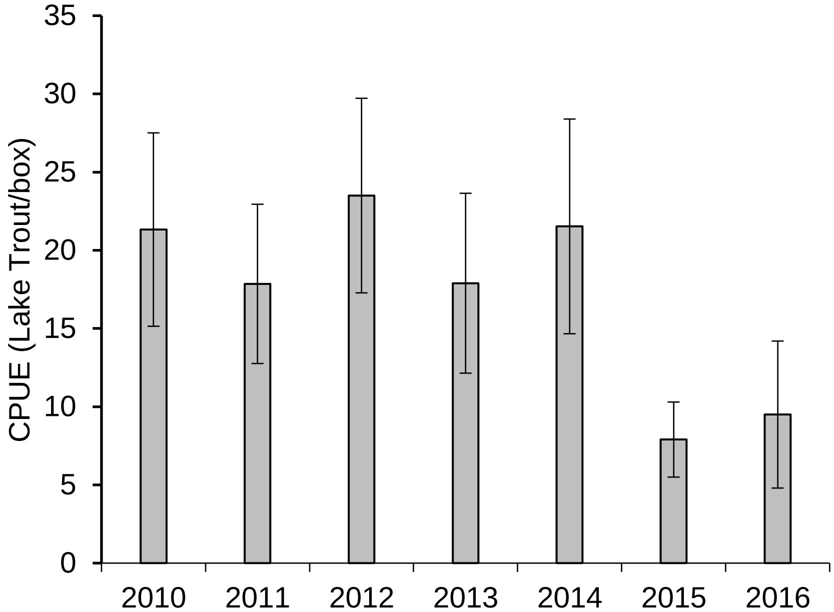

Figure 1. Average daily Lake Trout catch per unit effort (CPUE fish/box) and 80% confidence intervals by year from combined standard gill net mesh sizes (51 mm, 64 mm, and 76 mm) fished in Upper Priest Lake, Idaho between 2010 and 2016.

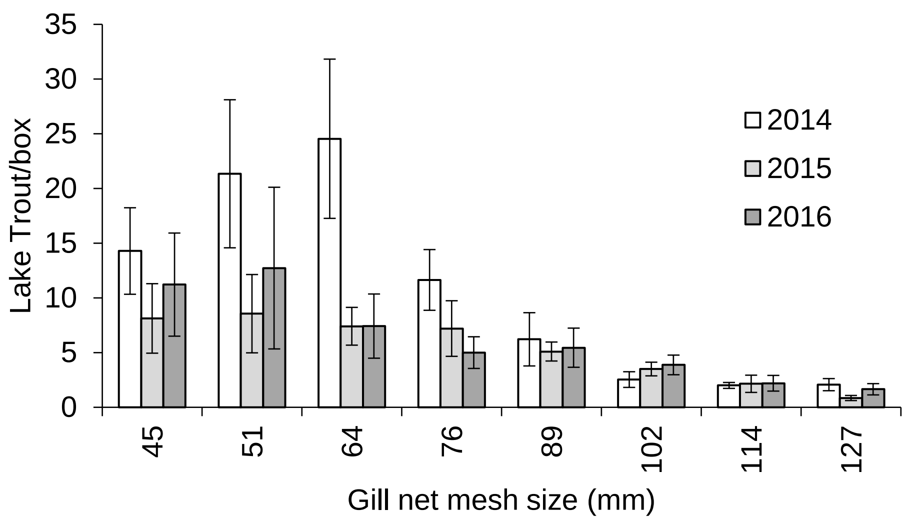

Figure 2. Average daily Lake Trout catch rate (Lake Trout/box) and 80% confidence intervals by mesh size from all standardized gill nets fished in Upper Priest Lake, Idaho in 2014, 2015, and 2016.

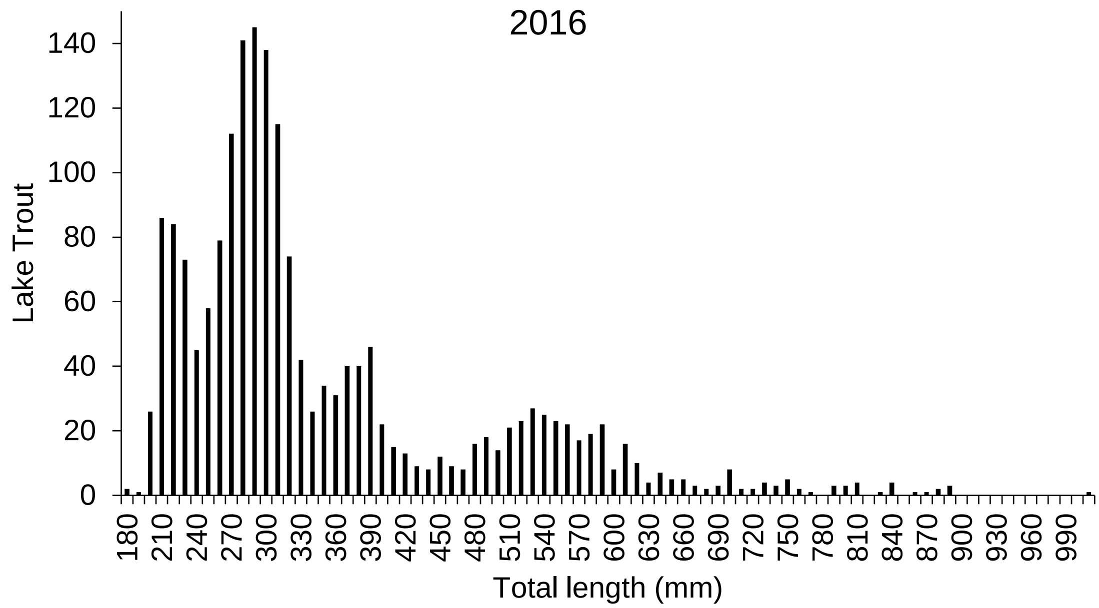

Figure 3. Frequency of total lengths from Lake Trout collected in Upper Priest Lake during 2016 gill net effort completed to reduce Lake Trout abundance.

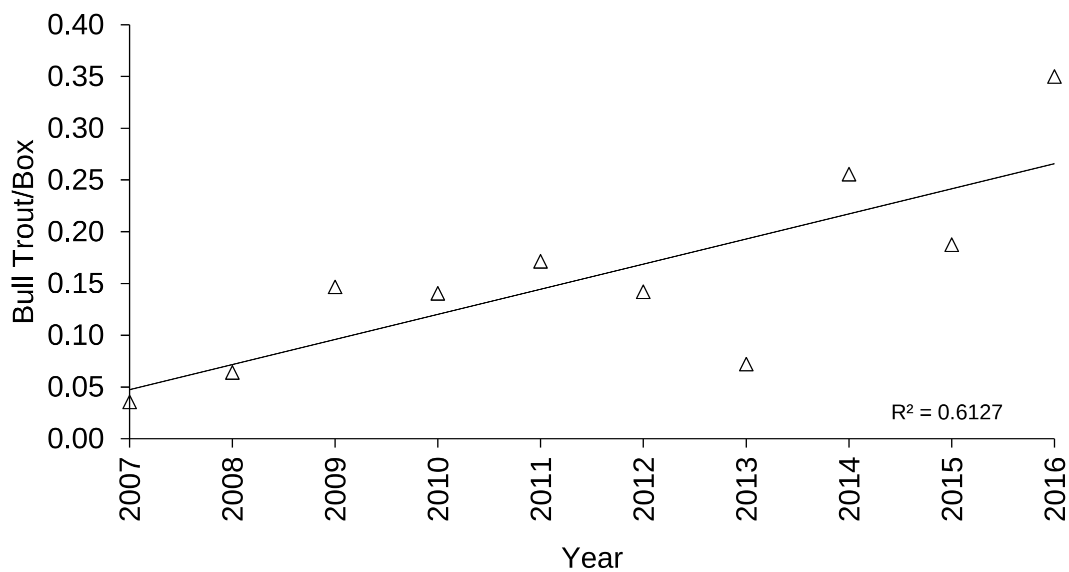

Figure 4. Bull Trout catch rate (fish/box, calculated as total catch divided by total effort) from Upper Priest Lake gill netting efforts between 2007 and 2016.

PRIEST LAKE FISHERY INVESTIGATIONS

ABSTRACT

In 2016, 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. We also monitored kokanee spawner abundance in Priest Lake by counting mature spawning adults at five standard areas. Estimated density of Priest Lake kokanee in August 2016 was 32 fry/ha and 8 age-1 to age-4 kokanee/ha. A total of 4,925 mature adult kokanee were observed along five shoreline areas of Priest Lake in November. The combined observations from surveys suggested kokanee densities were low and overall abundance had declined from a recent peak observed between 2011 and 2014.

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INTRODUCTION

Priest Lake is located in Idaho's panhandle approximately 28 km south of the Canadian border. Surface area of the lake is 9,446 ha with 8,190 ha of open water 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 (Liter et al. 2009, Watkins et al. *in review*). The Priest Lake fishery is popular and economically valuable, with an estimated $5.9 million spent by anglers fishing the lake in 2011(IDFG, unpublished data).

Priest Lake fisheries management has changed significantly since the early 1900's. 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 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 kokanee collapse. However, increased Lake Trout abundance between the 1970s and 90s led to shifting management objectives and the current yield fishery (IDFG 2013a). 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 and negatively influenced other once–abundant fish species (i.e., kokanee, Bull Trout, Westslope Cutthroat Trout; IDFG 2013a).

Current fishery management objectives for Priest Lake are independent of Upper Priest Lake, a 566-ha lake north of Priest Lake. However, observations of fish movements through the Thorofare, approximately 3 km of flowing water connecting the two lakes, clearly demonstrate the fish communities within the lakes are not entirely independent (Fredericks and Venard 2001). Current management prioritizations include a native species focus in Upper Priest Lake and a mixed species focus including Lake Trout, kokanee, and Westslope Cutthroat Trout in Priest Lake. Due to the interaction between these connected water bodies, independent management of these fisheries may be in conflict and create challenges for maintenance of quality fisheries in either lake. In addition, Priest Lake anglers are currently divided between interests in Lake Trout and enhancement of other species (i.e., Westslope Cutthroat Trout, kokanee; IDFG 2013a). To address these issues, the Idaho Department of Fish and Game Fisheries Management Plan (2013-2018) indicates a better understanding of the fish communities in this system is necessary to guide future management direction (IDFG 2013a). Consistent with this objective, we investigated Priest Lake kokanee abundance during 2016 to describe current population trends.

METHODS

Acoustic Survey

We conducted a lake-wide mobile acoustic survey on Priest Lake to estimate kokanee abundance on the night of August 3, 2016. We used a Simrad EK60 split-beam, scientific echosounder with a 120 kHz transducer, with the ping rate set at 0.3 to 0.51 seconds per ping. A pole-mounted transducer was located 0.52 m below the surface, off the port side of the boat, and

pointed downward. The echosounder was calibrated prior to the survey using a 23-mm copper calibration sphere to set the gain and to adjust for signal attenuation to the sides of the acoustic axis. Prior to our survey, we measured one temperature profile as a calibration of signal speed and as a reference of the expected zone of occupancy for kokanee. Water temperatures were measured at 1-m intervals for 15 meters using a YSI 85-50 dissolved oxygen temperature meter (YSI Incorporated). Mean water temperature for water depths between 0 and 10 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. 2013a). 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 the 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 from 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) were used to estimate density of kokanee age classes one to four.

We calculated kokanee abundance by multiplying estimated densities by the area of pelagic usable habitat in Priest Lake. Priest Lake has been estimated to contain 8,190 ha of pelagic habitat usable by kokanee (Maiolie et al. 2013a). 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 Spawner Count

We monitored mature adult kokanee abundance in Priest Lake on November 5, 2016. Spawning kokanee were observed and counted at five standard near shore 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, sex, and age class information. One gill net was set for 15 minutes. The monofilament gill net was 46 m long with variable mesh panels from 1.9 cm to 6.4 cm bar mesh. We estimated mature kokanee ages by examining freshly removed whole otoliths under a dissecting microscope. Sexes were determined by examining external characteristics and gonads.

Gill Net Survey

We attempted to use other sampling methods to physically sample kokanee in an effort to better partition acoustic abundance estimates into age groups. Sampling methods included gill nets and a mid-water trawl. Sampling efforts were incorporated into an ongoing doctoral study on kokanee monitoring methods (Zach Kline, University of Idaho, personal communication). Priest Lake was included in the study as a representative low density kokanee population.

Mid-water suspended gill nets were fished overnight on the nights of August 1 and 2, 2016. Gill nets were 48.8 m long and 6 m deep. Eight mesh sizes including 12.7, 19.0, 25.4, 38.1, 50.8, 63.5, 76.2, and 101.6 mm (stretch measure) were used in each net. Two panels of each mesh size were randomly positioned. Gill nets were suspended horizontally in the water column. Depths between 10 to 28 m were fished by hanging each net from lengths of rope under floats. Depth range represented the expected kokanee layer, although no true layer was observed during the survey period. We fished three nets per sample site, staggering net depth to cover the desired depth range. A total of six sample sites was fished. Sample sites were selectively chosen in areas of the lake thought to have higher densities of kokanee based on acoustic surveys in prior years (Ryan et al. *In Review*). All fish caught were identified, measured (TL, mm), and weighed (g).

Mid-Water Trawl Survey

We also sampled kokanee in Priest Lake by mid-water trawl. Trawling was conducted on the night of August 3rd, 2016, during the dark phase of the moon. Six trawls were conducted in open water areas of the lake corresponding to areas sampled with gill nets. We used a mid-water trawl, as described by Bowler et al. (1979) and Rieman (1992). We modified methods to include a fixed-frame trawl. The net was 2.2 m wide by 3.01 m tall by 10.5 m long and was towed through the water at a speed of 1.55 m/s by an 8.8 m boat. The trawl was towed at four depth zones sequentially covering depths between 10 to 23 m. Each depth zone was fished for three minutes. All fish caught were identified and measured (TL, mm).

RESULTS

Acoustic survey

Estimated density of Priest Lake kokanee in August 2016 was 32 fry/ha ± 19.3 (80% C.I.; Table 1) and 8 age-1 to age-4 kokanee/ha ± 2.6 (80% C.I.,Table 1). Expanded densities represented total estimates of 262,212 kokanee fry and 63,043 kokanee ages 1 to 4.

Target strengths observed during the acoustic surveys showed a bimodal distribution that we used to parse out kokanee fry from older age classes (Figure 2). Based on the bimodal distribution, we were comfortable splitting kokanee fry from older age classes at -44.0 dB. Distribution of target strengths included large individuals as observed in previous Priest Lake kokanee acoustic surveys. We expected to see larger target strengths given the size of the fish caught by fishermen and observed during surveys of spawning kokanee.

Shoreline Spawner Count

We counted a total of 4,925 mature kokanee along five shoreline areas of Priest Lake in 2016 (Table 2). Counts continued to decline from a peak observed in 2013 (Figure 3). Mature kokanee collected near Hunt Creek varied in length from 380 to 464 mm and averaged 423 mm (n = 12) and 415 mm (n = 4), for males and females, respectively. All mature adults collected were estimated to be three years of age.

Gill Net Survey

Twelve kokanee (137 mm - 385 mm) were captured among all gill net sets (Table 3). Bycatch included Lake Trout, Northern Pikeminnow *Ptychocheilus oregonensis*, Pygmy Whitefish *Prosopium coulterii*, and Westslope Cutthroat Trout. Because of the limited catch of kokanee we did not apply catch at age data from gill net catches to acoustic abundance estimates.

Mid Water Trawl Survey

Ten kokanee fry (57 mm – 70 mm) and one 200 mm fish were caught among all trawl transects. Similar to our gill net effort, limited catch of kokanee prevented our use of age data to apportion acoustic abundance estimates.

DISCUSSION

The combined observations from our surveys suggested kokanee densities in Priest Lake were low and overall abundance had declined from a recent peak observed between 2011 and 2014. Our acoustic estimate of abundance represented a decline from recent peak levels. However, the observed variability of recent estimates limited our ability to identify significant changes in abundance among the most recent survey years (Figure 4; Fredericks et al. 2013, Maoilie et al. 2013, and Ryan et al. 2014, Watkins et al. *In review*, Ryan et al. *In Review*). Regardless, we were confident that abundance remained low relative to other waters in the region. Our observations of kokanee spawner abundance and length also provided evidence abundance was low and suggested a decline in abundance may have occurred. Specifically, we

continued to see Priest Lake kokanee spawner counts decline relative to counts completed from 2011 through 2015 (Figure 3; Fredericks et al. 2013, Maoilie et al. 2013, and Ryan et al. 2014, Watkins et al. *In review*, Ryan et al. *In review*). In addition, average length of kokanee spawners continued to increase, a trend observed since 2013, corresponding to declining spawner counts (Figure 4).

One of the primary limitations of our current monitoring efforts continued to be a lack of age-specific abundance information. This limited our ability to investigate kokanee survival and more specifically identify critical periods in Priest Lake kokanee life history that may influence trends in abundance. Although we attempted to sample kokanee in Priest Lake using both gill nets and a trawl, we experienced low catches. We assumed densities were too low and/or distribution too scattered to effectively sample fish in the population. Based on our experiences, it seems unlikely more descriptive information is obtainable with reasonable effort unless abundance increases. We recommend continuation of acoustic survey techniques as the primary monitoring tool for Priest Lake kokanee. We also recommend continuation of fall shoreline spawner counts. Although this tool remains course relative to tracking abundance it provides support for interpreting acoustic survey results under low precision conditions.

MANAGEMENT RECOMMENDATIONS

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

2. Discontinue kokanee sampling with suspended gill nets unless kokanee abundance increases appreciably.

Table 2. Acoustic kokanee survey results from Priest Lake, Idaho on August 3, 2016.

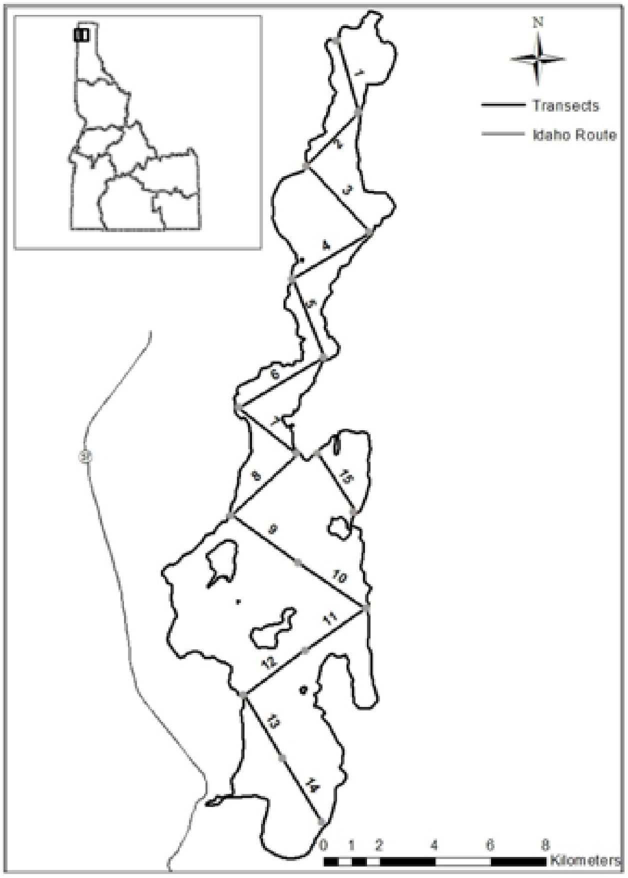
Transect	Single targets	NASC	Mean TS	Total density (fish/ha)	% Fry	Fry density	% Ages 1-4	Age 1-4 density
1	0	0.00	0.00	0	0%	0	0%	0
2	9	7.79	-39.33	16	56%	9	44%	7
3	11	33.77	-33.90	19	64%	12	36%	7
4	13	9.00	-39.64	19	69%	13	31%	6
5	50	7.18	-48.05	106	94%	100	6%	6
6	28	9.47	-50.20	230	96%	222	4%	8
7	17	3.83	-40.79	11	88%	9	12%	1
8	17	11.85	-37.68	16	65%	10	35%	6
9	24	13.28	-36.02	12	67%	8	33%	4
10	24	27.71	-40.26	68	67%	46	33%	23
11	45	44.73	-37.32	56	53%	30	47%	26
12	14	16.35	-37.69	22	36%	8	64%	14
13	1	0.19	-48.18	3	100%	3	0%	0
14	0	0.00	0.00	0	0%	0	0%	0
15	21	15.53	-36.59	16	57%	9	43%	7
Mean				40		32		8

Table 3. Kokanee spawner counts at three standard locations on Priest Lake, Idaho from 2001 - 2016.

Location	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Cavanaugh Bay	523	921	933	1,673	916	972	463	346	550	331	1,340	3,135	2,295	838	1,155	710
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
Huckleberry Bay	200	49	38	359	120	43	38	0	37	18	90	665	340	525	7	34
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	2987
Indian Creek Bay	222	0	0	441	58	0	40	27	15	49	1,050	830	1,270	2,750	520	670
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

Table 4. Species, catch (n), and size ranges (TL) for fishes caught in suspended gill nets fished in Priest Lake, August 2016.

Species	n	Min of TL	Max of TL
Kokanee	12	137	385
Lake Trout	6	432	610
Northern Pikeminnow	1	355	355
Pygmy Whitefish	5	71	124
Westslope Cutthroat Trout	9	205	439



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

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

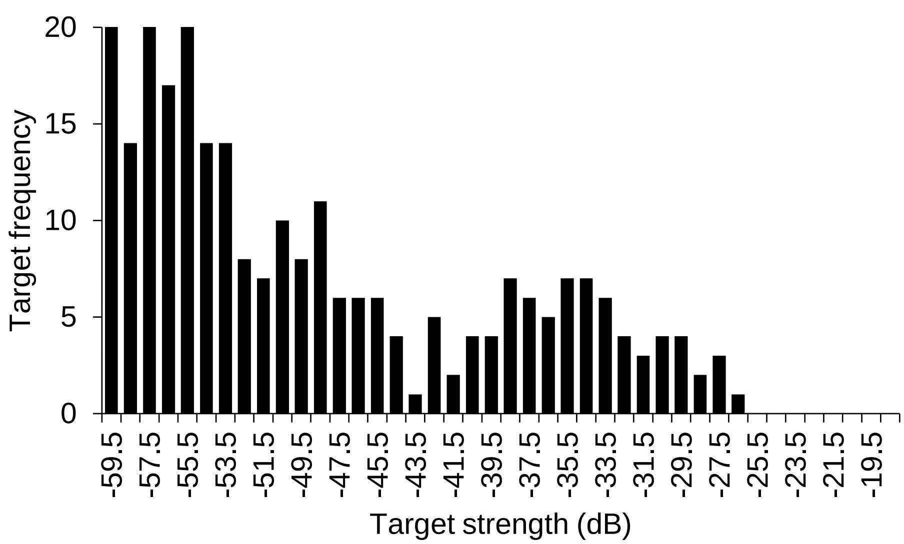


Figure 6. Frequency of target strengths detected in an August 2016 acoustic survey of Priest Lake, Idaho.

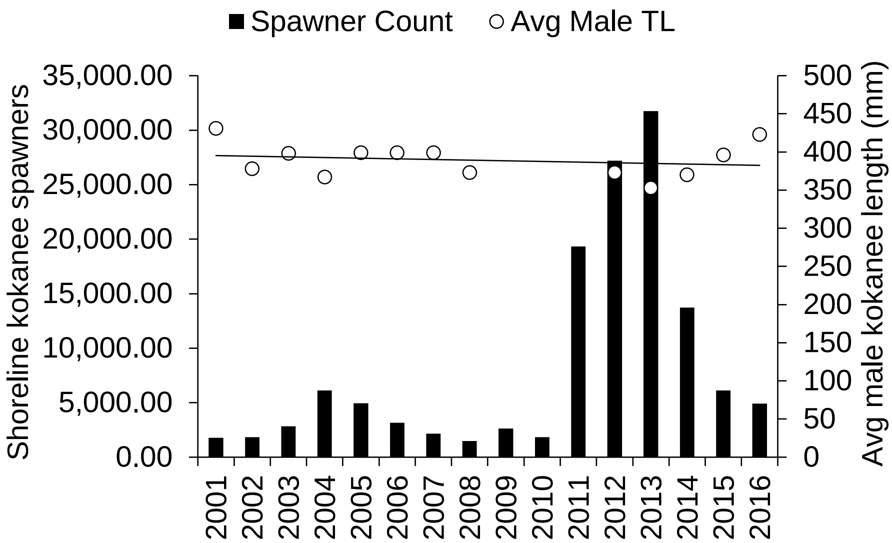


Figure 7. Adult kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 through 2016 and lengths (TL = total length) of male kokanee spawners sampled using gill nets.

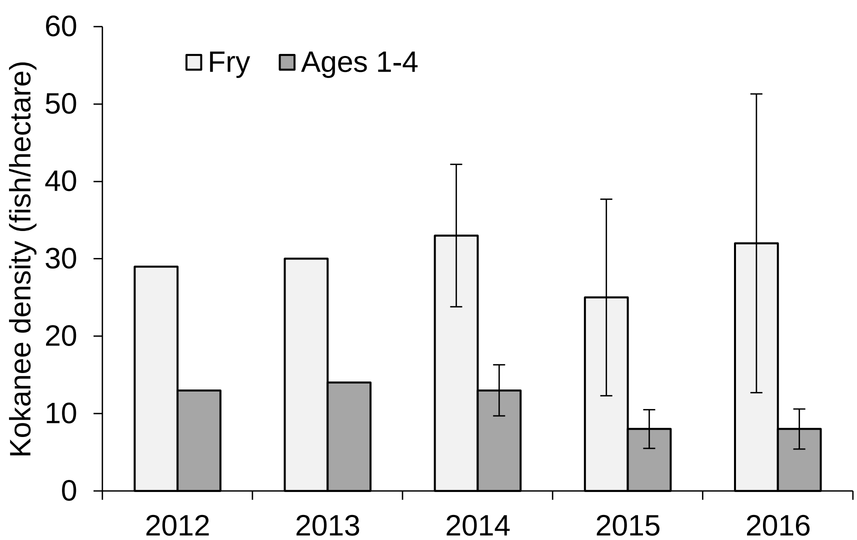


Figure 8. Kokanee density estimates from Priest Lake, Idaho acoustic surveys from 2012 through 2016.

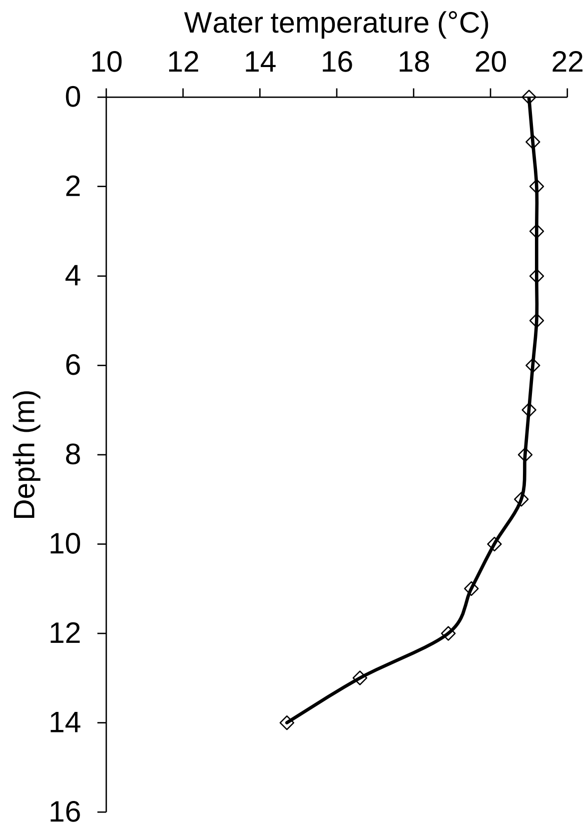


Figure 9. Temperature profile measured in association with our August, 2016 acoustic survey of Priest Lake, Idaho.

PRIEST BASIN TRIBUTARY INVENTORY

ABSTRACT

Recreational fisheries within the Priest Basin have changed dramatically over time, reflecting population changes in the fish species present, their distribution, and abundance. In an effort to both better understand the current status of tributary fish communities in the Priest Basin and identify potential conservation opportunities, we completed inventories of tributary fish communities in 2015 and 2016. We evaluated species distribution and estimated abundance by sampling 54 sites among 17 tributaries. To provide historical perspective, we compared the findings of our survey efforts with prior surveys. We found Westslope Cutthroat Trout *Oncorhynchus clarkii* to be abundant and the most widely distributed fish species among sampled tributaries. Bull Trout *Salvelinus confluentus* were rare in our samples, while Brook Trout *Salvelinus fontinalis* were distributed in approximately half of the sampled tributaries at low densities. Our survey suggested Westslope Cutthroat Trout populations were generally strong and stable. In contrast, we found evidence that Bull Trout had declined in both distribution and abundance within the sampled tributaries. We also found evidence to suggest Brook Trout distribution was relatively stable and increases in abundance were limited.

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INTRODUCTION

Priest Lake and Upper Priest Lake are located in the northern Idaho Panhandle near the Canadian border. Upper Priest Lake (542 ha; 31 m deep) is connected to Priest Lake (9,450 ha; 111 m deep) by a 4.4 km channel referred to as the Thorofare (IDFG 2013a). Water levels in the lakes and the Thorofare are controlled by an outlet dam structure at the southwest end of Priest Lake. A variety of native and non-native fishes occupy the system. Native fish species include Westslope Cutthroat Trout *Oncorhynchus clarkii*, Bull Trout *Salvelinus confluentus,* Mountain Whitefish *Prosopium williamsoni*, Pygmy Whitefish *Prosopium coulterii*, Longnose Dace *Rhinichthys cataractae* Northern Pikeminnow *Ptychocheilus oregonensis*, Peamouth Chub *Mylocheilus caurinus*, and Torrent Sculpin *Cottus rhotheus*. Non-native fishes include Lake Trout *Salvelinus namaycush*, Brook Trout *Salvelinus fontinalis,* Rainbow Trout *Oncorhynchus mykiss*, and kokanee *Oncorhynchus nerka*.

Recreational fisheries within the Priest Basin have changed dramatically over time. Introductions of non-native fishes altered the fish community and the resulting recreational fisheries. Historically, native fishes (i.e., Westslope Cutthroat Trout and Bull Trout) provided robust fisheries in both Upper Priest Lake and Priest Lake as well as within major tributaries (Bjornn 1957). Kokanee and later Lake Trout replaced native fishes as the primary angler targets between the late 1950s and the present (Watkins et al. 2018). Introductions of mysid shrimp *Mysis relicta* in Priest Lake in the 1960s are assumed to have benefited Lake Trout abundance and subsequently influenced continued declines of other fish species once abundant (i.e., kokanee, Bull Trout, Westslope Cutthroat Trout; IDFG 2013a, Watkins et al. 2018). Currently, Bull Trout and Westslope Cutthroat Trout are managed conservatively under a catch-and-release regulation in all waters of the Priest River drainage.

Numerous tributary streams flow into Priest Lake and Upper Priest Lake. These streams are important spawning and juvenile rearing areas for native and non-native fishes exhibiting migratory and resident life histories. Periodic surveys of tributary fish communities have suggested distribution and abundance of native and non-native fishes have changed over time (Bjornn 1957, Irving 1987, Fredericks et al. 2002, DuPont et al. 2008). These investigations and others (Rieman et al. 1979, Mauser et al. 1988, Horner et al. 1988) suggested angler harvest, habitat degradation, and interactions with non-native fishes (i.e., competition, predation) likely contributed to reductions in abundances of native fishes. Most recently, investigation of tributary fish communities in the Priest Basin suggested Westslope Cutthroat Trout were still abundant and commonly represented across surveyed tributaries. However, Bull Trout were much less abundant than historic levels, while Brook trout were more abundant and widespread (DuPont et al. 2008).

The Idaho Department of Fish and Game 2013-2018 Fisheries Management Plan identifies multiple needs to improve current knowledge of fish communities in the Priest Basin (IDFG 2013a). In addition, the management plan identifies objectives directed at conserving native fish populations. In an effort to both better understand the current status of tributary fish communities in the Priest Basin and identify potential conservation opportunities, an inventory of tributary fish communities was completed in 2016. Surveys were completed in major tributaries of Priest Lake and Upper Priest Lake to describe distribution and abundance of native and non-native fishes on a basin-wide scale.

METHODS

We sampled 49 sites among 16 tributaries during July, August, and September 2016. Five sites previously sampled in July of 2015 were also included in this report. Streams sampled included the Hughes Fork in the Upper Priest River drainage; Muskegon, Gold, Bench, and Boulder creeks in the Hughes Fork drainage; Trapper Creek in the Upper Priest Lake drainage; Thorofare tributaries, including Bugle and Caribou creeks; Hunt, Horton, Indian, North Fork Indian, Lion and Two Mouth creeks as east-side Priest Lake drainages; and Kalispell, Tango and Beaver creeks as west-side Priest Lake drainages. Sampled tributaries were selected to provide a largescale view of fish distribution and abundance throughout the basin and to allow for evaluation of trends in fish populations. As such, we selected tributaries based on location, size (i.e., suitable for sampling with a backpack electrofisher), and sampling history. Individual sample sites were distributed from a stream's confluence with its parent tributary or lake to headwater reaches of each tributary. Access to the upstream extent of most tributaries was difficult. Although sample sites were distributed widely in each tributary, uppermost sample sites in most cases did not represent the full distribution of fish habitat. We sampled three to five sample sites per stream that were pre-determined using ArcMap software (Environmental Systems Research Institute). In an effort to describe species distribution and variation in abundance, sampling followed a systematic design within each tributary.

We collected fish using a Smith-Root LR-24 backpack electrofisher. Settings varied among sites due to differences in water conductivity, but generally included 60 Hz and 700 to 800 volts. Most sites were sampled using two people, with one person shocking and another netting fish. Channel width in lower Hughes Fork was generally wider than many other sites and an additional electrofisher and netters were used sample the stream efficiently. All fish collected were identified, measured (total length, mm) and released downstream of the sample transect. We estimated the width of each sample transect using an average of eight transect width measurements. Measured widths were spaced at 10 to 20 m intervals throughout each transect.

Abundance of tributary fish populations was estimated using multi-pass removal estimates (Zippin 1958) in combination with single-pass samples. Single-pass sampling was used to increase the number of possible sample sites surveyed. We estimated abundances from single pass samples by generating a multi-pass regression model of abundance based on first pass collections (Meyer and Schill 1999). A single model of abundance based on first pass collections was developed and included sample data from all tributaries and all target species. Capture efficiencies were consistent among all tributaries and species providing support that model predictions were valid across these boundaries. Abundance estimates included fish ≥75 mm total length, due to sampling efficiency considerations. Sample sections were typically 100 m in length. We closed sample sections using block nets at the downstream end of a survey section at most sites to prevent escapement during downstream electrofishing passes. Block nets were not used at several sites due to high flows or the creek being too wide for the net. At sites where no block net was used, we sampled in an upstream direction and used a natural stream feature, such as a cascade, to limit upstream movement of fish during sampling. On multi-pass samples, we completed sequential passes until captures of an individual pass were no more than 20% of the total capture by species summed across all passes. Typically, two or three passes were completed. We derived abundance estimates and associated 80% confidence intervals for two and three pass samples using calculations for removal estimates in closed populations (Hayes et. al 2007). We reported the total catch on the first pass as the population estimate when all the individuals of a particular species were captured on the first pass. In cases where lower confidence bounds were less than the total number of fish captured, the total number of fish captured was reported as the lower bound. We reported density estimates as the number per 100

m^2. We also used sampled fishes to describe population characteristics within sampled streams, including age, size structure, and species composition.

HISTORICAL COMPARISONS

Understanding the current status of fish populations in Priest Basin tributaries is most insightful if the historical population status is also known. Although surveys of fish populations within these drainages have been completed in the past, no standardized sampling protocol was previously established. To provide historical perspective, we compared our survey results with prior surveys as a qualitative evaluation of change in abundance and distribution relative to contemporary conditions. Specifically, we described changes in species composition (i.e., percent of reported mean density by species) and shifts in distribution indicated by presence or absence of species within streams over time. The results from our survey were compared with reported results from the same waters sampled periodically in 1982-1984[(a)], 1994-1998[(b)], and 2003-2004[(c)] (Irving 1987[a], IDEQ BURP data[b], Fredericks et al. 2002[b], DuPont et al. 2008[c]) adapted from DuPont et al. 2008. Prior surveys were not consistent in methodology. In most cases, relative sampling frequency within a given stream was not similar. Not all streams were surveyed in all time periods and data were only reported where available. Our comparisons focused on Brook Trout, Bull Trout, and Westslope Cutthroat Trout - the primary species encountered historically in the surveyed tributaries.

RESULTS

Water was present and an electrofishing survey was completed at all sections visited (Table 1). Fish were detected at 50 of 54 sites (Table 3). A single regression model was developed to estimate abundance based on first pass collections (Figure 1). Our capture efficiencies in multi-pass samples were consistent (0.73 ± 0.04, 80% C.I.) among tributaries and species, providing support that our model predictions were valid across these variables. Based on the developed linear model, our first pass collections described approximately 92% of the variation in estimated abundance from multi-pass samples.

Westslope Cutthroat Trout were the most abundant fish species and were found in 13 of the 17 tributaries surveyed. Mean densities varied from 0.2 to 16.8 fish/100 m^2 (Table 2). We found Westslope Cutthroat Trout in all surveyed tributaries except Bugle Creek (Figure 2). However, no salmonids were detected in Bugle Creek. Total length of sampled Westslope Cutthroat Trout varied from 39 to 240 mm (Table 3).

Brook Trout were present in nine of the 17 tributaries sampled. Although widely distributed, Brook Trout mean densities were generally low, varying from 0.3 to 4.6 fish/100 m^2 (Table 2). Brook Trout were the dominant species in Caribou Creek, Kalispell Creek, and the Hughes Fork. Distribution of Brook Trout within individual tributaries was not consistent (Figure 2). In Indian Creek, Two Mouth Creek, Tango Creek, Beaver Creek, Trapper Creek, and Bench Creek, Brook Trout were detected primarily in lower stream reaches. In contrast, Brook Trout were widely distributed in Kalispell Creek, Caribou Creek, and the Hughes Fork. Total length of sampled Brook Trout varied from 40 to 307 mm (Table 3).

Several other species, including hybrids, were detected in sampled tributaries (Table 3; Figure 2). We found Bull Trout in Gold Creek, the Hughes Fork, and the North Fork of Indian Creek. Bull Trout density was highest in Gold Creek at 2.2 fish/100 m^2 (Table 2). Bull Trout varied

from 87 to 307 mm (Table 3). Rainbow Trout were only found in Gold Creek and Muskegon Creek (Table 3; Figure 2). Rainbow Trout x Westslope Cutthroat Trout hybrids were also detected in Gold Creek (Table 3, Figure 2). Rainbow Trout and their hybrids varied in length from 78 mm to 151 mm (Table 3). Mountain Whitefish and Bull Trout x Brook Trout hybrids were found only in the Hughes Fork (Table 3; Figure 2).

HISTORICAL COMPARISONS

Westslope Cutthroat Trout represented 15% to 100% of the fish community in tributary stream surveys from 1984 through 2016 (Figure 3). In 13 of the 17 streams in which we described fish community composition over time, Westslope Cutthroat were the primary species present and this was consistent across all surveys. We found apparent declining relative composition only in Bugle Creek, Caribou Creek, Hughes Fork, and Kalispell Creek. The survey history of Bugle Creek was limited to our effort and surveys completed in 2003-04. Fish densities in the prior survey were low (0.5 fish/m^2), suggesting the declining abundance we observed may reflect periodic occupancy of the stream by fishes rather than changes in species composition.

Bull Trout were the least abundant fish species in most tributaries among all survey periods (Figure 3). Bull Trout were found in Gold Creek, Hughes Fork, and North Fork Indian Creek in all survey years. Bull Trout were previously detected in Bench Creek, Boulder Creek, and Trapper Creek in at least one prior survey, but were not found during our 2016 sampling.

Brook Trout were detected in nine of the 17 streams we surveyed (Figure 3). In at least one prior survey, Brook Trout had been detected in Boulder Creek, Bugle Creek, Gold Creek, and Lion Creek, but were not detected in our survey. Brook Trout were proportionally the most abundant species in 2016 surveys of Caribou Creek, Hughes Fork, and Kalispell Creek. An increasing trend in Brook Trout abundance was apparent in these three tributaries, whereas similar trends were not as apparent in other tributaries we sampled.

DISCUSSION

Westslope Cutthroat Trout were the most abundant and widely distributed fish species among the tributaries we surveyed. Our findings suggest Westslope Cutthroat Trout populations across the Priest Basin generally remain strong. Within the scope of our surveys, we found evidence that Westslope Cutthroat Trout populations were also stable in most tributaries. For example, the proportional abundance of Westslope Cutthroat Trout was relatively consistent among comparable survey efforts in 14 of 17 streams surveyed. Our interpretation of population trends based on relative species composition differed from that reported by DuPont et al. (2008). Based on mean density, they suggested Westslope Cutthroat densities had generally declined since the early 1980s. As indicated in the methods guiding this survey, we did not feel comfortable comparing densities between survey years. Differences in the number of sites sampled and the distribution of sites within streams were highly variable among survey years, potentially influencing comparisons of density estimates. As an example of potential bias, we observed isolated distributions of Brook Trout in several of the sampled streams in our survey (Figure 2). Samples focused solely within or outside of these isolated distributions would result in much different estimates of density than if sampled sites occurred throughout the stream. To facilitate trend evaluations in the future, we recommend application of a consistent method of sampling that allows for broad characterization of fish communities throughout each sampled stream. Our

sample design provided characterization of fish communities both on a stream and basin scale. We recommend this design be applied in future surveys.

Bull Trout were not widely distributed among tributaries we surveyed and we found evidence of declining abundance where they were detected. Prior to our surveys, we expected Bull Trout abundances would be low. The expansion of Lake Trout in Priest Lake and Upper Priest Lake is thought to have been a primary factor in Bull Trout decline. Although our expectations were met, we do not believe our results were necessarily representative of the entire drainage. To this point, the Upper Priest River was not included in our survey because its size makes it difficult to sample with our applied methods. The Upper Priest River is the primary spawning stream for Bull Trout in the basin (see Bull Trout Redd Count Chapter in this report). Bull Trout redd counts in the river have demonstrated an increasing trend over the previous decade, suggesting Bull Trout abundance in that tributary has increased. An ongoing Lake Trout reduction program has occurred on Upper Priest Lake since the late 1990's and has been attributed to improving conditions in the lake for Bull Trout (see Upper Priest Lake Lake Trout Management chapter in this report).

Bull Trout, where found in our survey, occurred at low densities. Similarly density estimates from prior surveys were also generally low (DuPont et al. 2008). Based on these observations, we expected the probability of detection to also be low relative to more abundant species. To better define Bull Trout occurrence throughout the drainage, a finer scale monitoring tool may be beneficial. For example, we suggest sampling environmental DNA (eDNA) as an alternative method for detecting presence or absence throughout the drainage.

A migratory life history is typical of Bull Trout populations in northern Idaho streams. Fish lengths observed in most of our survey work generally represented younger age classes (age-0 to age-3) typical of other migratory Bull Trout populations in the area. However, we also observed larger (≥ 300 mm) Bull Trout in the North Fork of Indian Creek that suggested older fish were present and a resident life history may occur within that tributary. Small atypical redds have been observed in this tributary during periodic Bull Trout redd counts. Redd count observers speculated resident fish may be present in this tributary (Scott Deeds, USFWS retired, personal communication). Our observations lend credibility to this speculation.

Expansion of Brook Trout in Priest Basin tributaries is a concern relative to potential impacts to native fishes. DuPont et al. (2008) suggested Brook Trout densities had increased over time and have displaced Westslope Cutthroat Trout on some level in multiple tributaries. We also found Brook Trout were dominant in several tributaries once known to be populated primarily by Westslope Cutthroat Trout. In addition, we found the proportion of Brook Trout in several streams had increased since 2004. In contrast, we did not find Brook Trout in four streams in which they were found in 2004. Generally, our interpretation of these findings is that Brook Trout expansion was not a rapid drainage-wide issue, but rather a condition related to individual streams. We did not quantify habitat complexity or channel slope in this survey, but we generally observed Brook Trout were more abundant in streams or stream reaches with low relative complexity and gradient. DuPont et al. (2008) observed similar habitat-related ties to Brook Trout presence and abundance. This condition highlighted the value of habitat complexity and its benefit to native fishes.

There is limited opportunity to manipulate fish populations in Priest Basin tributaries, although it may be desired to increase abundance of native fishes or address conflicts among species where they may occur. Angling-related mortality, once thought to have influenced populations in the drainage (Bjornn 1957), is not likely as influential today. Fishing effort on

tributary populations in the Priest Basin, although not quantified, is generally believed to be low and harvest of native fishes is currently not allowed. Similarly, on Priest Lake and Upper Priest Lake, angler effort targeting migratory fishes (i.e., Westslope Cutthroat Trout, Bull Trout) is also low ($\leq$ 10%) and similar harvest restrictions exist (Watkins et al., 2018). As such, manipulations of angling related mortality would likely be inconsequential. Manipulations of the fish communities in Priest and Upper Priest lakes likely could influence migratory components of the fish populations in the drainage. Where feasible and supported, manipulations of the in-lake fish community have occurred and are believed to be beneficial. Specifically, an ongoing Lake Trout reduction effort has occurred on Upper Priest Lake annually. Similar manipulations on Priest Lake are not widely supported by the public and have not occurred. Opportunity for mechanical fish removal to address conflicts among species in tributaries is also limited, as most tributaries in the drainage are complex and connected systems, rather than isolated populations. Alternatively, habitat manipulations may be feasible in some locations and offer benefits where habitat quality is low. Lands in the Priest Basin are predominantly in Federal or State ownership and managed for multiple uses, including timber harvest. As such, we recommend continued efforts to work with land managers to emphasize a need for management that encourages protection and enhancement of quality stream habitat, in turn promoting conservation of native fishes.

MANAGEMENT RECOMMENDATIONS

1. Apply a consistent method of sampling following the design in this survey to allow for comparable characterization of tributary fish communities.

2. Periodically replicate this survey to monitor population trends over time.

3. Apply a fine-scale sampling method (e.g., eDNA) to better describe presence or absence of low density fishes in the drainage.

4. Work with land managers to emphasize protection and enhancement of quality stream habitat that promotes conservation of native fishes.

Table 5. Locations (UTM) of sites sampled during 2015 - 2016 inventories of Priest Basin tributaries. Site length and average wetted width at the time of sampling are listed for each survey site.

Stream	Site ID	Date	Site length (m)	Avg width (m)	Zone	Datum	Northing	Easting
Beaver Creek	38	7/21/2016	95	5.7	11.0	WGS84	5398388	509353
	39	7/14/2016	110	4.5	11.0	WGS84	5399133	506969
	40	7/14/2016	110	3.5	11.0	WGS84	5399167	504721
Bench Creek	1	7/13/2015	105	3.1	11	WGS84	5413370	499399
	2	7/13/2015	100	4.1	11	WGS84	5413648	499102
Boulder Creek	33	7/27/2016	100	6.5	11.0	WGS84	5405723	502544
	34	8/16/2016	100	6.6	11.0	WGS84	5403832	502104
	35	7/21/2016	95	3.0	11.0	WGS84	5401983	502668
Bugle Creek	90	8/1/2016	100	8.0	11.0	WGS84	5406217	512806
	91	8/1/2016	100	8.0	11.0	WGS84	5407866	512703
	92	8/1/2016	96	5.4	11.0	WGS84	5409325	513271
Caribou Creek	84	8/4/2016	100	7.5	11.0	WGS84	5405153	513810
	85	8/4/2016	100	10.5	11.0	WGS84	5405986	514718
Gold Creek	16	8/18/2016	100	6.7	11.0	WGS84	5407438	501372
	17	7/26/2016	100	8.6	11.0	WGS84	5406556	499711
	18	7/26/2016	100	6.6	11.0	WGS84	5406250	498612
Horton Creek	55	7/19/2016	80	3.2	11.0	WGS84	5381018	512478
	56	7/19/2016	87	2.7	11.0	WGS84	5381638	513984
	57	7/19/2016	100	2.3	11.0	WGS84	5382458	515758
Hughes Fork	1	7/16/2015	100	8.0	11.0	WGS84	5411347	499905
	2	7/14/2015	110	8.3	11.0	WGS84	5411983	499609
	3	7/14/2015	95	7.2	11.0	WGS84	5412990	499865
	27	8/15/2016	100	13.3	11.0	WGS84	5407060	502972
	28	8/15/2016	117	8.6	11.0	WGS84	5408266	501382
	29	9/6/2016	67.9	9.9	11.0	WGS84	5410518	500159
Hunt Creek	52	7/11/2016	93	7.2	11.0	WGS84	5379161	513371
	53	7/28/2016	81	9.7	11.0	WGS84	5380855	516030
	54	7/20/2016	100	5.0	11.0	WGS84	5381441	519343
Indian Creek	59	7/18/2016	105	8.9	11.0	WGS84	5384338	512054
	60	8/17/2016	100	9.0	11.0	WGS84	5385850	512848
	61	8/17/2016	100	9.6	11.0	WGS84	5386721	514422
Kalispell Creek	46	7/12/2016	120	8.3	11.0	WGS84	5380421	503794
	47	8/10/2016	100	7.1	11.0	WGS84	5384646	500792
	48	7/12/2016	100	9.6	11.0	WGS84	5383467	494685
Lion Creek	73	8/9/2016	95	9.4	11.0	WGS84	5398815	513400
	74	8/9/2016	105	12.3	11.0	WGS84	5399003	515440
	75	8/9/2016	96	11.1	11.0	WGS84	5399751	517494
	76	8/8/2016	117	5.2	11.0	WGS84	5400465	519626
	77	8/8/2016	75	12.4	11.0	WGS84	5401125	521631
Muskegon Creek	25	7/26/2016	90	3.6	11.0	WGS84	5405275	498013

Table 5 (continued)

Stream	Site ID	Date	Site length (m)	Avg width (m)	Zone	Datum	Northing	Easting
NF Indian Creek	62	7/28/2016	111	8.2	11.0	WGS84	5388002	516799
	63	7/18/2016	87	9.0	11.0	WGS84	5388755	518524
	64	7/18/2016	50	6.7	11.0	WGS84	5389444	520272
Tango Creek	49	7/13/2016	100	2.8	11.0	WGS84	5394441	509419
	50	7/13/2016	100	3.2	11.0	WGS84	5394656	508101
	51	7/13/2016	100	1.7	11.0	WGS84	5394734	506710
Trapper Creek	95	8/2/2016	100	6.2	11.0	WGS84	5405515	507707
	96	8/2/2016	90	5.3	11.0	WGS84	5406491	507996
	97	8/3/2016	90	4.7	11.0	WGS84	5407915	507726
	98	8/3/2016	100	6.4	11.0	WGS84	5408913	508254
Two Mouth Creek	67	8/11/2016	113	6.8	11.0	WGS84	5393756	512863
	68	8/10/2016	95	8.6	11.0	WGS84	5393556	515227
	69	8/10/2016	80	12.8	11.0	WGS84	5393926	517707
	70	8/11/2016	90	6.9	11.0	WGS84	5393764	520513

Table 6. Mean density of salmonids sampled during Priest Basin tributary surveys in 2015-2016. Density estimates represent only fish ≥ 75 mm. Mean density values were calculated by species for all surveyed sections per stream.

Stream	BRKxBLT	BLT	BRK	MWF	RBT	WCT	WCTxRBT
Beaver Creek	0.0	0.0	3.9	0.0	0.0	11.3	0.0
Bench Creek	0.0	0.0	4.6	0.0	0.0	13.4	0.0
Boulder Creek	0.0	0.0	0.0	0.0	0.0	16.8	0.0
Bugle Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caribou Creek	0.0	0.0	4.0	0.0	0.0	0.4	0.0
Gold Creek	0.0	2.2	0.0	0.0	0.4	6.3	0.8
Horton Creek	0.0	0.0	0.0	0.0	0.0	10.7	0.0
Hughes Fork	<0.1	<0.1	3.8	0.1	0.0	3.2	0.0
Hunt Creek	0.0	0.0	0.0	0.0	0.0	7.1	0.0
Indian Creek	0.0	0.0	0.6	0.0	0.0	1.9	0.0
Kalispell Creek	0.0	0.0	2.0	0.0	0.0	0.2	0.0
Lion Creek	0.0	0.0	0.0	0.0	0.0	3.1	0.0
Muskegon Creek	0.0	0.0	0.0	0.0	1.4	7.4	0.0
NF Indian Creek	0.0	0.5	0.0	0.0	0.0	11.6	0.0
Tango Creek	0.0	0.0	1.1	0.0	0.0	6.6	0.0
Trapper	0.0	0.0	0.7	0.0	0.0	6.5	0.0
Two Mouth Creek	0.0	0.0	0.3	0.0	0.0	8.0	0.0

BRKxBLT = Brook Trout x Bull Trout Hybrid
BLT = Bull Trout
BRK = Brook Trout
MWF = Mountain Whitefish
RBT = Rainbow Trout
WCT = Westslope Cutthroat Trout
WCTxRBT = Westslope Cutthroat x Rainbow Trout Hybrid

Table 7. Priest Basin tributary survey results by stream, sampled section, and species from 2015-2016. Catch includes all lengths (mm), while only fish ≥ 75 mm were included in abundance estimates (Est. n). Species sampled included Brook Trout (BRK), Bull Trout (BLT), Brook Trout x Bull Trout hybrids (BRK x BLT) Rainbow Trout (RBT), Westslope Cutthroat Trout (WCT), Westslope Cutthroat Trout x Rainbow Trout hybrids (WCT x RBT), unidentified *Oncorhynchus* fry (ONC FRY), Longnose Dace (LND), and Sculpin (SCL).

Stream	Species	Site ID	Catch	Min TL	Max TL	Est n	80% CI-	80% CI +	Fish/100m^2
Beaver Creek	BRK	39	11	83	165	16	11	34	3.4
Beaver Creek	SCL	39	15	36	91	N/A	--	--	--
Beaver Creek	WCT	39	30	89	188	45	30	62	9.2
Beaver Creek	WCT	40	65	59	174	58	54	62	14.9
Beaver Creek	BRK	38B	40	44	188	45	30	62	8.4
Beaver Creek	ONC FRY	38B	1	32	32	N/A	--	--	--
Beaver Creek	SCL	38B	31	37	95	N/A	--	--	--
Beaver Creek	WCT	38B	38	70	162	52	35	70	9.8
Bench	BRK	1	24	90	179	25	24	27	7.8
Bench	WCT	1	53	51	240	55	53	57	17.0
Bench	BRK	2	6	55	165	6	6	6	1.5
Bench	WCT	2	39	47	182	40	39	41	9.7
Boulder Creek	WCT	34	64	67	212	94	77	112	14.3
Boulder Creek	WCT	35	78	55	186	61	58	64	21.2
Boulder Creek	WCT	33B	69	61	191	97	80	115	14.9
Bugle Creek	NO FISH	91	--	--	--	N/A	--	--	--
Bugle Creek	NO FISH	92	--	--	--	N/A	--	--	--
Bugle Creek	SCL	90B	10	54	82	N/A	--	--	--
Caribou Creek	BRK	85	46	53	202	63	46	80	6.0
Caribou Creek	BRK	84B	14	65	166	14	13	17	1.9
Caribou Creek	LND	84B	1	146	146	N/A	--	--	--
Caribou Creek	ONC FRY	84B	7	40	44	N/A	--	--	--
Caribou Creek	SCL	84B	31	39	84	N/A	--	--	--
Caribou Creek	WCT	84B	6	89	146	6	6	7	0.8
Gold Creek	BLT	16	4	173	201	6	4	24	0.9
Gold Creek	ONC FRY	16	3	39	48	N/A	--	--	--
Gold Creek	RBT	16	5	78	101	7	5	25	1.1
Gold Creek	WCT	16	41	84	197	61	44	79	9.1
Gold Creek	WCTxRBT	16	11	103	212	16	11	34	2.4
Gold Creek	BLT	17	2	136	165	3	2	21	0.3
Gold Creek	WCT	17	32	82	217	48	32	65	5.6
Gold Creek	BLT	18	24	94	158	36	24	53	5.5
Gold Creek	WCT	18	18	82	195	27	18	44	4.1
Horton Creek	WCT	56	22	61	196	30	20	47	12.6
Horton Creek	WCT	55B	24	62	173	22	22	23	8.6
Horton Creek	WCT	57B	17	85	168	25	17	43	11.0
Hughes Fork	BRK	1	31	42	258	31	31	31	3.9
Hughes Fork	WCT	1	6	67	96	6	6	6	0.8
Hughes Fork	BRK	2	6	44	126	6	---	---	0.7
Hughes Fork	WCT	2	3	75	86	3	3	3	0.3
Hughes Fork	BRK	3	25	47	167	29	25	35	4.3
Hughes Fork	BLT	3	1	167	167	1	---	---	0.1
Hughes Fork	WCT	3	9	64	137	10	9	13	1.5
Hughes Fork	BRK	28	134	40	216	53	51	55	5.2

Table 7 (continued)

Stream	Species	Site ID	Catch	Min TL	Max TL	Est n	80% CI-	80% CI +	Fish/100m^2
Hughes Fork	BRKxBLT	28	1	147	147	1	1	19	0.1
Hughes Fork	BLT	28	1	202	202	1	1	19	0.1
Hughes Fork	SCL	28	93	42	121	N/A	--	--	--
Hughes Fork	WCT	28	126	39	170	85	83	88	8.5
Hughes Fork	BRK	27B	34	61	304	45	30	62	3.4
Hughes Fork	BRKxBLT	27B	1	129	129	1	1	19	0.1
Hughes Fork	MWF	27B	3	91	108	4	3	22	0.3
Hughes Fork	SCL	27B	106	42	113	N/A	--	--	--
Hughes Fork	WCT	27B	48	45	160	60	43	77	4.5
Hughes Fork	BRK	29B	33	52	230	34	23	52	5.1
Hughes Fork	SCL	29B	27	40	81	N/A	--	--	--
Hughes Fork	WCT	29B	21	46	157	24	16	41	3.6
Hunt Creek	WCT	52	17	63	205	22	15	40	3.4
Hunt Creek	WCT	54	54	59	187	53	50	57	10.7
Hunt Creek	WCT	53B	48	63	177	57	40	74	7.2
Indian Creek	BRK	59	2	55	108	1	1	19	0.2
Indian Creek	SCL	59	29	37	86	N/A	--	--	--
Indian Creek	BRK	60	12	89	183	12	12	13	1.3
Indian Creek	SCL	60	11	54	94	N/A	--	--	--
Indian Creek	WCT	60	12	88	189	12	12	13	1.3
Indian Creek	BRK	61	1	118	118	1	1	19	0.2
Indian Creek	WCT	61	29	80	236	43	29	61	4.5
Kalispell Creek	BRK	46	19	55	286	22	15	40	2.3
Kalispell Creek	ONC FRY	46	5	34	48	N/A	--	--	--
Kalispell Creek	SCL	46	20	32	71	N/A	--	--	--
Kalispell Creek	BRK	47	16	59	307	10	9	12	1.4
Kalispell Creek	ONC FRY	47	17	37	50	N/A	--	--	--
Kalispell Creek	SCL	47	74	20	90	N/A	--	--	--
Kalispell Creek	WCT	47	2	54	134	1	1	19	0.2
Kalispell Creek	BRK	48	22	46	210	22	15	40	2.3
Kalispell Creek	ONC FRY	48	6	29	45	N/A	--	--	--
Kalispell Creek	SCL	48	5	34	85	N/A	--	--	--
Kalispell Creek	WCT	48	3	66	94	3	2	21	0.3
Lion Creek	SCL	73	9	74	95	N/A	--	--	--
Lion Creek	WCT	73	18	70	186	25	17	43	2.8
Lion Creek	SCL	74	38	48	102	N/A	--	--	--
Lion Creek	WCT	74	43	76	240	46	43	50	3.6
Lion Creek	SCL	75	3	83	97	N/A	--	--	--
Lion Creek	WCT	75	55	80	194	82	65	100	7.7
Lion Creek	WCT	76	5	113	183	7	5	25	1.2
Lion Creek	NO FISH	77	--	--	--	N/A	--	--	--
Muskegon Creek	ONC FRY	25	1	30	30	N/A	--	--	--
Muskegon Creek	RBT	25	3	99	151	4	3	22	1.4
Muskegon Creek	WCT	25	38	57	150	24	23	26	7.4
NF Indian Creek	BLT	62	9	87	307	13	9	31	1.5
NF Indian Creek	WCT	62	85	85	237	127	109	146	13.9
NF Indian Creek	WCT	63	121	52	186	129	116	141	16.4
NF Indian Creek	WCT	64	11	62	207	15	10	32	4.5
Tango Creek	BRK	49	6	109	185	9	6	27	3.2
Tango Creek	WCT	49	12	66	157	16	11	34	5.9
Tango Creek	WCT	50	49	61	141	44	39	51	13.9
Tango Creek	NO FISH	51	--	--	--	N/A	--	--	--

Stream	Species	Site ID	Catch	Min TL	Max TL	Est n	80% CI-	80% CI +	Fish/100m^2
Trapper Creek	WCT	95	13	65	160	18	12	35	2.9
Trapper Creek	WCT	98	30	79	184	45	30	62	7.1
Trapper Creek	BRK	96B	10	71	158	13	9	31	2.8

Table 7 (continued)

Trapper Creek	WCT	96B	17	72	175	24	16	41	5.1
Trapper Creek	WCT	97B	43	77	167	46	43	50	10.9
Two Mouth Creek	BRK	67	4	99	120	6	4	24	0.8
Two Mouth Creek	ONC FRY	67	4	35	51	N/A	--	--	--
Two Mouth Creek	SCL	67	34	51	95	N/A	--	--	--
Two Mouth Creek	WCT	67	24	49	144	31	21	49	4.1
Two Mouth Creek	BRK	68	2	170	202	3	2	21	0.4
Two Mouth Creek	SCL	68	5	81	94	N/A	--	--	--
Two Mouth Creek	WCT	68	35	75	207	52	35	70	6.4
Two Mouth Creek	WCT	69	57	65	184	82	65	100	8.1
Two Mouth Creek	WCT	70	70	63	198	84	71	97	13.5

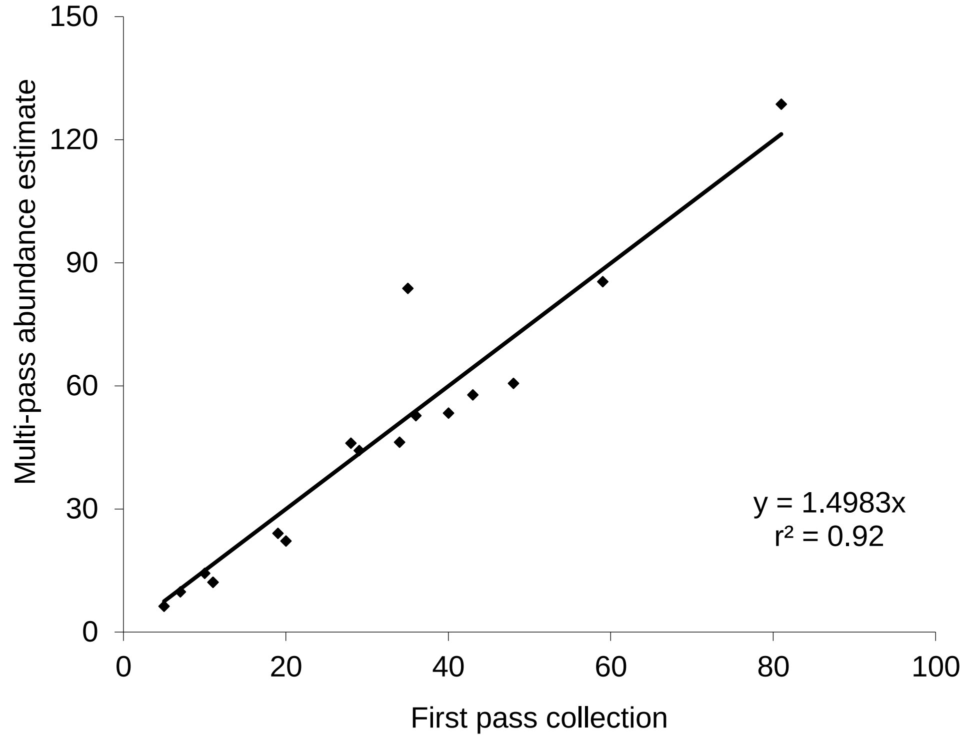

Figure 10. Linear model showing the relationship between multi-pass abundance estimates and first pass catch from Priest Basin tributaries sampled in 2015 and 2016.

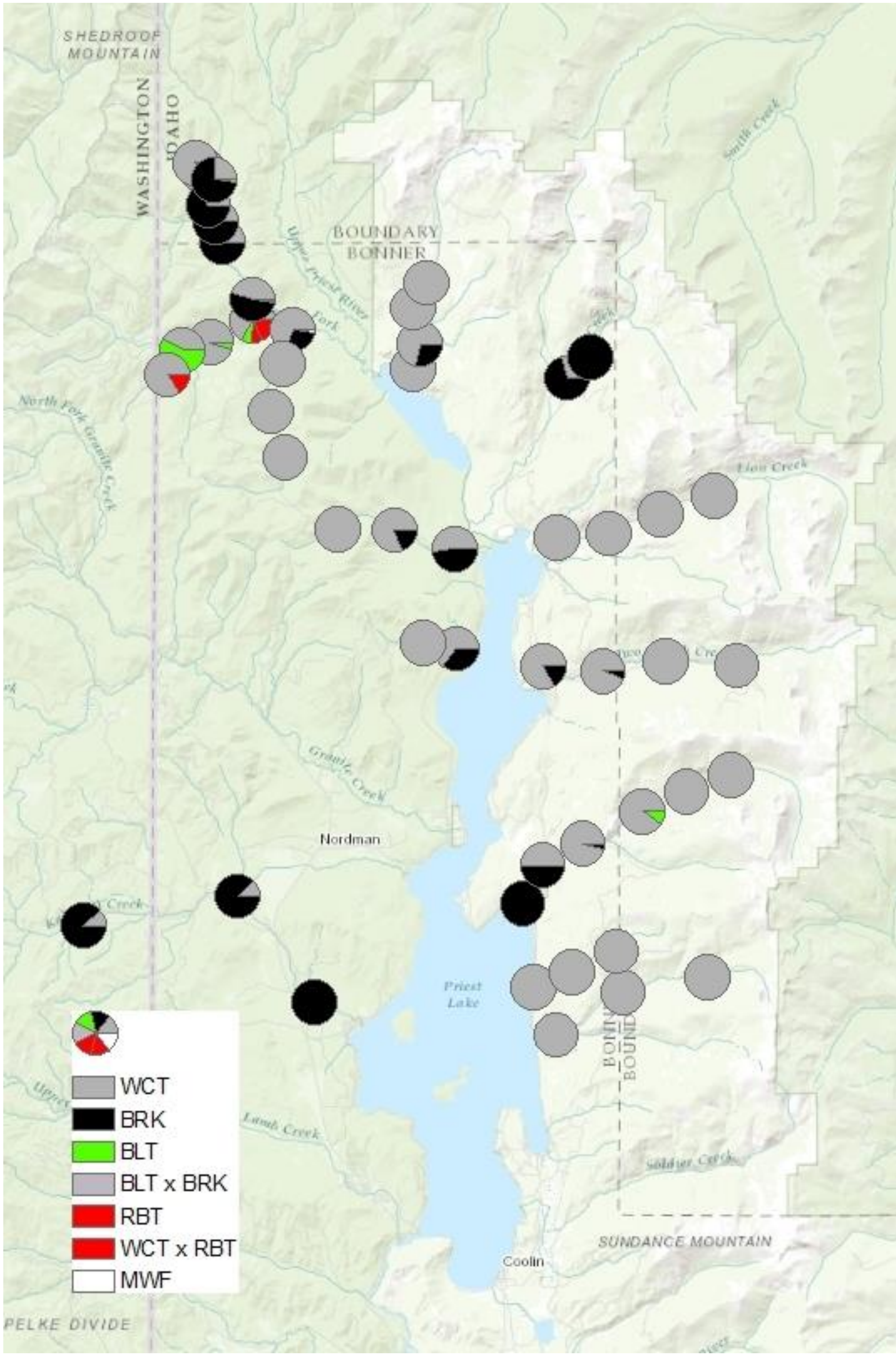

Figure 11. Sampled species by site from Priest Basin tributaries surveyed in 2015 and 2016.

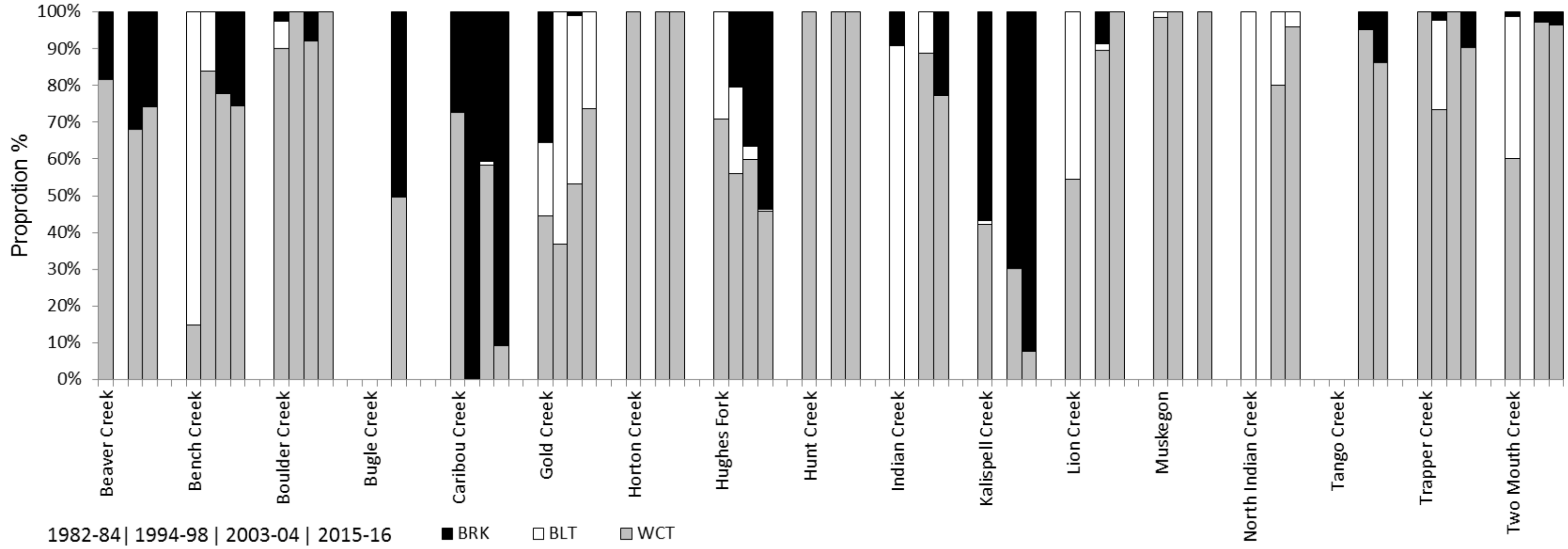

Figure 12. Relative proportion of Brook Trout (BRK), Bull Trout (BLT), and Westslope Cutthroat Trout (WCT) by stream from surveys conducted in 1982-1984, 1994-1998, 2003-2004, and 2015-2016. Proportions were based on estimates of mean density among all sampled sites throughout a stream. Comparisons are grouped by stream and survey period. Absent bars represent survey periods where no survey was completed on a stream.

MOYIE RIVER MONITORING

ABSTRACT

The Moyie River fishery has been managed as a wild trout fishery since 2000. In June of 2016, we completed a fishery survey of the Moyie River to monitor trends in the fish community and evaluate current fishery opportunities. We sampled fish using a drift boat-mounted electrofisher. Species-specific abundance estimates were derived using a Schnabel multiple mark-recapture estimator where feasible. Seven fish species were observed, including Mountain Whitefish *Prosopium williamsoni*, Rainbow Trout *Oncorhynchus mykiss*, Rainbow Trout x Westslope Cutthroat Trout *Oncorhynchus clarkii* hybrids, Brook Trout *Salvelinus fontinalis*, Largescale Sucker *Catostomus macrocheilus*, Longnose Dace *Rhinichthys cataractae*, and Sculpin *Cottus spp*. We estimated abundance of Mountain Whitefish ≥ 125 mm in the survey reach at 7,937 fish or approximately 467 fish/km. Recapture rates of Rainbow Trout, Brook Trout, and Mountain Whitefish ranged from 0% to 3%. Low capture efficiency of all species in our survey made it difficult to estimate and compare abundance over time. Capture and recapture rates from our survey were similar to prior electrofishing surveys, suggesting some root condition of the survey reach is likely influential. Our survey provided indirect evidence that fish populations were sustainable under the current management direction, despite our difficulties in confidently estimating abundance.

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INTRODUCTION

The Moyie River flows south from its origin in British Columbia, Canada approximately 148 km to its confluence with the Kootenai River in Idaho. The Moyie River is a third order stream with a drainage area of approximately 539 km^2 and average discharge of 19.4 m^3/s. Native gamefish in the drainage include Westslope Cutthroat Trout *Oncorhynchus clarkii*, Redband Rainbow Trout *Oncorhynchus mykiss gairdnerii*, and Mountain Whitefish *Prosopium williamsoni* (IDFG 2013a). Genetic evaluation of fish distribution in the Moyie River suggested Redband Rainbow Trout were historically distributed below Moyie Falls, low in the drainage, while Westslope Cutthroat Trout were found above Moyie Falls (Paragamian et al. 2008). The current fish community in the river is dominated by Mountain Whitefish (Dupont et al 2009). Rainbow Trout of coastal origin are also abundant (Dupont et al. 2009, Paragamian et al. 2008). Westslope Cutthroat Trout are present in tributaries to the Moyie River, but are rare in the river (Dupont et al. 2009, Walters 2006). Brook Trout *Salvelinus fontinalis* are also present in the river and tributaries in lower abundance (Dupont et al. 2009, Walters 2006).

Management of the Moyie River fishery has been focused on providing wild trout fishing opportunities since 2000 (IDFG 2013a). Current fishing regulations include a restricted harvest limit of two trout of any size per day and a more liberal region-wide general bag limit of 25 Brook Trout per day. Rainbow Trout were stocked routinely in the Moyie River prior to 2000 to provide liberal harvest opportunity. However, stocking was discontinued following evaluations suggesting hatchery trout returned poorly to anglers and with concern for transfer of disease from hatchery fish to upstream stocks in British Columbia (Fredericks et al. 2002). Since stocking was discontinued, angler exploitation on Rainbow Trout has remained low and wild trout densities have been suitable to maintain a quality fishing opportunity comparable to other popular regional fisheries (Dupont et al. 2009). In 2016, we completed a survey of the Moyie River to monitor trends in the fish community and evaluate current fishery opportunities.

METHODS

We conducted a survey of the Moyie River fish community from June 10 to June 20, 2016. Sampling occurred from approximately the U.S. Highway 95 crossing upstream of Line Creek downstream to the junction of the Moyie River and Moyie River Road below Snyder Creek (otherwise known as "Twin Bridges"). The total survey reach was approximately 17 km long and similar to the upper river reach surveyed in 1999, 2005, and 2006 (Fredericks et al. 2002, Dupont et al. 2009).

We sampled fish using a drift boat-mounted electrofisher. Four electrofishing passes were completed through the survey reach. Each pass of the survey reach was completed with one netter and one person rowing the drift boat. We attempted to net all fish species encountered on the first and second electrofishing passes. Only salmonids were targeted on the last two passes. Due to electrofishing control box failure, we were unable to sample the lower portion of the survey reach on June 15 and June 20. Flows measured at the USGS gauging station at Eastport, Idaho during the survey period varied from 24 to 14 m^3/s.

Sampled fish were processed and released periodically throughout the survey reach to maintain the distribution of marked fish. Fish were identified, measured (total length, mm) and weighed (g). Rainbow Trout, trout hybrids, Brook Trout, and Mountain Whitefish greater than 100 mm were marked on passes one, two and three. Marks were unique by pass and consisted of fin punches. Fish captured on runs two through four were examined for marks prior to release.

We described the composition of the fish community as the relative percentage of each species in the sample and the relative percentage of biomass of each species in the sample. Size structure of sampled species was described using length-frequency histograms and stock density indices, including proportional stock density (PSD) and relative stock density (RSD) (Anderson and Neumann 1996) for primary species targeted. Relative stock density was calculated using length ranges described by Dupont (2009). Rainbow Trout RSD-325 was calculated as the proportion of fish greater than or equal to 325 mm to fish greater than or equal to 200 mm. Brook Trout RSD-250 was calculated as the proportion of fish greater than or equal to 250 mm to fish greater than or equal to 125 mm. Changes in size structure of the population over time were evaluated by comparing RSD values from 2016 for Rainbow Trout and Brook Trout to estimates from 1999, 2005, 2006. We used a Chi-square test (α = 0.2) to determine differences in RSD proportions. Average relative weight (W_r; Wege and Anderson 1978, Rogers et al. 1996) was used to describe the condition of fish. We described variation in W_r estimates using 80% confidence intervals calculated by methods for normally distributed data.

Abundance of Mountain Whitefish greater than or equal to 125 mm TL was estimated using a Schnabel multiple mark-recapture estimator as described by Hayes et al. (2007). Confidence intervals around population estimates were estimated using a Poisson distribution to account for small recapture sample size (Ricker 1975). Confidence intervals were estimated at α = 0.05 (i.e., 95%) to conform to methods of previous abundance estimates from the Moyie River. Confidence intervals were examined between years to evaluate significant differences between surveyed years. We did not estimate abundance of Rainbow Trout, trout hybrids, or Brook Trout because recaptures were not observed.

Pectoral fin rays were removed from a subsample of Rainbow Trout for use in age estimation. We targeted three to five ageing structures per centimeter group per species. 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.

We used Rainbow Trout length and age data to estimate rates of growth and mortality. Growth rates were described as von Bertalanffy growth coefficients, estimated using Fisheries Analysis and Modeling Simulator (FAMS; Slipke and Maceina 2014) from mean values of total length-at-age observed in our sample. Catch-at-age of sampled Rainbow Trout was used to describe general patterns of recruitment and to estimate mortality rates. An age-length key was used to predict ages of Rainbow Trout by length from a subsample of age estimates. Age frequencies were applied to a weighted catch curve generated in FAMS to estimate instantaneous total mortality (*Z*), from which annual mortality (*A*) and annual survival (*S*) was derived (Miranda and Bettoli 2007).

RESULTS

Seven fish species were observed in our survey of the Moyie River (Table 1). Mountain Whitefish were the most abundant species captured in our survey, making up 72% of fish caught and 52% of the biomass. Rainbow Trout were also abundant, making up 19% of the sample. Rainbow x Westslope Cutthroat Trout hybrids, Brook Trout, Largescale Sucker *Catostomus macrocheilus*, Longnose Dace *Rhinichthys cataractae*, and Sculpin *Cottus spp.* were also collected in lesser proportions. We estimated abundance of Mountain Whitefish ≥ 125 mm in the survey reach at 7,937 (4,861 – 13,757; 95% C.I.) fish or approximately 467 fish per km (Table 2).

We found recapture rates (i.e., proportion of marked sample recaptured) ranged from 0% to 3% (Table 2).

Mountain Whitefish varied from 92 mm to 430 mm in TL (Table 1). PSD of Mountain Whitefish was four. We found Mountain Whitefish to be in good condition with a near average W_r of 96 ± 1 (80% C.I.).

Rainbow Trout varied from 90 mm to 470 mm in length (Table 1) and had a PSD of 33. Rainbow Trout RSD-325 was 45, which was significantly greater than all prior surveys, except 1999 (x^2= 17.16; *df* = 3; *P* <0.001). This suggested larger fish made up a greater proportion of the sample in our 2016 survey. Average W_r of Moyie River Rainbow Trout was 93 ± 2, suggesting fish were in average condition. We estimated Rainbow Trout grew to 300 mm in approximately 3.6 years (Figure 3). Von Bertalanffy growth coefficients were estimate as K = 0.205, L_∞ = 571 mm, and t_0 = 0.011. Instantaneous mortality was estimated at Z = -0.54, corresponding to an annual mortality was 42% (Figure 4).

Brook Trout length varied from 116 to 305 mm (Table 1). PSD was estimated at 10. RSD-250 was estimated at 56 and no significant difference was detected from previous survey years (x^2= 1.54; *df* = 3; *P* > 0.60). Average W_r of Brook Trout was 102 ± 17, suggesting fish were in good condition.

DISCUSSION

Low capture efficiency of all species in our survey made it difficult to estimate abundance and compare abundance estimates over time. Factors potentially influencing capture efficiency included water volume during the survey, fish distribution within the survey reach, and equipment failure during our survey. Our survey was completed during the descending limb of the hydrograph following spring runoff. Although our survey was intentionally completed during this period to enable a drift boat to be used during the survey, fish were likely widely distributed across the channel, thus limiting our ability to sample a large proportion of the population in a single pass. Fish distribution longitudinally within the river may have also influenced our ability to sample the population effectively. Anecdotally, we found trout were concentrated in pool sections of the river which were deep relative to the efficiency of our electrofishing gear. The survey reach had relatively little pool habitat that resulted in concentrations of fish in a few areas where sampling efficiency may have been low. As noted, we also experienced equipment failure on two occasions that precluded completion of sampling effort in the lower portion of our survey reach. We were unable to identify which one factor most influenced capture efficiency and speculate it was likely a combination of factors described.

Capture and recapture rates from our survey were similar to prior electrofishing surveys, suggesting some root condition of the survey reach is likely influential (Table 2). Fredericks et al. (2002) experienced low capture efficiency (0%; Table 2) in their survey of the Moyie River that resulted in failure to estimate abundances. Dupont et al. (2009) sampled greater numbers of all species, but also experienced low recapture efficiency (1% to 3%; Table 2). Robson and Regier (1964) suggested the probability of recapture is influenced by the proportion of the population sampled, suggesting our inability to recapture marked fish was related to sample size being small relative to the population. As such, we suggested abundance of fishes in the Moyie River were likely high relative to samples from this and previous surveys. To improve confidence in estimating abundance of Moyie River fishes, we suggest more effort be applied to future surveys or an alternative survey technique be considered. Prior investigators estimated abundance in the Moyie River by census from observers snorkeling the river (Fredericks et al. 2002; Dupont et al. 2009). Although this may be a plausible technique to consider for future surveys, there is some disagreement as to its effectiveness on the Moyie River. Fredericks et al. (2002) indicated stream size and water clarity were not conducive to effectively completing a snorkel survey in this system. In contrast, Dupont et al. (2009) suggested snorkeling was a preferred sampling technique for this system.

We cautiously interpreted results from our survey that suggested Mountain Whitefish abundance in the Moyie River declined since the previous 2006 survey. Dupont et al. (2009) estimated Mountain Whitefish densities to be 1,178 fish/km (Table 2), more than two times greater than our estimate. No other electrofishing estimate was available for reference. We recaptured Mountain Whitefish in our survey and were able to estimate abundance. However, recapture efficiency was low (3%; Table 2) and resulted in low confidence in our estimate. We did not measure and were not aware of environmental influences that may have significantly altered Mountain Whitefish abundance.

Our survey provided indirect evidence that trout populations were sustainable under the current management direction, despite our difficulties in confidently estimating abundance. Both size structure and mortality of Rainbow Trout in the Moyie River suggest angling regulations and angler use are currently compatible with maintaining a quality fishery. Our results suggested that the proportion of larger (≥ 325 mm, Table 3) Rainbow Trout increased from prior surveys, an indication harvest was sufficiently low to allow survival of fish to larger and older age classes.

Corresponding annual mortality decreased since the 2006 survey (2006 annual mortality = 0.58; Dupont et al. 2009), indicating any changes in angler-related mortality were not negatively impacting the population. We also did not observe a significant change in the proportion of large Brook Trout (Table 3). Based on these observations, we recommend the Moyie River continue to be managed as a wild trout fishery with restricted harvest allowed. Although we are comfortable this recommendation is sound, a more direct measure of angler exploitation would be beneficial. As such, we also recommend angler exploitation be estimated periodically in association with future monitoring efforts.

MANAGEMENT RECOMMENDATIONS

1. Continue to manage the Moyie River as a wild trout fishery with restricted harvest allowed.

2. Consider increasing sampling effort or choosing an alternative survey technique when conducting future monitoring of fish abundance in the Moyie River.

3. Estimate angler exploitation in association with future Moyie River monitoring efforts.

Table 8. Descriptive statistics for fish species sampled from the Moyie River in June 2016. Statistics summarized include catch (*n*), minimum and maximum total length (TL), proportion of catch by number and biomass, proportional stock density (PSD), and relative weight (W_r).

Species	n	Min TL	Max TL	% of n	% Biomass	PSD	W_r
Brook Trout	26	116	305	3%	3%	10	102
Largescale Sucker	29	115	550	4%	18%	--	--
Longnose Dace	3	52	105	1%	> 1.0%	--	--
Mountain Whitefish	603	92	430	72%	52%	4	96
Rainbow Trout	156	90	470	19%	24%	33	93
Rainbow x Cutthroat hybrid	4	400	453	1%	3%	--	--
Sculpin spp.	5	62	68	1%	> 1.0%	--	--

Table 9. Estimated abundance by species and survey year from mark-recapture electrofishing surveys of the Moyie River. Abundance estimates are listed by year and include the number of fish marked in the populations (M), the number of marked fish recaptured (R), the proportion of marks recaptured (R/M), estimated abundance (N), 95% confidence intervals around N (UL, LL), and estimated fish density in the survey reach (Fish/km).Survey results represent sampled fish within the Moyie River from approximately the Canadian border to Twin Bridges.

Year	Species (≥125 mm)	Method	M	R	R/M	N	UL	LL	Fish/km
2016	Rainbow Trout	Electrofishing	99	0	0%	--	--	--	--
2016	Mountain Whitefish	Electrofishing	490	14	3%	7,937	4,861	13,575	467
2016	Brook Trout	Electrofishing	25	0	0%	--	--	--	--
2006	Rainbow Trout	Electrofishing	398	4	1%	24,020	40,016	8,023	1,278
2006	Mountain Whitefish	Electrofishing	1,094	38	3%	22,153	27,770	16,535	1,178
2006	Brook Trout	Electrofishing	139	10	7%	807	1,179	435	43
2005	Rainbow Trout	Electrofishing	266	9	3%	4,885	9,645	3,271	260
2005	Mountain Whitefish	Electrofishing	--	--	--	--	--	--	--
2005	Brook Trout	Electrofishing	45	4	9%	493	1273	305	26
1999	Rainbow Trout	Electrofishing	96	0	0%	--	--	--	--
1999	Mountain Whitefish	Electrofishing	651	0	0%	--	--	--	--
1999	Brook Trout	Electrofishing	27	0	0%	--	--	--	--

Table 10. Number sampled by size group and relative stock densities (RSD) for Brook Trout and Rainbow Trout from four surveys on the Moyie River during the period of 1999 through 2016.

Species	Size Group	2016	2006	2005	1999
Brook Trout	≥125	25	144	98	70
	≥250	14	56	34	28
	RSD - 250	56%$_a$	39%$_a$	35%$_a$	40%$_a$
Rainbow Trout	≥200	64	299	127	81
	≥325	29	51	18	19
	RSD - 325	45%$_a$	17%$_b$	14%$_b$	23%$_a$

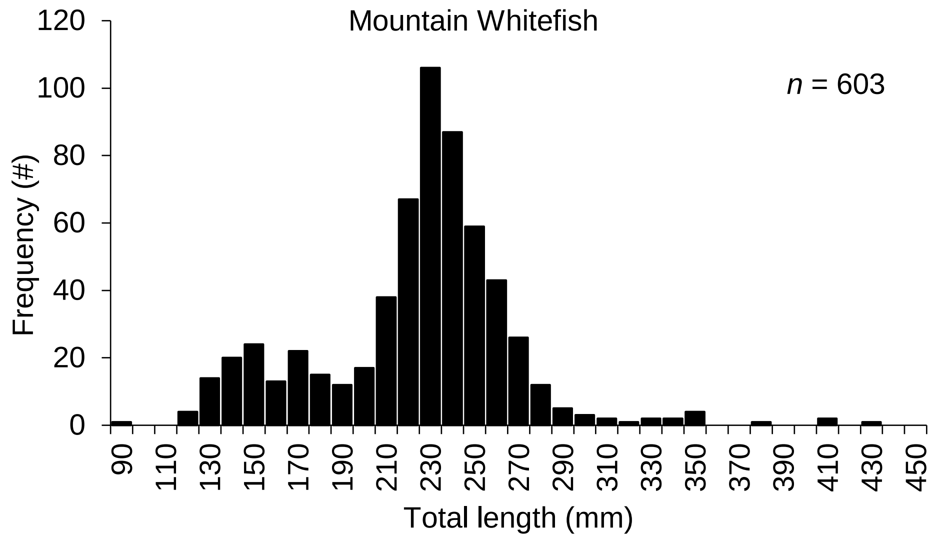

Figure 13. Length distribution of Mountain Whitefish sampled from the Moyie River in 2016.

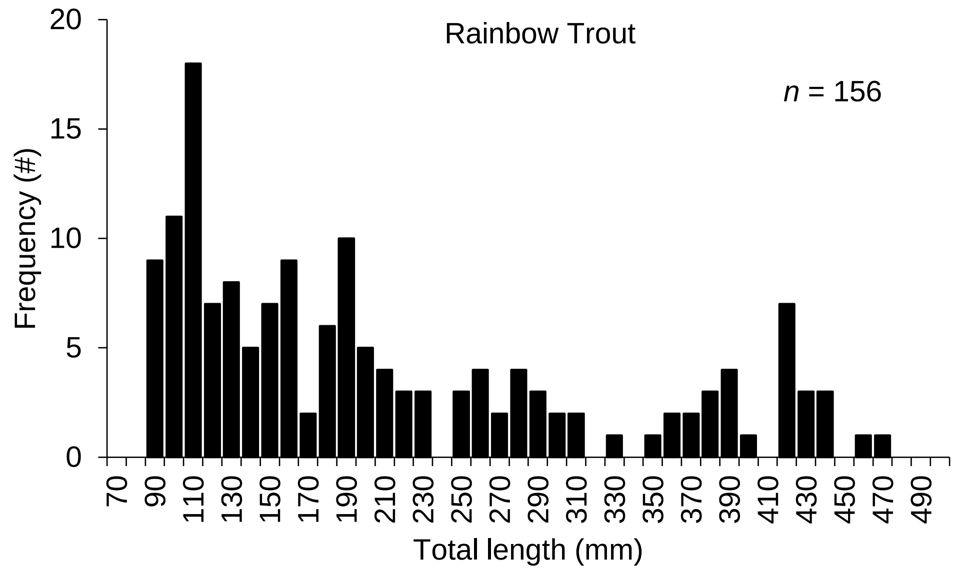

Figure 14. Length distribution of Rainbow Trout sampled from the Moyie River in 2016.

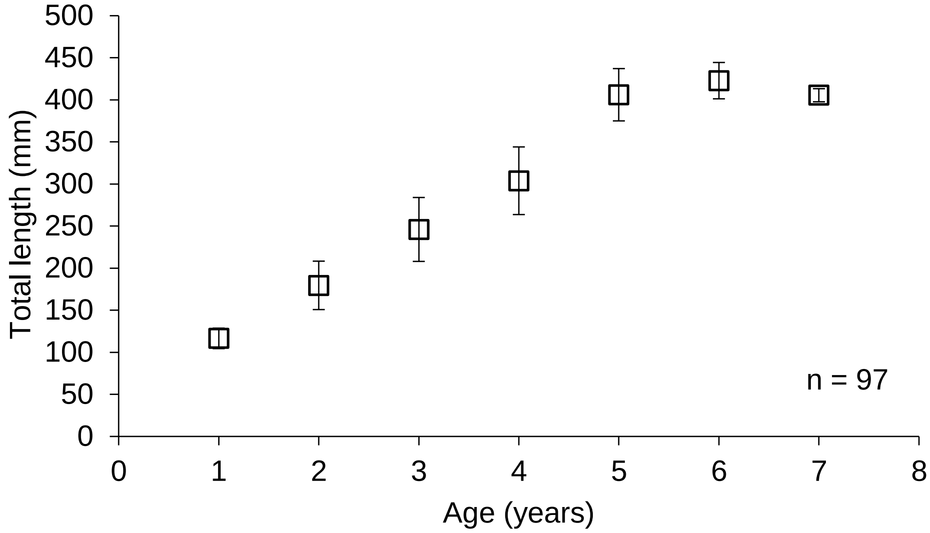

Figure 15. Mean length-at-age (± 1 SD) of Rainbow Trout sampled from the Moyie River in 2016. Ages were estimated from pectoral fin ray sections.

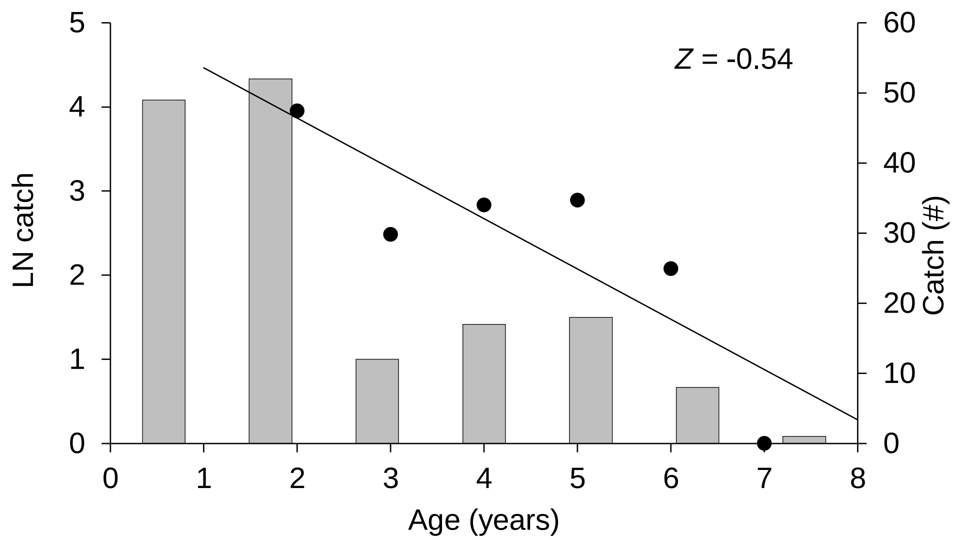

Figure 16. Catch-at-age (grey bars) and corresponding natural log of catch-at-age (black dots) of Rainbow Trout from the 2016 survey of the Moyie River. Age and catch data were used to estimate instantaneous annual mortality (Z).

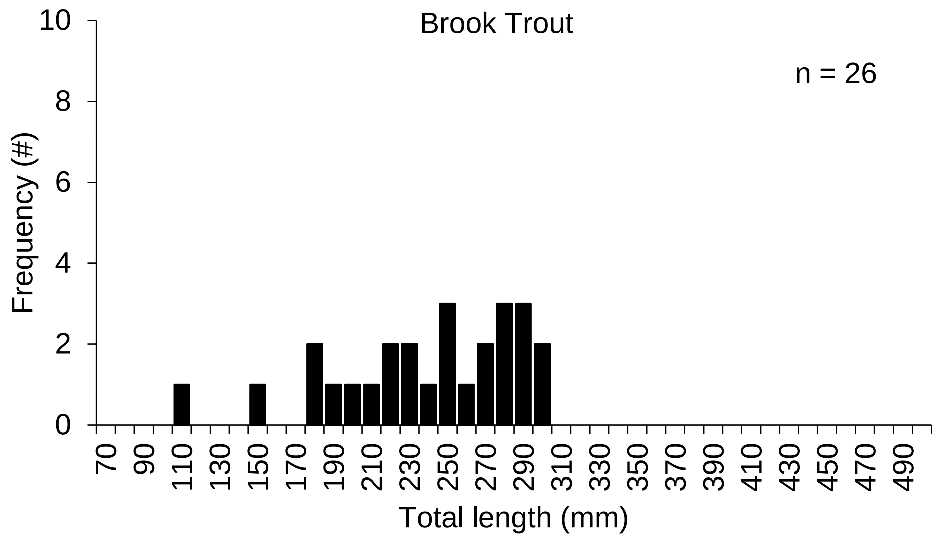

Figure 17. Length distribution of Brook Trout sampled from the Moyie River in 2016.

NORTHERN PANHANDLE REGIONAL LOWLAND LAKE INVESTIGATIONS

ABSTRACT

Lowland lake surveys were conducted on Freeman and Mirror lakes in June 2016. These surveys were conducted using Idaho Department of Fish and Game lowland lake standard methods. We collected eight fish species from Freeman Lake, including Black Crappie *Pomoxis nigromaculatus,* Brown Bullhead *Ameiurus nebulosus,* Largemouth Bass *Micropterus salmoides*, Northern Pike *Esox lucius*, Pumpkinseed *Lepomis gibbosus,* Yellow Perch *Perca flavescens*, Rainbow Trout *Oncorhynchus mykiss*, and Tench *Tinca tinca*. Yellow Perch were the most abundant species sampled. Only one Northern Pike and no tiger muskellunge *E. lucius* × *E. masquinongy* were sampled. Rainbow Trout caught in our sample were representative of recently stocked catchable-size fish. Largemouth Bass were abundant and grew at a moderate rate. We observed evidence of sporadic recruitment of both Black Crappie and Yellow Perch. Freeman Lake survey results suggested the fish community experienced changes in composition and size structure since the last survey of the lake in 2001. Current densities of Northern Pike and tiger muskelluge are unlikely to have a predation impact on the existing fish community. Results also suggested that spring stocking of Rainbow Trout is suitable to provide a viable fishery in Freeman Lake. A simple fish community was observed in Mirror Lake consisting of three species, including Brook Trout *Salvelinus fontinalis*, kokanee *Oncoryhnchus nerka*, and Rainbow Trout. The fish community closely resembled the coldwater fish assemblage established following renovation in 1991. The Mirror Lake fishery was consistent with the desired management focus of a yield salmonid fishery. Hatchery Rainbow Trout appeared to contribute to year round fishing opportunity in Mirror Lake.

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INTRODUCTION

Lowland lakes provide a diversity of angling opportunities in the Idaho Panhandle Region. Lowland lake surveys are conducted periodically to monitor the composition and quality of these fisheries. Many lowland lakes within the Panhandle Region are routinely stocked to enhance fishing opportunities. Lowland lake surveys also provide a means of evaluating the use of hatchery products for enhancement of lowland lake fisheries. In 2016, we completed standardized lowland lake surveys on Freeman and Mirror lakes.

FREEMAN LAKE

Freeman Lake is located in Bonner County, Idaho, approximately 4 km north of the city of Old Town, Idaho. Freeman Lake is a small lowland lake with an area of 21.4 ha. The lands surrounding the lake are primarily private lands. An Idaho Department of Fish and Game access point provides public access on the west side of the lake. Amenities available include a primitive boat ramp and outhouse. Watercraft use on the lake for fishing is restricted to electric motors only.

Freeman Lake is managed as a mixed species fishery under general regional bag and possession limits. Catchable length Rainbow Trout *Oncorhynchus mykiss* are stocked annually in the lake. Tiger muskelluge *Esox lucius* × *E. masquinongy* have also been stocked in Freeman Lake at low densities. Warmwater species previously known to be found in Freeman Lake included Black Crappie *Pomoxis nigromaculatus,* Brown Bullhead *Ameiurus nebulosus,* Largemouth Bass *Micropterus salmoides*, Northern Pike *Esox lucius*, Pumpkinseed *Lepomis gibbosus,* and Yellow Perch *Perca flavescens*. Although Northern Pike and tiger muskellunge are known to occur, the abundance and influence of these fishes on the larger fish community was uncertain. Angler exploitation of Rainbow Trout in Freeman Lake was previously found to be low (Ryan et al. 2018), potentially due to predation

In 2016, we surveyed Freeman Lake to better describe the current fish community. We used information collected to evaluate the current status and potential impacts of Northern Pike and tiger muskellunge on the fishery. We also evaluated angler exploitation of hatchery Rainbow Trout to determine how hatchery products were utilized in that fishery. Exploitation evaluations are reported in the *Stocking Evaluations* chapter of this report.

MIRROR LAKE

Mirror Lake is located in Bonner County, Idaho, southeast of Sagle Idaho. Mirror Lake is a small lowland lake with an area of 34.4 ha. The lands surrounding the lake are a mix of private and public (U.S. Forest Service) ownership, but access is primarily through private ownership. A public access easement is held by the Idaho Department of Fish and Game through private ownership on the north end of the lake. A primitive boat ramp and limited parking are available at this site. Watercraft use on the lake for fishing is restricted to electric motors only.

Mirror Lake is a unique lowland lake in the Panhandle Region as it offers a salmonid-only fishery. Mirror Lake was renovated in 1991 to remove illegally introduced Black Crappie and re-establish a trout and kokanee *Oncorhynchus nerka* fishery (Davis and Horner 1995). Catchable Rainbow Trout are stocked annually in the lake (IDFG, unpublished data). Kokanee are also regularly stocked, although natural recruitment has been observed. Brook Trout *Salvelinus fontinalis* and Westslope Cutthroat Trout *Oncorhynchus clarkii* have also been periodically

stocked in the lake (IDFG, unpublished data). Brook Trout have since become established with natural recruitment maintaining the population. Little contemporary information was available to determine the current composition and quality of the fishery or how hatchery products contribute.

Public access to Mirror Lake was limited for many years. Although Federal lands are adjacent to a portion of the lake shoreline, topography makes for difficult access. An easement for public access through private land was established in 1953, but subsequent property owners challenged the validity of the easement and required a fee for lake access at the only existing boat ramp. In 2014, an agreement was reached with the landowner that allowed for non-fee access to anglers. Due to access issues, angler use and, more specifically, hatchery product utilization was uncertain.

In 2016, we surveyed Mirror Lake to better describe the current fish community and determine what the available fishery provided. We also evaluated angler exploitation of hatchery Rainbow Trout to determine how hatchery products were utilized in that fishery. Exploitation evaluations are reported in the *Stocking Evaluations* chapter of this report.

METHODS

We surveyed Freeman Lake on May 24 and 25, 2016 and Mirror Lake from May 3 to May 5, 2016. Lowland lake surveys were conducted using Idaho Department of Fish and Game (IDFG) lowland lakes standard methods (IDFG 2012). In both lakes, we completed three trap net nights, four gill net nights (two floating and two sinking standard experimental gillnet), and electrofished the entire shoreline at night (Table 1).

Fish collected during surveys were identified, measured (total length, mm) and weighed (g). We estimated relative abundance as catch per unit effort (CPUE) for electrofishing (fish/hour) and netting (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 was described using length frequency histograms and stock density indices (Anderson and Neumann 1996) for primary species targeted. We used Fisheries Analysis and Modeling Simulator (FAMS, Slipke and Maceina 2014) software to calculate stock density indices. Average relative weight (W_r, Wege and Anderson 1978) was used to describe the condition of fish. We described variation around W_r estimates using 80% confidence intervals calculated using methods for normally distributed data.

Hard structures were collected from a subsample of targeted species caught during our survey of Freeman Lake and used to describe a length-at-age relationship. Length-at-age information was used to describe patterns of growth, mortality, and recruitment. We collected dorsal spines from Largemouth Bass and otoliths from a sample of Yellow Perch and Black Crappie. We targeted three to five structures per centimeter length group for each species. Dorsal spines were mounted in epoxy, cross sectioned on a Buehler Isomet saw (Illinois Tool Works Inc., Lake Bluff, Illinois), sanded for viewing clarity, and viewed on a compound microscope under 10x to 30x magnification. Otoliths were broken centrally on the transverse plane, browned, sanded on the broken surface, and viewed under a dissecting microscope using a fiber optic light to illuminate the broken surface. Length-at-age at time of capture was reported as an index of growth where applicable. Age-length keys were used to predict ages for an entire sample using subsampled age estimates. We used a frequency of catch by age for sampled fish in describing general

patterns of recruitment and in estimating annual mortality. Annual mortality was estimated using weighted catch curve analyses run in FAMS.

We collected zooplankton from Mirror Lake to evaluate the quality and quantity of available forage for planktivorous fishes. Zooplankton samples were collected on August 9 from three randomly selected locations distributed throughout the lake. Zooplankton were collected using three nets fitted with small (153µm), medium (500µm) and large (750µm) mesh. Nets were lowered to the bottom for each tow. Samples were preserved in denatured ethyl alcohol and were processed using methods described by Teuscher (1999). We used the zooplankton ratio method (ZPR) and the zooplankton quality index (ZQI) to assess zooplankton quality and quantity (Teuscher 1999). We described variation around ZPR and ZQI estimates using 80% confidence intervals calculated using methods for normally distributed data. Zooplankton collections were paired with measured temperature and dissolved oxygen profiles. Profiles were used to describe the general condition of habitat in the lake during a potentially limiting period for cold water fishes, such as Rainbow Trout.

RESULTS

Freeman Lake

We collected eight species from Freeman Lake, including Black Crappie, Brown Bullhead, Largemouth Bass, Northern Pike, Pumpkinseed, Rainbow Trout, and Tench *Tinca tinca* (Table 2). Yellow Perch were the most abundant species sampled, comprising 36% of the catch by number and 12% of the biomass. Pumpkinseed and Largemouth Bass were also abundant respectively comprising 19% and 18% by number. Black Crappie represented 12% of the catch by number. Electrofishing was the most efficient method of capture for Largemouth Bass (99.6 fish/hr; Table 2). In contrast, gill nets were most efficient for sampling Rainbow Trout (7.3 fish/net; Table 2) and Yellow Perch (10.6 fish/net; Table 2). Trap nets were effective at collecting Black Crappie (6.7 fish/net), Brown Bullhead (2.3 fish/net), Pumpkinseed (18.3 fish/net), and Tench (2.7 fish/net). Only one Northern Pike was sampled in our survey. We did not detect tiger muskellunge despite this species having been stocked the lake in 2013, 2014, and 2015.

Rainbow Trout caught in our sample were representative of recently stocked catchable-length fish. Mean TL of Rainbow Trout was 307 mm with measured lengths ranging from 228 to 355 mm (Table 2). We did not observe Rainbow Trout of lengths representing stocking events in prior years.

Largemouth Bass were abundant in Freeman Lake and grew at a moderate rate. Total length of collected fish varied from 82 to 434 mm, with a PSD of 44 (Table 2; Figure 1). We estimated Largemouth Bass reached 305 mm by 5.2 years of age (Figure 2). Largemouth Bass collected in our sample generally exhibited below average condition. Average W_r of stock length fish was 82 ± 2 (80% C.I.; Figure 3). Annual mortality of the population (ages 3-10) was low at 27.5% (z = -0.32 ± 11, 80% C.I.)

We observed evidence of sporadic recruitment of both Black Crappie and Yellow Perch. Only two year classes of Black Crappie and three year classes of Yellow Perch were well represented in our sample (Figure 4). Too few age classes were present to accurately estimate mortality rates of either species. Black Crappie total length varied from 55 to 253 mm and with a PSD of 30 (Table 2, Figure 1). Yellow Perch total length varied from 81 mm to 255 mm and was

represented by a PSD of 22 (Table 2; Figure 1). Black Crappie and Yellow Perch had average to below average condition with relative weights of 97 ± 2 and 83 ± 1, respectively (Figure 3).

Total length of Pumpkinseed varied from 90 mm to 193 mm (Table 2) With a PSD of 51 (Table 2; Figure 1). Average W_r of Pumpkinseed was 101 ± 2 (Figure 3), reflecting good condition.

Mirror Lake

We collected three species from Mirror Lake, including Brook Trout, kokanee, and Rainbow Trout (Table 4). Brook Trout were the most abundant species sampled, comprising 67% of the total catch by number and 61% by weight. Rainbow Trout were also well represented. Kokanee were caught primarily in gill net sets at lower catch rates (2.0 fish/net).

Total length of Brook Trout varied from 134 to 531 mm, with a PSD of 26.3 (Table 4; Figure 5). Few fish were larger than 350 mm, and average W_r was 93 ± 1 (Figure 6).

The size and condition of Rainbow Trout primarily represented recently stocked catchable-length fish. Rainbow Trout lengths varied from 187 to 371 mm (Table 4; Figure 5) and significant fin wear was observed on most fish, suggesting hatchery origin. We sampled one Rainbow Trout (306 mm TL) with good fin condition that had the appearance of a wild Rainbow Trout. Electrofishing caught the majority of sampled Rainbow Trout. However, the first stocking event of 2016 occurred after sampling with gill nets and trap nets, but before electrofishing.

We caught few kokanee among sampling efforts. Those fish caught varied from 203 mm to 254 mm total length. Distribution of kokanee lengths in the catch likely represented one age class, although ages of collected individuals were not estimated.

Zooplankton biomass was estimated at 0.10 g/m. ZPR and ZQI were estimated at 0.13 ± 0.06 (80% C.I.) and 0.01 ± 0.01, respectively.

Late summer water temperature and dissolved oxygen profiles in Mirror Lake indicated suitable habitat for coldwater fishes was available in the lake from approximately 6 to 10 m (Figure 7). Anoxic hypolimnetic conditions and warm epilimnetic water temperatures were present at the time of measurements, reducing available habitat to metalimnetic waters.

DISCUSSION

Freeman Lake

Freeman Lake survey results suggested the fish community experienced changes in composition and size structure since the last survey of this water (Dupont et al. 2004; Table 3). We observed increases in the relative proportion of the population made up of Black Crappie and Yellow Perch. Age frequencies of these species suggested increased abundance was related to two or three strong year classes in recent years (Figure 4). PSD values for both species decreased between surveys, thus supporting observations that strong year classes produced an increased abundance of smaller and younger fish. We also observed a substantial increase in Largemouth Bass PSD, suggesting larger fish were available to anglers. In contrast to Black Crappie and Yellow perch, Largemouth Bass demonstrated relatively consistent recruitment that suggested changes in population size structure were not related to isolated recruitment events

(Figure 4). The cause of changes in the fish community was not determined from this survey. Freeman Lake was consistently managed as a general rule fishing water throughout the period of both surveys. General rules restricted angler harvest of Largemouth Bass to fish 305 mm and larger prior to 2008, but did not limit harvest by size since 2008.

We were unable to compare metrics of relative abundance (i.e., CPUE) with prior surveys of Freeman Lake and were limited in our ability to compare general survey results with a 1995 Freeman Lake survey (Nelson et al. 1997). Standard IDFG methods for sampling lowland lakes differed between current and previous survey periods (IDFG 2012). Specifically, units of sampling effort were reduced, which influenced catch rate calculations and resulting comparisons. In addition, a 1995 survey of Freeman Lake did not incorporate electrofishing effort and caught few fish among other sampling methods.

We found densities of Northern Pike in Freeman Lake were low, with only one fish observed in our survey. Northern Pike were not detected in previous surveys of Freeman Lake (Dupont et al. 2004, Nelson et al. 1997). Northern Pike were known to be present in Freeman Lake prior to our survey based on angler reports, but the level of abundance and potential impact of Northern Pike on other fish species was unknown. The results of our survey suggested current abundance likely has little impact the existing fish community. High to moderate exploitation of Northern Pike is thought to limit abundance in other regional waters (Ryan et al. 2018). Angler exploitation on Northern Pike in Freeman Lake was not evaluated, but may explain the low occurrence of Northern Pike in our survey.

Tiger muskellunge were not collected in our survey of Freeman Lake despite having been stocked the three previous years. Tiger muskellunge were stocked at 2.3 fish/ha , reflecting low density out plants (IDFG, unpublished data). Although detection rates may be low due to existing densities, the absence of tiger muskellunge in our sample suggested few if any were present. The cause of potentially poor survival of stocked fish was not clear as a result of our survey. Low detection rates of tiger muskellunge were common among surveys of other area lakes where stocking has occurred (Dupont et al. 2011, Liter et al. 2008, Dupont et al. 2004). This commonality suggested that conditions affecting the success of stocked tiger muskellunge may be shared among waters. We recommend a targeted evaluation of tiger muskellunge stocking rates and fishery contribution be completed to better determine how to use this hatchery product in regional fisheries.

Catch of Rainbow Trout in our survey suggested spring stocking events should provide a seasonally viable fishery in Freeman Lake. Rainbow Trout were abundant in our survey and represented a significant portion of the biomass observed in the lake at that time. Qualitatively, their abundance suggested stocking efforts provided a quality fishing opportunity during cool water periods. However, evaluation of angler exploitation suggested anglers did not harvest Rainbow Trout from Freeman Lake in 2016 (Stocking Evaluations, *see this report*). We recommend additional evaluation of angler exploitation on stocked Rainbow Trout to confirm angler use of hatchery products is low. If angler use of stocked Rainbow Trout is confirmed to be low, we recommend reducing stocking rates to limit underutilization of hatchery products.

Rainbow Trout in Freeman Lake are likely influenced by summer habitat availability. We did not detect carryover Rainbow Trout from stocking events in prior years. Although we did not measure habitat conditions (i.e., temperature and dissolved oxygen) conditions were likely poor for cold water fishes in mid- to late-summer. Freeman Lake is shallow and heavily vegetated, characteristics typically associated with warm water and low dissolved oxygen during warm weather periods.

Mirror Lake

We observed a simple fish community in Mirror Lake consistent with the desired management focus of a yield trout fishery (Davis and Horner 1995, IDFG 2013a). The fish community closely resembled the cold water fish assemblage established post-renovation (Nelson et al. 1996). Brook Trout, Rainbow Trout, and kokanee remained the only species in Mirror Lake. Westslope Cutthroat Trout had been stocked periodically in Mirror Lake, but were not stocked in recent years prior to our survey. Fingerling Westslope Cutthroat Trout were stocked in Mirror Lake following our survey and may provide an additional element to the fishery in the future. We recommend monitoring the contribution of Westslope Cutthroat Trout in the fishery to determine the value of stocking an additional species.

Hatchery Rainbow Trout appeared to contribute to year-round fishing opportunity in Mirror Lake. We sampled hatchery Rainbow Trout in gill nets in Mirror Lake prior to the first stocking event in the spring of 2016. The presence of these fish provided evidence that hatchery Rainbow Trout survived overwinter to provide an additional fishery component the following spring. No information was gathered in this survey to determine if carryover fish originated from prior spring or fall stocking events, but the combination of both appear to provide good fishing opportunity. Ongoing evaluation of angler exploitation on Rainbow Trout stocked in Mirror Lake should provide insight as to how the timing of stocking events impacts the fishery (Stocking Evaluations, *see this report*). We recommend Rainbow Trout continue to be stocked in Mirror Lake at current rates and times. Ongoing stocking evaluations should be used to modify stocking practices if deemed necessary.

MANAGEMENT RECOMMENDATIONS

1. Continue current Rainbow Trout stocking rates and frequencies in Freeman Lake, but confirm exploitation estimates are accurate. Consider modifying stocking practices if Rainbow Trout are being underutilized.

2. Complete targeted evaluation of tiger muskellunge stocking rates and fishery success to better determine how to best use this species in regional fisheries.

3. Monitor the contribution of Westslope Cutthroat Trout in the Mirror Lake fishery to determine the value of stocking this additional species.

4. Continue Rainbow Trout stocking in Mirror Lake at current rates and times. Use ongoing Mirror Lake stocking evaluations to modify stocking practices if deemed necessary.

Table 11. Sample locations (UTM) by date and method for lowland lakes surveyed in 2016. Sampling methods included floating gill nets (FGNET), sinking gill net (SGNET), and trap nets (TNET). In addition to the sampling listed, electrofishing encompassed the entire shoreline of Mirror and Freeman lakes.

Water	Date	Method	Unit	Z	Easting	Northing	Datum
Mirror Lake	5/3/2016	FGNET	1	11	537157	5334951	WGS84
Mirror Lake	5/3/2016	FGNET	2	11	537492	5334244	WGS84
Mirror Lake	5/3/2016	SGNET	3	11	537073	5335031	WGS84
Mirror Lake	5/3/2016	SGNET	4	11	537334	5334826	WGS84
Mirror Lake	5/3/2016	TNET	5	11	536798	5335052	WGS84
Mirror Lake	5/3/2016	TNET	6	11	537217	5334359	WGS84
Mirror Lake	5/3/2016	TNET	7	11	537569	5334333	WGS84
Freeman Lake	5/24/2016	TNET	1	11	498015	5341445	WGS84
Freeman Lake	5/24/2016	TNET	2	11	497873	5340941	WGS84
Freeman Lake	5/24/2016	TNET	3	11	497925	5341170	WGS84
Freeman Lake	5/24/2016	FGNET	4	11	497671	5341288	WGS84
Freeman Lake	5/24/2016	SGNET	5	11	497633	5341073	WGS84
Freeman Lake	5/24/2016	FGNET	6	11	497684	5340899	WGS84
Freeman Lake	5/24/2016	SGNET	7	11	497933	5341012	WGS84

Table 12. Descriptive statistics from survey samples of Freeman Lake in June 2016. Statistics summarized include catch, proportion of catch by number and biomass, minimum and maximum total length (TL), and catch rates (80% C.I.) by gear type.

Species	Catch	% of Catch	% of Biomass	Min TL	Max TL	Electrofishing Fish/hour	Gill Net Fish/net	Trap Net Fish/net
Black Crappie	55	12%	5%	55	253	20.4(6.7)	4.5(2.6)	6.7(5.5)
Brown Bullhead	11	2%	4%	168	325	4.8(2.9)	0.0	2.3(3.0)
Hatchery Rainbow Trout	38	8%	13%	228	355	9.6(5.2)	7.3(2.9	0.3(0.4)
Largemouth Bass	87	18%	25%	82	434	99.6(16.8)	0.8(0.6)	0.3(0.4)
Northern Pike	1	0%	7%	871	871	0.0	0.3(0.3)	0.0
Pumpkinseed	90	19%	7%	90	193	42.0(30.0)	0.0	18.3(19.2)
Tench	18	4%	27%	399	497	4.8(7.8)	1.5(0.8)	2.7(0.4)
Yellow Perch	172	36%	12%	81	255	63.6(22.9)	21.5(16.6)	11.0(7.1)

Table 13. Summary of lowland lake survey metrics from past and present surveys of Freeman Lake. Metrics include percent of catch by number and biomass, proportional Stock Density (PSD), and range of observed relative weight (W_r).

Year	Species	% of Catch	% of Biomass	PSD	W_r Range
1995	Black Crappie	3%	5%	---	---
2001	Black Crappie	3%	2%	100	109-139
2016	Black Crappie	12%	5%	30	79-126
1995	Largemouth Bass	8%	11%	0	---
2001	Largemouth Bass	48%	27%	6.6	82-108
2016	Largemouth Bass	18%	26%	44	71-119
1995	Hatchery Rainbow Trout	82%	98%	---	---
2001	Hatchery Rainbow Trout	9%	6%	---	---
2016	Hatchery Rainbow Trout	8%	13%	---	---
1995	Yellow Perch	3%	3%	---	---
2001	Yellow Perch	9%	5%	86	86-105
2016	Yellow Perch	36%	12%	22	60-136

Table 14. Descriptive statistics from survey samples of Mirror Lake in May 2016. Statistics summarized include catch, proportion of catch by number and biomass, minimum and maximum total length (TL), and catch rates (80% confidence intervals) by gear type.

Species	Catch	% of Catch	% of Biomass	Min TL	Max TL	Electrofishing Fish/hour	Gill Net Fish/net	Trap Net Fish/net
Brook Trout	96	67%	61%	134	531	67.7 (11.2)	4.0 (5.1)	0.3 (0.4)
Hatchery Rainbow Trout	34	24%	33%	187	371	26.6 (8.7)	0.8 (0.6)	0
Kokanee	12	8%	5%	203	254	3.4 (3.3)	2.0 (2.2)	0
Rainbow Trout	1	1%	1%	306	306	0.9 (1.1)	0	0

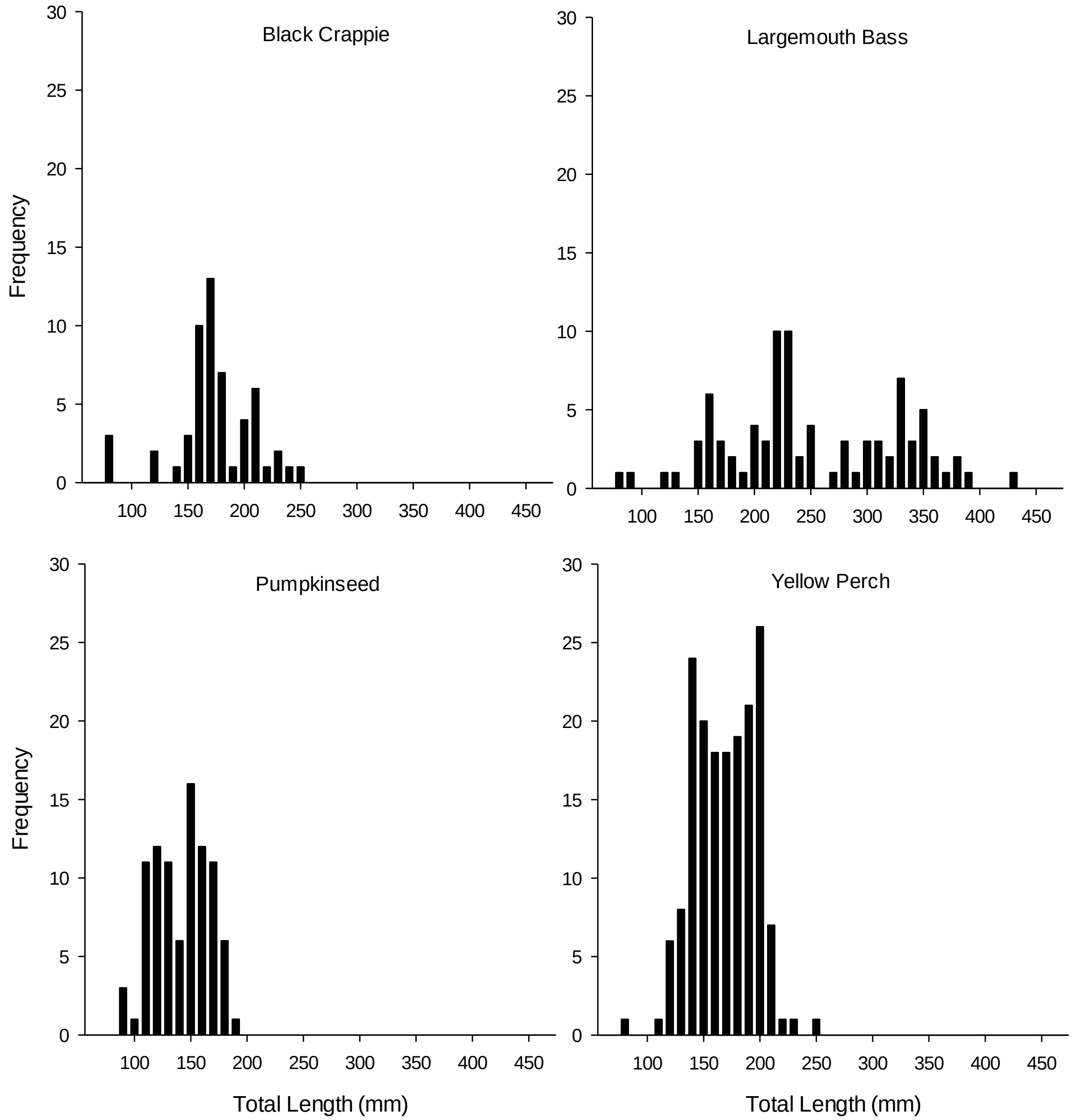


Figure 18. Length frequency (count) distributions of Black Crappie, Largemouth Bass, Pumpkinseed, and Yellow Perch collected using boat electrofishing, gill nets, and trap nets from Freeman Lake in June 2016.

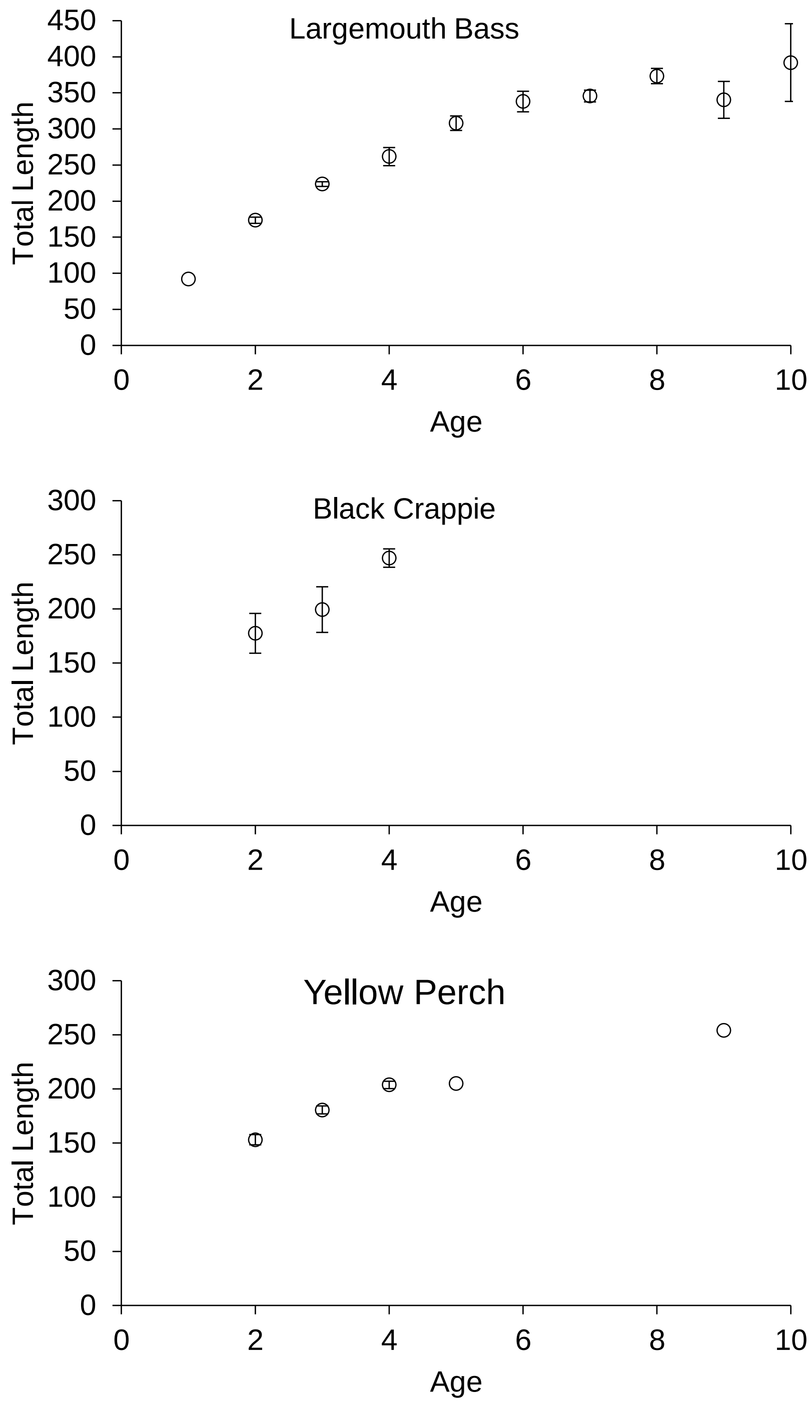


Figure 19. Mean length-at-age at time of capture and 80% confidence intervals estimated for Largemouth Bass, Black Crappie, and Yellow Perch sampled from Freeman Lake in June 2016.

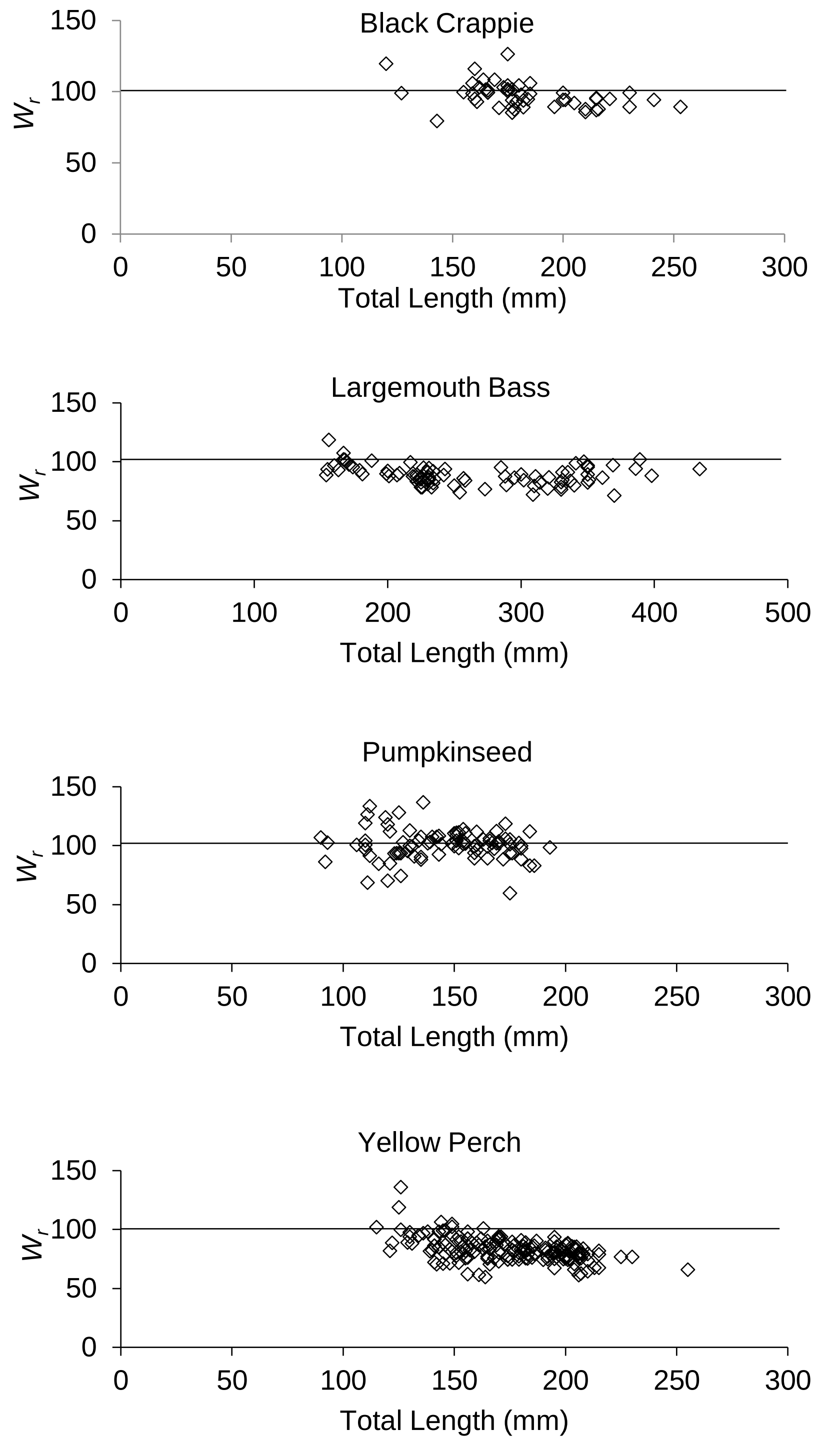
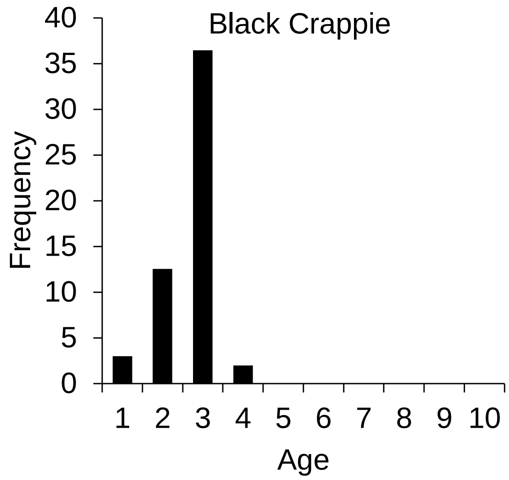
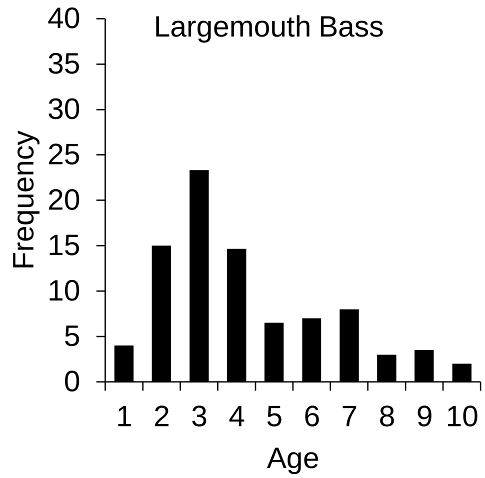


Figure 20. Relative weight (W_r) distributions of Black Crappie (> 100 mm), Largemouth Bass (>150 mm), Pumpkinseed (>50 mm), and Yellow Perch (>100 mm) sampled from Freeman Lake in June 2016.





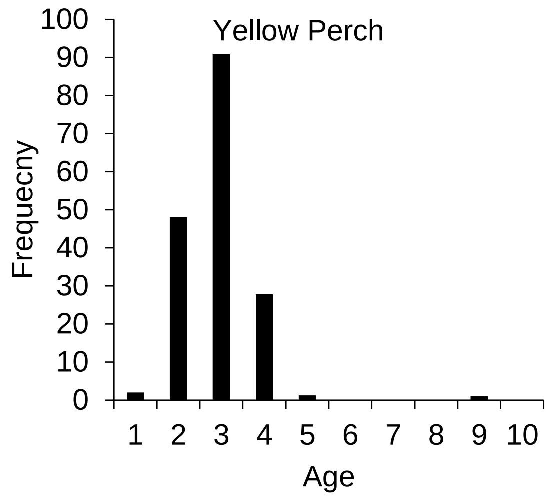


Figure 21. Age frequency of Black Crappie, Largemouth Bass, and Pumpkinseed sampled from Freeman Lake in June 2016.

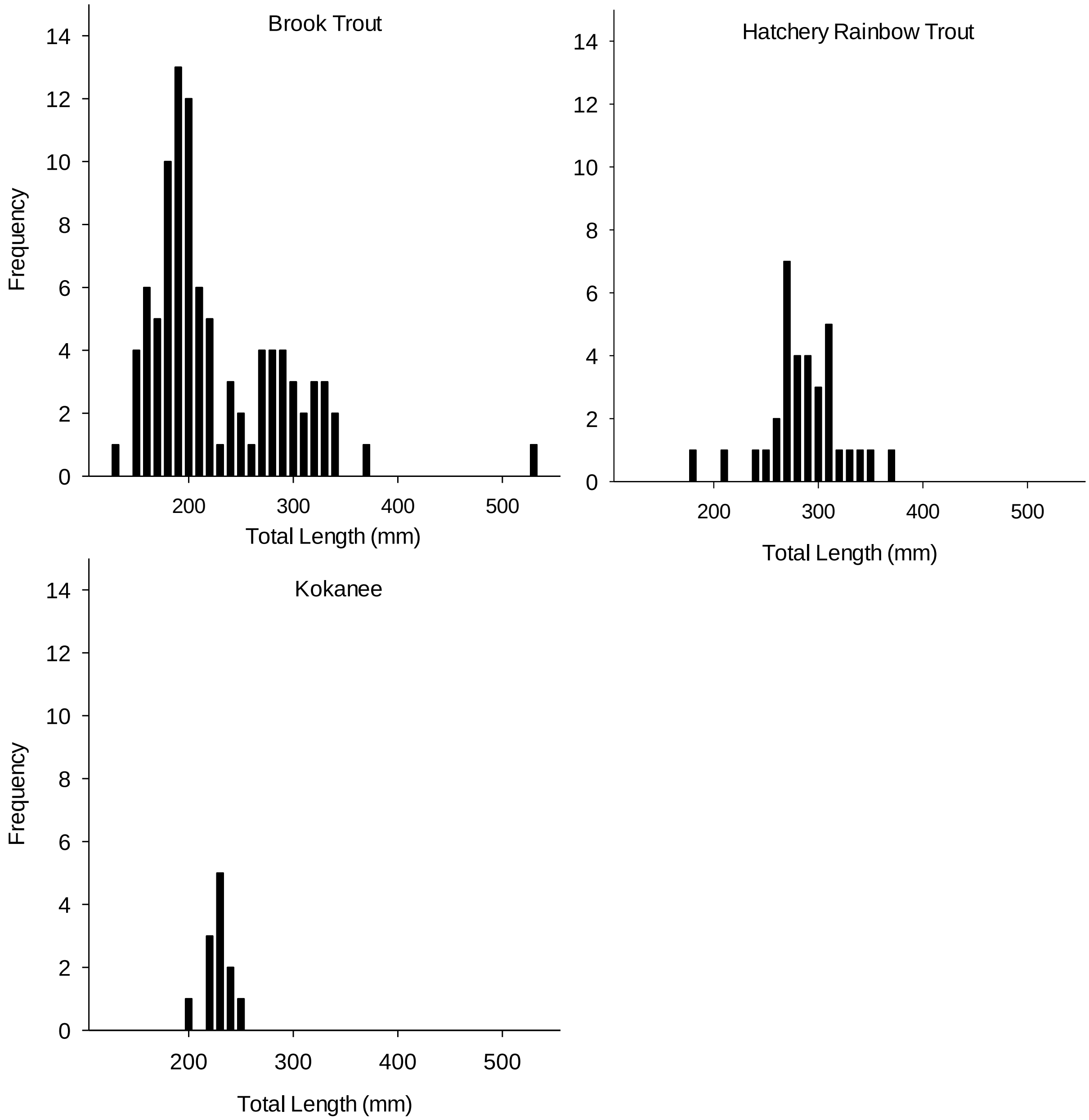


Figure 22. Length frequency distributions of Brook Trout, Rainbow Trout, Largemouth Bass, and kokanee sampled from Mirror Lake in May 2016.

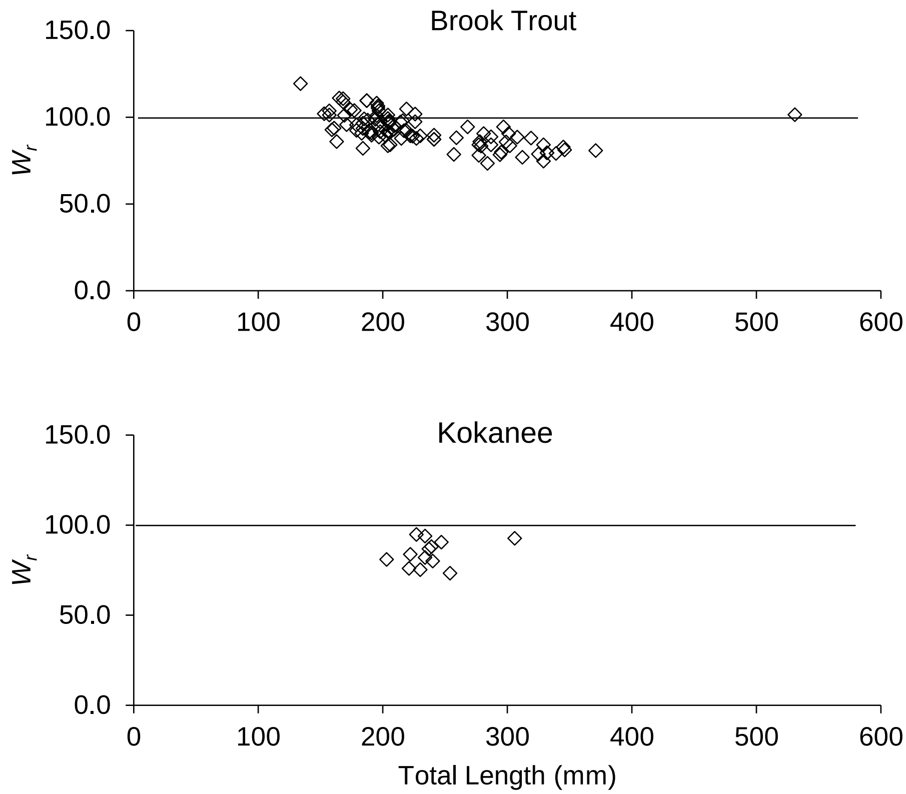


Figure 23. Relative weight (W_r) distributions of Brook Trout (> 120 mm) and kokanee (>120 mm) sampled from Mirror Lake in May 2016.

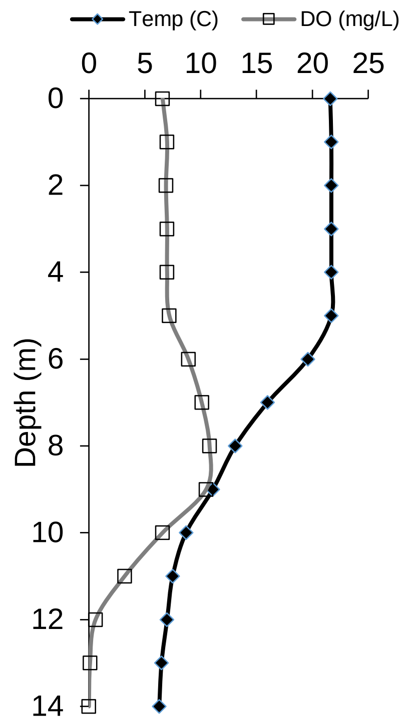


Figure 24. Temperature and dissolved oxygen profiles from Mirror Lake on August 9, 2016.

SOUTHERN PANHANDLE REGIONAL LOWLAND LAKE SURVEYS

ABSTRACT

Holistic fish community monitoring is useful for understanding coarse-scale fishery shifts and updating management plans. We conducted standard lowland lake surveys on Fernan, Lower Twin, and Spirit lakes during May–June of 2016 to understand fish assemblage structure and population characteristics of important game fish species. Fish communities were similar among the study lakes in terms of species richness, but varied somewhat by composition. Specifically, Spirit Lake had a greater number of coldwater fish species and higher relative abundance of common coldwater species. We report good size structure of adult Black Crappies *Pomoxis nigromaculatus* in Fernan and Lower Twin lakes, but disconcertingly low size structure of Largemouth Bass *Micropterus salmodies* relative to a 2015 survey. Size structure of Largemouth Bass in Spirit Lake was good and similar to nearby lakes that are managed for quality Largemouth Bass angling. We found that Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* stocking efforts in Spirit Lake are likely sufficient for producing satisfactory angler catch rates by comparison to information from recent creel surveys and population monitoring on Lake Pend Oreille and Priest Lake. Overall, we provide information germane to multiple-species management and assessments of various put-and-take and put-grow-and-take hatchery populations in three mixed fisheries in the Panhandle Region.

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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 important 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 Fernan, Lower Twin, and Spirit lakes.

2. Estimate size structure of sport fish species in Fernan, Lower Twin, and Spirit lakes.

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

STUDY AREA

Fernan Lake

Fernan Lake is located in Kootenai County immediately east of the city of Coeur d'Alene. It is classified as an mesotrophic water body, but has undergone rapid eutrophication in recent history. The lake has a surface area of 171 ha and elevation of 647 m. Fernan Creek is the most significant tributary to Fernan Lake, entering the lake near its east end. Fernan Lake is one of the Panhandle Region's most popular lowland lakes and supports a mixed fishery for both warmwater and coldwater species. The fishery is managed under general regional fishing regulations, including daily bag limits of six trout (all species combined) and six bass (both species combined).

Lower Twin Lake

Lower Twin Lake is located in Kootenai County approximately 11 km north of Rathdrum, Idaho. The lake has a surface area of 158 ha, elevation of 704 m, mean depth of 6.9 m, and maximum depth of 19.1 m. Lower Twin Lake is part of a complex comprised of two individual lentic water bodies; Upper and Lower Twin lakes are connected via a small channel. Fish Creek is the largest tributary in the system, entering Upper Twin Lake on the western shoreline. Water exits the system via Rathdrum Creek at the southern end of Lower Twin Lake. The fishery is managed under general regional fishing regulations, including daily bag limits of six trout (all species combined), 15 kokanee, and six bass (both species combined).

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 entering Spirit Lake. Spirit Lake discharges into Spirit Creek, an intermittent outlet located at the northeastern end of the lake. Spirit Creek flows onto 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 1992). Spirit Lake does not have a history of fish assemblage monitoring and no standard surveys have focused on characterizing the fish community at-large. Most previous fish sampling activities on Spirit Lake have focused on monitoring or one-time assessments for individual species (Davis et al. 1997). The fishery is managed under general regional fishing regulations, including daily bag limits of six trout (all species combined) and six bass (both species combined). The only special regulation is for kokanee, which allows a daily bag of 25 fish instead of the general limit of 15 fish.

METHODS

Lowland lakes were surveyed during late spring following Idaho Department of Fish and Game's (IDFG) standard lowland lakes survey protocol (IDFG 2012). Surveys were conducted during May 24–25, 2016 on Fernan Lake, May 26–27, 2016 on Lower Twin Lake, and June 1–3, 2016 on Spirit 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). Body condition of fishes was evaluated using relative weight (W_r; Neumann et al. 2012). Relative weight values were calculated as

$$W_r = (W / W_s) \times 100,$$

where *W* is the weight of an individual and W_s is the standard weight predicted by a species-specific length-weight regression (Neumann et al. 2012). A W_r value of 100 indicates average body condition, W_r values below 100 indicate poor body condition, and W_r values above 100 indicate good body condition.

RESULTS

A total of 3,517 fish (*n* [Fernan Lake] = 790; *n* [Lower Twin Lake] = 888; *n* [Spirit Lake] = 1,839) representing 16 species were sampled during the effort (Table 2). The fish communities were similar among study lakes, but with Spirit Lake possessing more wild-origin coldwater species (e.g., kokanee *Oncorhynchus nerka*; Rainbow Trout *O. mykiss*; Brook Trout *Salvelinus fontinalis*; Mountain Whitefish Prosopium williamsoni). Species richness was similar between study lakes (*S* = 12–13; Table 2; Figure 1). Most warmwater sport fish species (i.e., Black Crappie *Pomoxis nigromaculatus*, Bluegill *Lepomis macrochirus*, Largemouth Bass *Micropterus salmodies*, Pumpkinseed *L. gibbosus*, and Yellow Perch *Perca flavescens*) were ubiquitous among study lakes. Westslope Cutthroat Trout *O. clarki lewisi* were also common among study lakes, but occurred in much lower abundance in Fernan and Lower Twin lakes compared to Spirit Lake.

Both relative abundance and size structure of warmwater sport fish species varied among study lakes, but showed some consistent patterns in the relationship between abundance and size. For example, electrofishing data showed that Black Crappie were most abundant in Spirit Lake (mean CPUE = 0.44 fish/min), but the size structure of those individuals (PSD = 32) was poorer than both Fernan (PSD = 83) and Lower Twin lakes (PSD = 50; Table 3; Figure 2). Similarly, electrofishing catch rates for Largemouth Bass were highest in Fernan Lake, followed by Spirit Lake and then Lower Twin Lake; however, size structure was best for Spirit Lake (PSD = 50) and Fernan Lake (PSD = 35; Tables 2 and 3; Figure 3). No kokanee sampled in Spirit Lake surpassed the minimum quality length. Kokanee in Lower Twin Lake had good size structure and a variety of age classes appeared to be present (Table 2; Figure 4). Size distributions for all other game fish species can be found in Figures 5–11.

Nearly all fish populations sampled during this study possessed individuals in good body condition. Nearly all fish populations had mean W_r values near 100, with the exception of Westslope Cutthroat Trout in Fernan Lake and Yellow Perch in Lower Twin Lake. Abundance was not associated with patterns in W_r among the various fish populations. Among salmonid species in Spirit Lake, Mountain Whitefish had good body condition, whereas Rainbow Trout and Westslope Cutthroat Trout had somewhat poor body condition. Westslope Cutthroat Trout did have better body condition in Lower Twin and Spirit lakes compared to Fernan Lake (Table 2). Hatchery-origin fish populations had only slightly below average body condition, regardless of water body.

Illegally introduced species occurred in Fernan and Lower Twin lakes. Northern Pike *Esox lucius* were again documented in both Fernan and Lower Twin lakes, but at low relative abundance compared to other nearby Northern Pike populations. Consistent with our expectations, no Northern Pike were detected in Spirit Lake. Smallmouth Bass *M. dolomieu* were sampled in both Fernan and Spirit lakes, but neither lake received intentional introductions. Relative abundance of Smallmouth Bass populations was low in both lakes (Table 3). Green Sunfish *Lepomis* cyanellus were sampled in both Fernan and Lower Twin lakes.

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 products.

Fernan Lake

The warmwater fishery in Fernan Lake is an important local resource for Panhandle anglers. In addition, the hatchery Rainbow Trout and Channel Catfish *Ictalurus punctatus* fisheries also provide important sources of opportunity, especially for harvest-oriented anglers. Fernan Lake has good public access which contributes to its continued popularity (Maiolie et al. 2013b). Long-term fish assemblage monitoring data is not available for Fernan Lake, but our assessment indicates that the fishery is meeting management objectives. Recent evaluations of catchable Rainbow Trout and Channel Catfish exploitation indicate that hatchery products are being adequately utilized by anglers and contributing to fish assemblage diversity (Maiolie et al. 2013a).

Channel Catfish have been stocked periodically in Fernan Lake since the mid-1980s (Carter-Lynn et al. 2015). Carter-Lynn et al. (2015) and Maiolie et al. 2013a noted that growth rates in many northern Idaho lakes (Fernan included) had slowed and compromised size structure. Moreover, size structure was poor relative to populations in systems at the same latitude. In Fernan Lake, PSD was estimated at 18 and 12 in 2011 and 2012, respectively; however, our results show that PSD has increased substantially (2016 estimate = 76). 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). 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 angler exploitation rate estimated for Channel Catfish in Fernan Lake (μ = 4.2%) is low compared to other put-grow-and-take fisheries for Channel Catfish in the Panhandle Region. Stocking rates of Channel Catfish were recently reduced by ~50% in Fernan Lake in 2013, so it is unclear whether changes in density-dependent growth or potential 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.

Fernan Lake supports a popular Largemouth Bass fishery (Liter et al. 2007) and our survey indicates that size structure of Largemouth Bass has declined since 2015 (Ryan et al. 2018). In comparison to similar size lakes in the Panhandle Region, the Largemouth Bass population in Fernan Lake experiences relatively high angler exploitation. Angler exploitation is known to influence Largemouth Bass in many populations throughout North America, particularly in populations where growth is slow (Allen et al. 2008). Given the small sample size attained in this study, it is difficult to surmise that this size structure shift is real. Monitoring should focus on the

population dynamics of Largemouth Bass to understand the long-term patterns in population characteristics.

Fernan Lake has been undergoing eutrophication over the past twenty years, and the relationship between changing water quality characteristics and the fishery are currently unknown. Our observations of fish assemblage and game fish population structure do not suggest negative impacts are associated with water quality changes. However, water quality changes appear to have greater potential to alter angler dynamics relative to lake aesthetics and health concerns. For instance, Blue-Green algae (cyanobacteria) *Anabaena flos-aquae* blooms now occur during most years and pose a significant human health risk. Idaho Department of Environmental Quality will respond to such blooms by issuing health advisories urging the public to use caution when recreating in or near the water. While Blue-Green algae blooms may not adversely affect game fish populations in Fernan Lake, water quality concerns may deter anglers due to health risks associated with water contact. Our future monitoring efforts should seek to understand the relationship between water quality and fishery shifts, particularly with respect to angler use.

Lower Twin Lake

Lower Twin Lake supports popular fisheries for warmwater and coldwater species necessitating monitoring to understand fish assemblage trends. Although current creel survey information is not available for Lower Twin Lake, anecdotal information suggests that Largemouth Bass and Black Crappie are likely the most significant species comprising the warmwater fishery while kokanee and catchable Rainbow Trout comprise the coldwater fishery. Comparisons of size structure indices between the most recent lowland lake survey (Liter et al. 2007) and our study shows that size structure of Black Crappies and Pumpkinseed remain relatively unchanged whilst size structure of Largemouth Bass has improved. Ryan et al. (2018) recently evaluated rules (i.e., 254 mm minimum length limit) for improving size structure of Black Crappie in Lower Twin Lake and found that general rules (unlimited daily bag; no length limit) were sufficient considering the slow somatic growth and high natural mortality experienced by this population. The Black Crappie fishery will likely be variable in the future (Guy and Willis 1995; Isermann et al. 2002), and size structure flux will likely be regulated by the progression of strong year-classes through the population. Largemouth Bass, on the other hand, tend to show more stable recruitment compared to other *Centrarchid* spp. in the Panhandle Region (Rieman 1987; Garvey et al. 2003; Ryan et al. 2018), and Largemouth Bass fisheries have a propensity to be more strongly regulated by adult mortality (Allen et al. 2008). In many systems, harvest has been shown to depress size structure necessitating the use of special rules (i.e., length limits; Eder 1984; Allen et al 2008). During a 2015 survey, Ryan et al. (2018) documented higher size structure of Largemouth Bass than what was estimated during the survey herein; however, the authors estimated angler exploitation rates of 0.0%. It is unlikely that angler exploitation rates or somatic growth had changed substantially during the two years between surveys, and the observed differences may be better explained by sampling efficiencies. Follow-up monitoring of the Lower Twin Lake Largemouth Bass population may seek to evaluate long-term trends in population characteristics and how it is related to harvest.

Hatchery fish appear to be sufficiently contributing to the coldwater fishery and providing reasonable angling opportunity. Return-to-creel rates of “magnum” hatchery catchables stocked in Lower Twin Lake have been comparable to estimates from other Panhandle Region lowland lakes of similar size (e.g., Fernan Lake; Ryan et al. 2018). In addition, early-spawning kokanee also contribute to the coldwater component of the fishery. The kokanee population is supported entirely by stocking, allowing managers to regulate densities at a level that promotes adequate

growth (Rieman and Meyers 1991). Indeed, our study confirmed that kokanee growth is supporting desired adult size structure. Although this study did not document many kokanee, anecdotal reports from anglers suggest that kokanee fishing remains adequate.

Northern Pike were introduced to Lower Twin Lake sometime during the late 1980s, but have remained at low abundance. The exact mechanism for this is unknown as the habitat appears to be sufficient to support more Northern Pike; however, Northern Pike are scarce in both Upper and Lower Twin lakes and do not support a significant fishery. The Idaho state record Northern Pike was taken from Lower Twin Lake in 2010, and Northern Pike sampled during our survey tended to be large individuals. The seemingly above average growth of Northern Pike in Lower Twin Lake further suggests that abundance is low relative to nearby waters.

Spirit Lake

The Spirit Lake survey was largely motivated by IDFG's interest in understanding the status of the warmwater component of the fishery and the efficacy of Westslope Cutthroat Trout stocking. However, many interesting observations and patterns emerged from the survey that broadened the understanding of the fishery at-large. The assemblage of warmwater species is likely more robust than previously thought. Electrofishing catch rates of Black Crappie were higher in Spirit Lake than either Fernan or Lower Twin lakes, although size structure was poorest in Spirit Lake. It appears that Black Crappies have potential to reach relatively large sizes in Spirit Lake, and future evaluations may seek to understand the dynamics of this population. Bluegill were less abundant while Pumpkinseed were more abundant in Spirit Lake compared to the other lakes in our study. Similar to patterns observed among Black Crappie populations, PSD values for both Bluegill and Pumpkinseed were lowest for Spirit Lake; however, both species reached the highest maximum TL in Spirit Lake. Small-bodied *Centrarchid* spp. do not currently support a significant fishery in Spirit Lake, but these species provide important forage for black basses. Largemouth Bass and Smallmouth Bass were sampled in Spirit Lake during this study, although Smallmouth Bass occur at rather low abundance. The Largemouth Bass population in Spirit Lake had the best size structure of all lakes in this study, and it produces some of the largest adult Largemouth Bass in the Panhandle Region (Maiolie et al. 2011; Ryan et al. 2018).

Spirit Lake has been stocked with Westslope Cutthroat Trout fry since the early 1990s and was previously stocked with Rainbow Trout fingerlings from the late 1960s to early 1990s to support a put-grow-and-take fishery. Our survey results indicate that catch rates of Westlsope Cutthroat Trout (CPUE [fish/net h] = 0.07; CPUE [fish/net night] = 1.2) in Spirit Lake are similar to or slightly lower than those reported in wild populations in other Panhandle Region lakes (Bouwens and Jakubowski 2017; Watkins et al. 2018). By comparison, relative abundance of wild adfluvial Westslope Cutthroat Trout in Lake Pend Oreille (CPUE [fish/net night] = 1.8) and Priest Lake (CPUE [fish/net night] = 1.9) was slightly higher than our estimate for Spirit Lake. Recent creel surveys in Lake Pend Oreille and Priest Lake have shown that angler catch rates for those targeting Westslope Cutthroat Trout exceed 0.5 fish/h. Catch rates in salmonid fisheries approaching 1.0 fish/h are considered excellent angling by regional standards. For example, the Lake Trout *Salvelinus namaycush* fishery in Priest Lake is highly popular and produces high angler satisfaction at angler catch rates around 1.0 fish/h (Watkins et al. 2018; R. G. Ryan, personal communication). As such, we can reasonably deduce that angler catch rates of Westslope Cutthroat Trout in Spirit Lake are likely supporting satisfactory angling. Although overall size structure is poor in Spirit Lake (PSD = 15; Table 2), our results suggest that Spirit Lake has the potential to grow very large Westslope Cutthroat Trout. With respect to TL statistics of Westslope Cutthroat Trout, we found that average TL was lower and maximum TL higher in

Spirit Lake relative to wild populations in Lake Pend Oreille (mean TL = 328.0 mm; max TL = 454.0 mm) and Priest Lake (mean TL = 358.6 mm; max TL = 445.0 mm; Bouwens and Jakubowski 2017; Watkins et al. 2018).

With the understanding that Westslope Cutthroat Trout supplementation in Spirit Lake supports a population comparable to other nearby lakes, we recommend maintaining the current management approach. In addition, there is likely interspecific exploitative competition between Westslope Cutthroat Trout and Rainbow Trout during part of their life histories (Scott and Crossman 1973). As such, changes to stocking regimes should consider trophic overlap between the two species and the potential influence of competition on growth and mortality on hatchery Westslope Cutthroat Trout. Spirit Lake supports a relatively robust population of Rainbow Trout with relative abundance values comparable to those of Westslope Cutthroat Trout. Rainbow Trout have not been stocked in the Spirit Lake system since 1994, and the most recent stockings have utilized fingerling Rainbow Trout. It is apparent that Rainbow Trout have naturalized in the system, whereby adults likely utilize Brickel Creek for spawning (Scott and Crossman 1973). We sampled wild Rainbow Trout representing a diversity of lengths (range = 605 mm; Table 2), suggesting recruitment is at least somewhat consistent. Anecdotal reports suggest that Rainbow Trout are most common during the winter ice fishery (conditions permitting); however, several recent reports have indicated that Rainbow Trout are commonly caught by troll anglers incidental to Westslope Cutthroat Trout. Overall, it appears that very few anglers target Rainbow Trout in Spirit Lake, particularly during the open water fishery season. Given the ability of the Rainbow Trout population to support a unique angling opportunity, we recommend a survey of Spirit Lake tributaries to identify sources of production and understand the population's ecology.

MANGEMENT RECOMMENDATIONS

1. Conduct a creel survey on Spirit Lake to understand associated angling characteristics and the relationship between Westslope Cutthroat Trout stocking and angler catch rates.

2. Conduct a fish assemblage survey in Brickel Creek (Spirit Lake tributary) to evaluate fish assemblage structure and verify production of naturalized Rainbow Trout.

3. Periodically monitor study lakes to assess fish assemblage changes.

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

Table 15. Number of sites sampled with various gears (floating GN = floating gillnet; sinking GN = sinking gillnet) used during standardized lowland lakes surveys of Fernan, Lower Twin, and Spirit lakes (2016).

	Gear data			
Water body	Modified fyke	Floating GN	Sinking GN	Electrofishing
Fernan Lake	6	8	8	6
Lower Twin Lake	6	8	8	6
Spirit Lake	6	13	13	15

Table 16. Sample size (n), mean catch-per-unit-effort (CPUE = fish/gill net night), total length (mm; Minimum–Maximum [Min–Max]) statistics, proportional size distribution (PSD), weight (g; Minimum–Maximum [Min–Max]) statistics, and relative weight (W_r) for fish populations sampled from Fernan, Lower Twin, and Spirit lakes (2016). Numbers in parentheses represent one standard error about the mean. Dashed lines indicated that data were unavailable or sample sizes were insufficient to estimate metrics.

		Total length			Weight		
Species	n	Mean	Min–Max	PSD	Mean	Min–Max	W_r
				Fernan Lake			
Black Crappie	64	212 (3.4)	144–281	83	165 (12.3)	50–340	103 (2.0)
Bluegill	183	163 (1.4)	53–214	83	118 (2.9)	15–230	117 (1.2)
Brown Bullhead	12	268 (7.6)	233–314	--	--	--	--
Channel Catfish	105	437 (7.1)	248–865	76	801 (32.1)	190–2,100	98 (1.1)
Green Sunfish	89	104 (8.0)	21–155	5	--	--	--
Largemouth Bass	123	256 (8.2)	72–482	35	353 (30.5)	15–1,815	97 (1.1)
Northern Pike	7	638 (82.4)	185–874	--	3,321 (836.1)	1,710–6,550	128 (5.1)
Pumpkinseed	7	165 (2.6)	153–175	--	--	--	--
Smallmouth Bass	33	233 (14.9)	85–384	48	251 (38.6)	20–770	97 (2.3)
Tench	112	436 (1.9)	340–476	--	--	--	--
Westslope Cutthroat Trout	5	311 (32.6)	217–395	--	300 (125.0)	100–530	81 (5.7)
Yellow Perch	50	218 (3.0)	190–272	80	141 (4.6)	90–225	97 (1.9)
				Lower Twin Lake			
Black Crappie	134	201 (2.1)	116–275	50	119 (3.7)	25–225	98 (7.7)
Bluegill	109	127 (2.9)	43–177	27	50 (4.2)	10–105	102 (5.0)
Brook Trout	1	285 (0.0)	--	--	--	--	--
Brown Bullhead	89	258 (2.8)	156–361	98	--	--	--

Table 16 (continued)

Green Sunfish	5	110 (7.6)	96–138	--	--	--	--
Kokanee	38	259 (5.0)	225–356	59	--	--	--
Largemouth Bass	77	220 (11.7)	73–519	24	355 (75.2)	15–2,145	101 (3.0)
Northern Pike	5	922 (30.7)	869–1,040	--	6,700 (885.8)	4,730–9,860	119 (4.7)
Pumpkinseed	366	130 (1.3)	66–189	27	--	--	--
Tench	18	429 (16.5)	190–522	--	--	--	--
Westslope Cutthroat Trout	3	322 (19.0)	303–360	--	89 (51.3)	255–420	89 (3.4)
Yellow Perch	43	197 (3.4)	155–237	51	98 (5.9)	50–125	78 (2.3)
Spirit Lake							
Black Crappie	172	177 (3.3)	87–304	32	--	--	--
Bluegill	105	121 (3.5)	37–228	22	--	--	--
Brook Trout	9	216 (10.5)	175–257	--	--	--	--
Brown Bullhead	228	271 (8.5)	97–369	95	--	--	--
kokanee	36	182 (1.4)	177–223	0	--	--	--
Largemouth Bass	267	211 (6.9)	65–523	50	--	--	--
Mountain Whitefish	36	298 (12.3)	162–392	--	426 (40.8)	315–725	107 (2.5)
Pumpkinseed	597	120 (2.1)	55–222	17	--	--	--
Rainbow Trout	44	305 (22.3)	90–695	30	1,206 (510.4)	263–2,225	86 (13.8)
Smallmouth Bass	24	139 (25.2)	77–466	--	--	--	--
Westslope Cutthroat Trout	34	277 (16.8)	174–624	15	312 (75.1)	45–2,170	89 (1.8)
Yellow Perch	287	163 (2.4)	68–295	25	--	--	--

Table 17. 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 h), sinking gill nets (CPUE = fish/h), and modified fyke nets (CPUE = fish/h) during 2016. Numbers in parentheses represent one standard error about the mean.

Species	Electrofishing	Floating gill net	Sinking gill net	Modified fyke net
Fernan Lake				
Black Crappie	0.12 (0.05)	0.02 (0.01)	0.22 (0.10)	0.16 (0.07)
Bluegill	1.13 (0.32)	0	0.31 (0.10)	1.80 (0.71)
Brown Bullhead	0	0	0.02 (0.01)	0.07 (0.06)
Channel Catfish	0.02 (0.02)	0.03 (0.2)	0.62 (0.09)	0.02 (0.02)
Green Sunfish	8.53 (2.1)	0.01 (0.01)	0.02 (0.02)	0.10 (0.04)
Largemouth Bass	1.43 (0.31)	<0.01 (<0.01)	0.20 (0.06)	0
Northern Pike	0	<0.01 (<0.01)	0.04 (0.02)	0
Pumpkinseed	0.03 (0.02)	0	0.01 (0.01)	0.03 (0.03)
Smallmouth Bass	0.44 (0.14)	0	0.04 (0.02)	0
Tench	0	0.12 (0.08)	0.30 (0.03)	0.41 (0.28)
Westslope Cutthroat Trout	0	0.03 (0.01)	0	0
Yellow Perch	0	0	0.35 (0.016)	0
Lower Twin Lake				
Black Crappie	0.03 (0.35)	0.18 (0.07)	0.37 (0.11)	0.24 (0.10)
Bluegill	0.97 (0.31)	0	0.02 (0.02)	0.41 (0.22)
Brook Trout	0	0.01 (0.01)	0	0.0 (0.0)
Brown Bullhead	0.02 (0.02)	0.08 (0.02)	0.26 (0.10)	0.37 (0.18)
Green Sunfish	0.06 (0.04)	0	0.01 (0.01)	0
Kokanee	0.02 (0.02)	0.08 (0.02)	0.16 (0.08)	0
Largemouth Bass	0.67 (0.18)	0	0.20 (0.08)	0
Northern Pike	0	0.02 (0.01)	0.02 (0.01)	0
Pumpkinseed	3.1 (0.71)	0.01 (0.01)	0.14 (0.04)	1.51 (0.36)
Tench	0.03 (0.03)	0.0 (0.0)	0.03 (0.02)	0.11 (0.05)
Westslope Cutthroat Trout	0	0.01 (0.01)	0.02 (0.01)	0
Yellow Perch	0.02 (0.02)	0	0.20 (0.07)	0.15 (0.06)
Spirit Lake				
Black Crappie	0.44 (0.13)	0.12 (0.04)	0.17 (0.06)	0.20 (0.13)
Bluegill	0.40 (0.10)	0.01 (0.01)	0.01 (0.01)	0.27 (0.13)

Table 17 (continued)

Species	Electrofishing	Floating gill net	Sinking gill net	Modified fyke net
Brook Trout	0	0.01 (0.01)	0.03 (0.01)	0.0 (0.0)
Brown Bullhead	0.32 (0.14)	0.23 (0.13)	0.34 (0.19)	0.13 (0.06)
Kokanee	0	0.05 (0.02)	0.11 (0.04)	0
Largemouth Bass	1.25 (0.22)	0.03 (0.02)	0.09 (0.04)	0.0 (0.0)
Mountain Whitefish	0	0.05 (0.02)	0.11 (0.06)	0.0 (0.0)
Pumpkinseed	3.11 (0.38)	0.13 (0.02)	0.23 (0.08)	1.50 (0.85)
Rainbow Trout	0.06 (0.02)	0.07 (0.03)	0.06 (0.02)	0.0 (0.0)
Smallmouth Bass	0.11 (0.03)	0.0 (0.0)	0.01 (0.01)	0.0 (0.0)
Westslope Cutthroat Trout	0.02 (0.01)	0.07 (0.02)	0.06 (0.02)	0.0 (0.0)
Yellow Perch	0.70 (0.20)	0.44 (0.18)	0.14 (0.07)	0.0 (0.0)

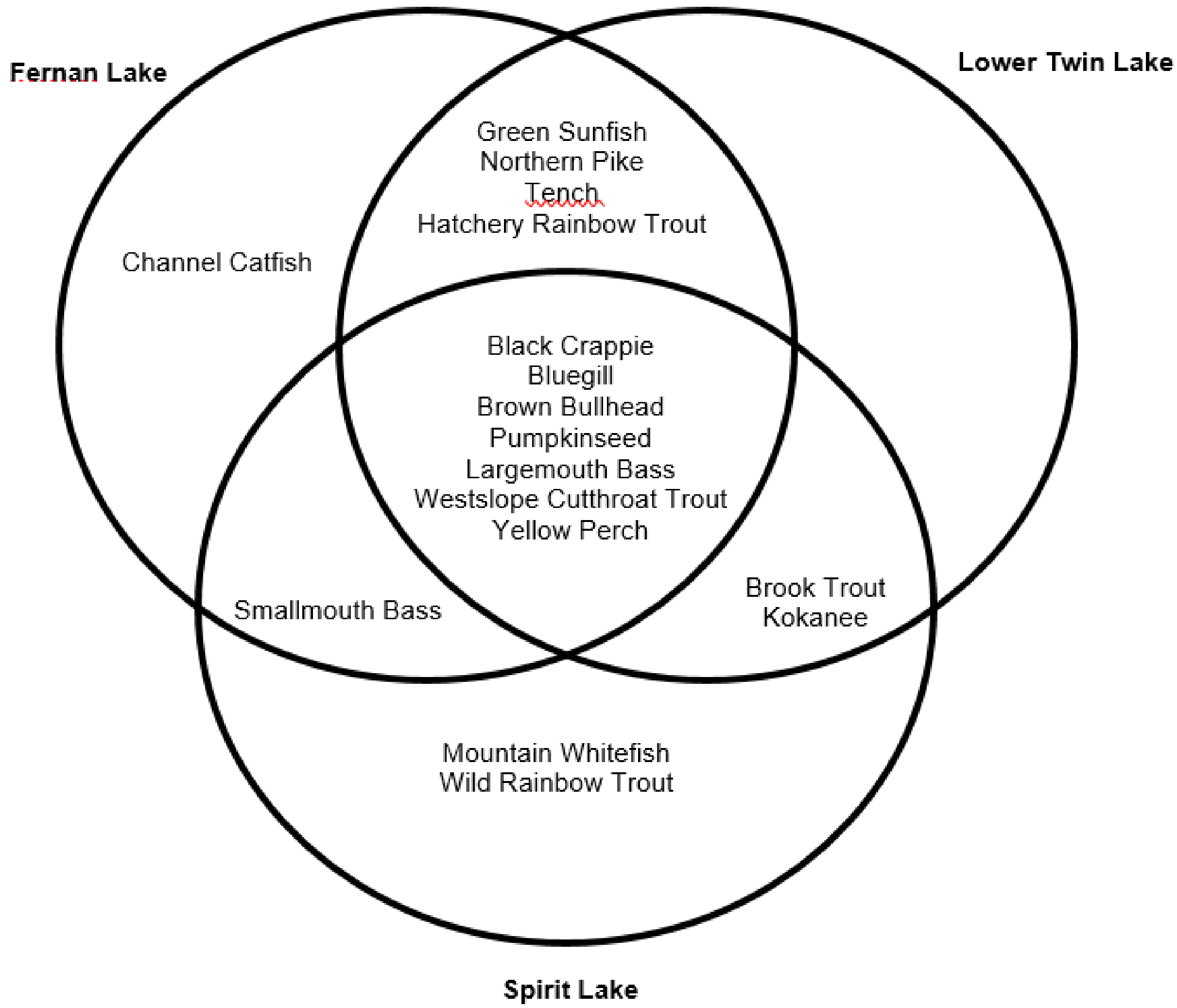

Figure 25. Venn diagram depicting the co-occurrence and species similarity among lowland lakes sampled in the Panhandle Region (2016).

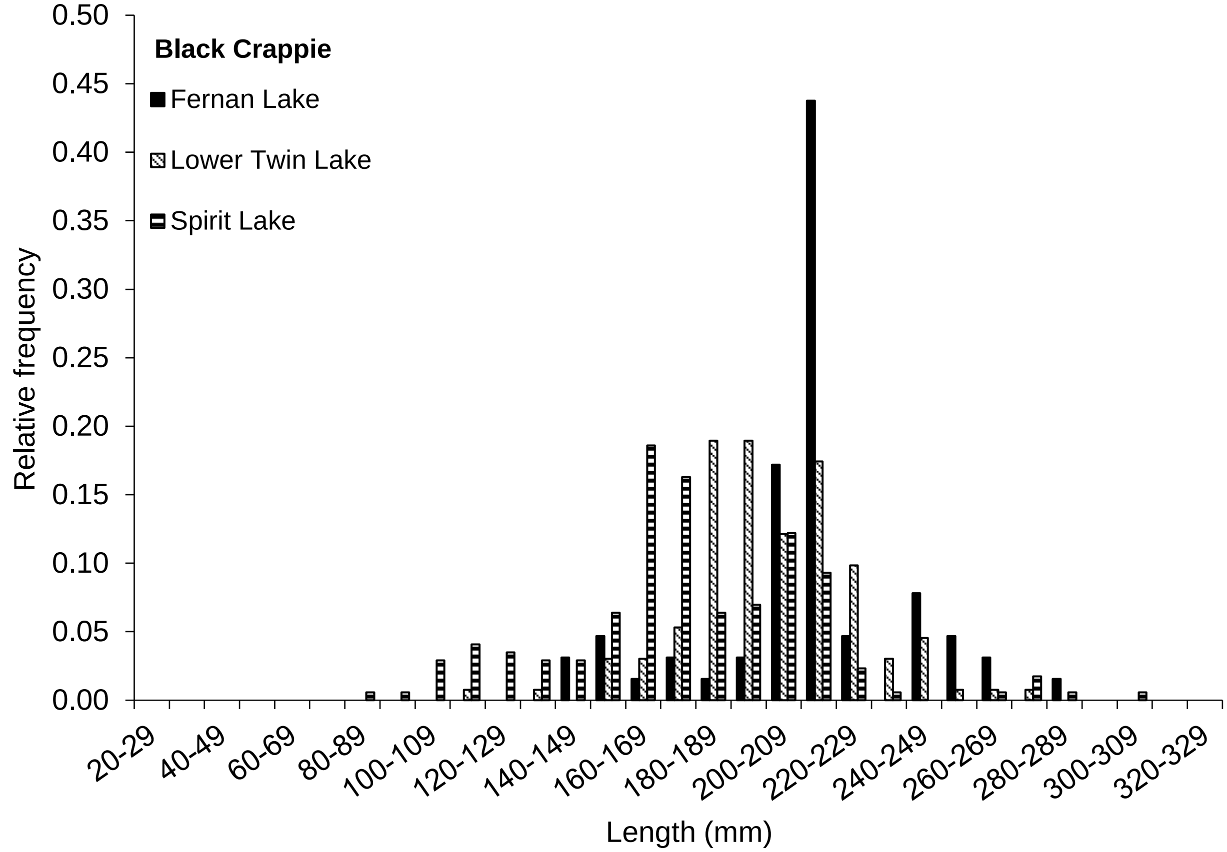

Figure 26. Length-frequency distributions for Black Crappie sampled from Fernan, Lower Twin, and Spirit lakes (2016).

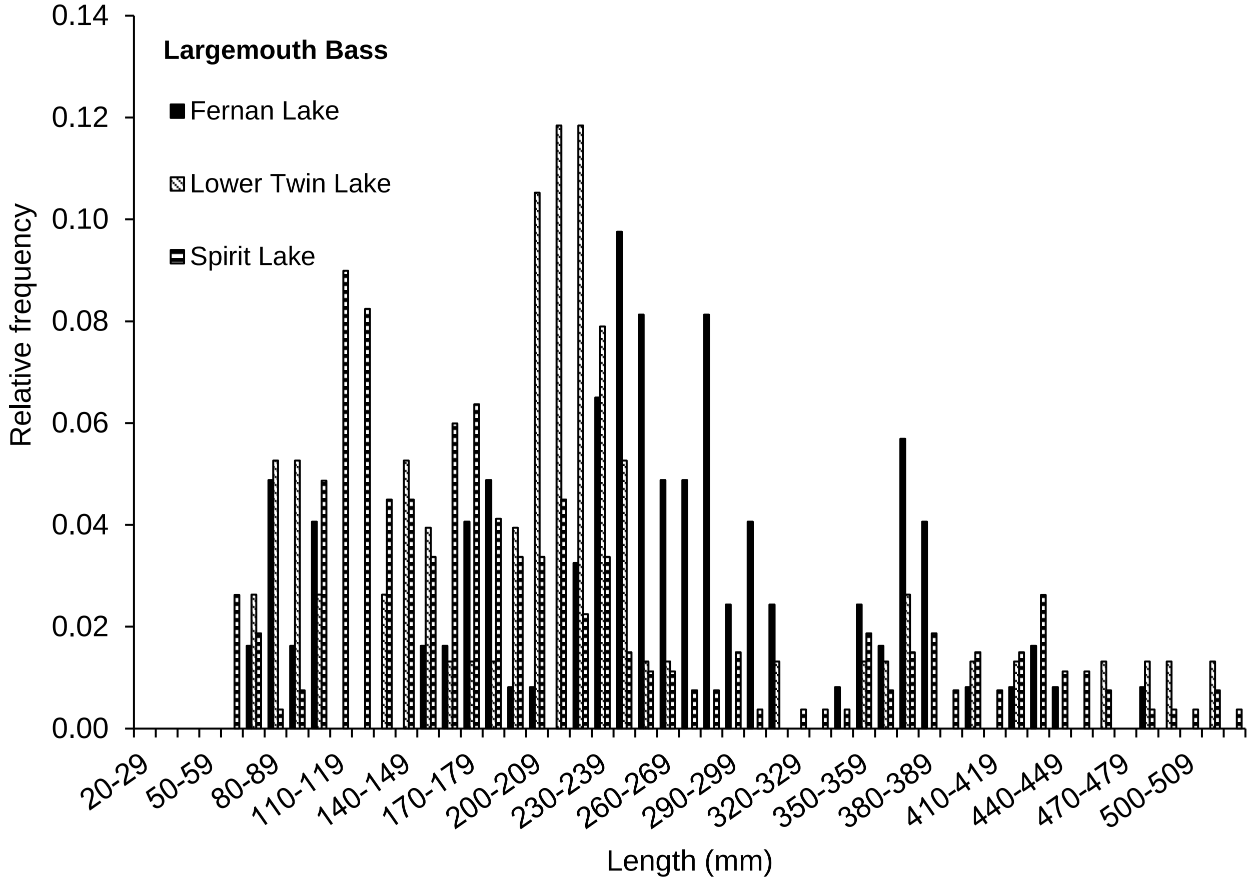

Figure 27. Length-frequency distributions for Largemouth Bass sampled from Fernan, Lower Twin, and Spirit lakes (2016).

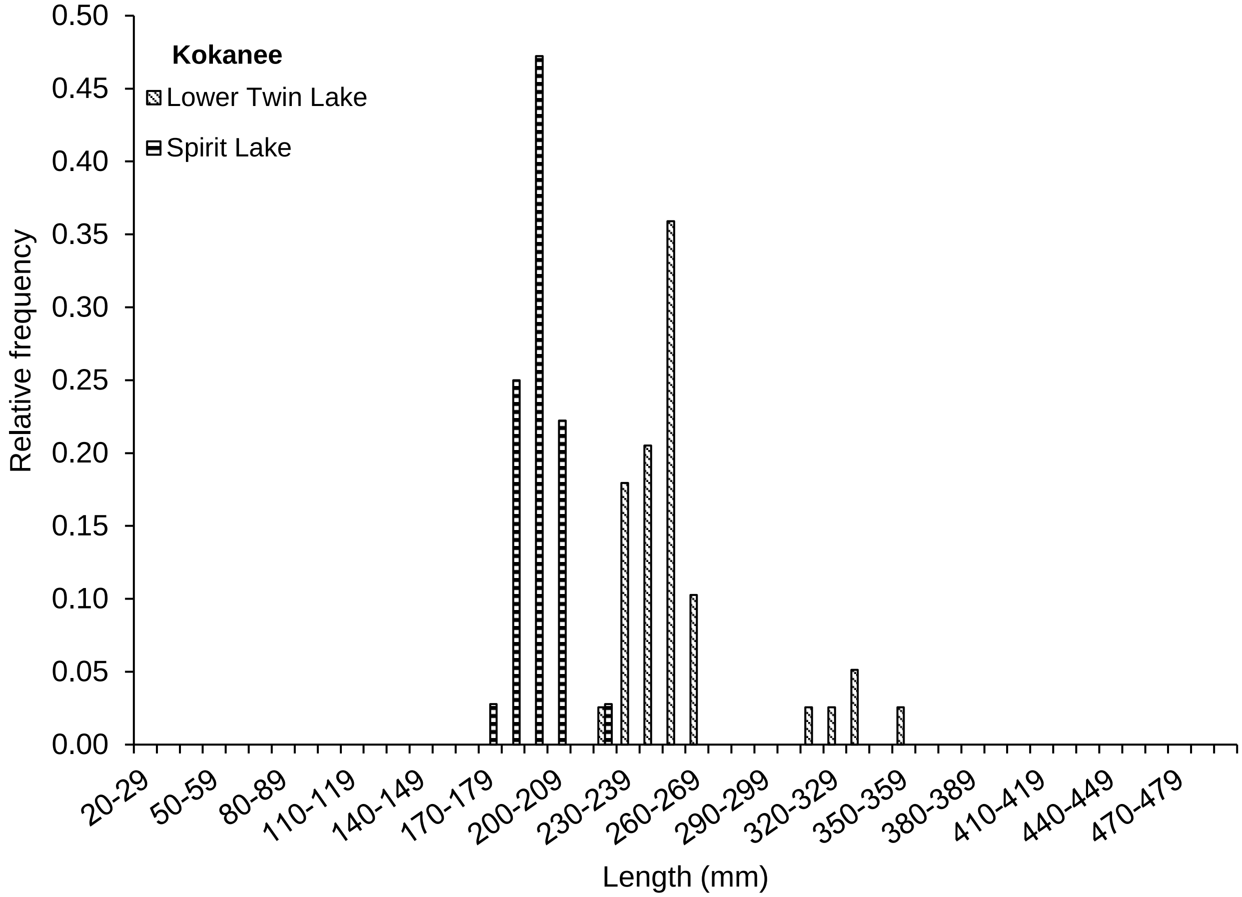

Figure 28. Length-frequency distributions for kokanee sampled from Lower Twin and Spirit lakes (2016).

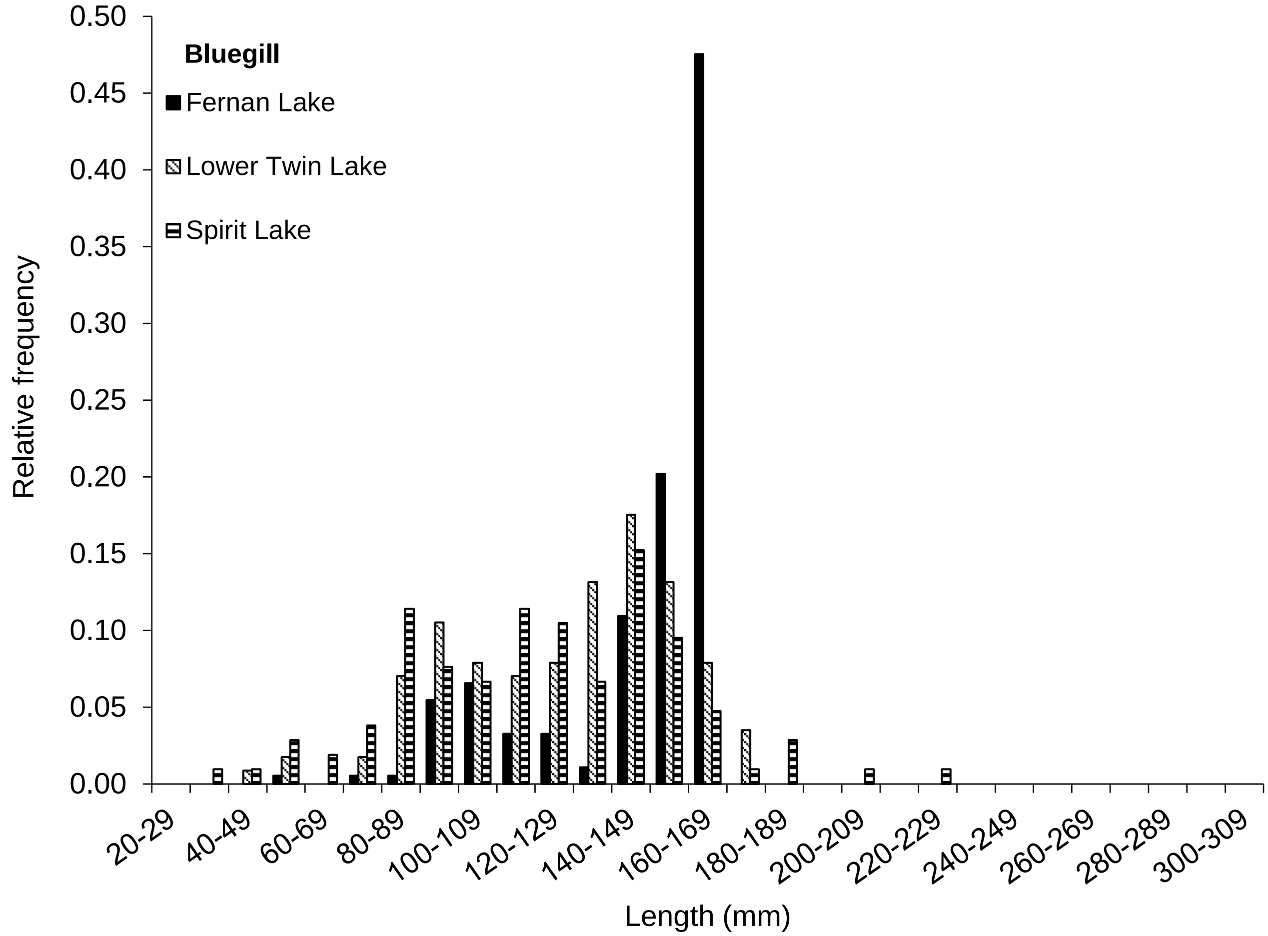

Figure 29. Length-frequency distributions for Bluegill sampled from Fernan, Lower Twin, and Spirit lakes (2016).

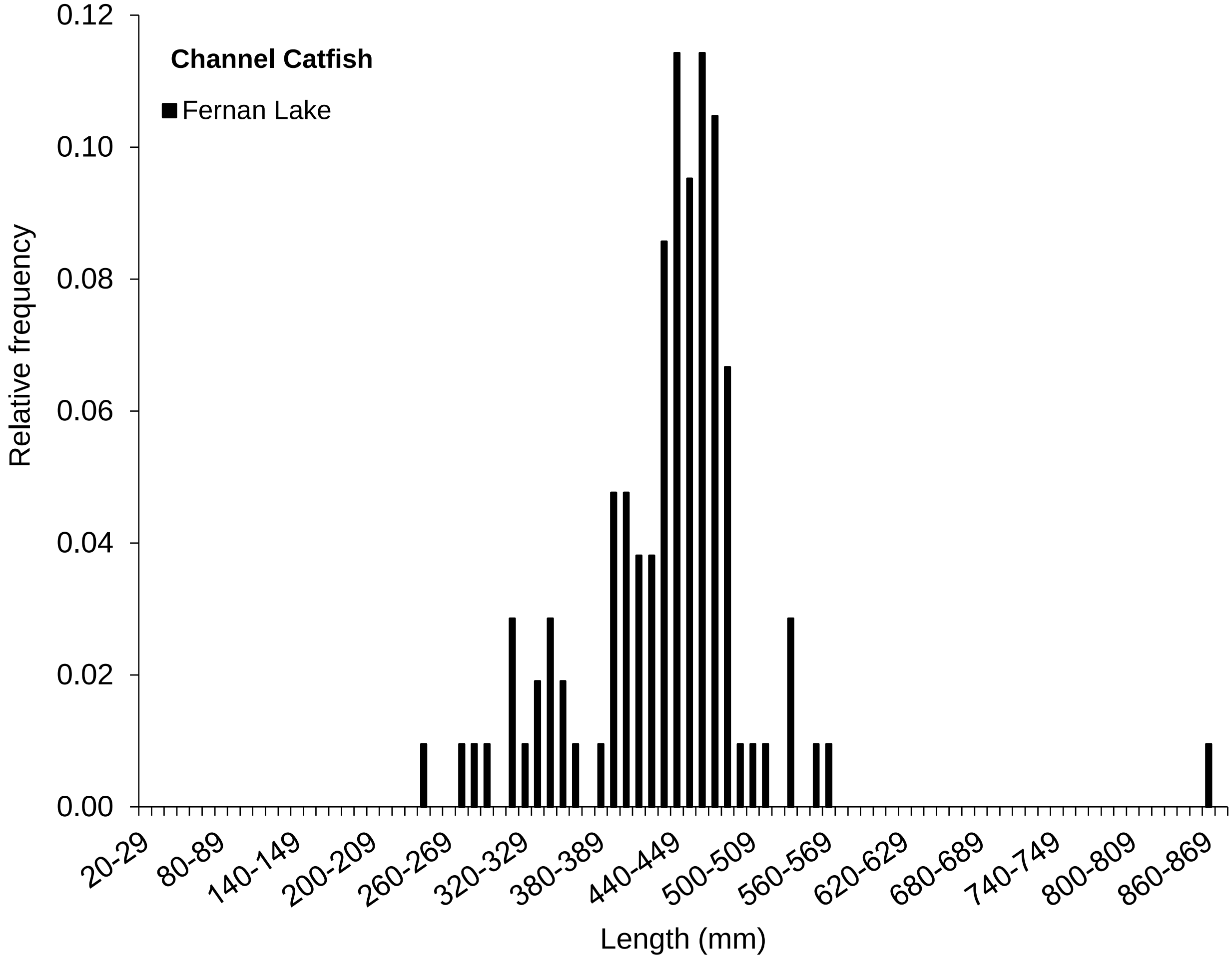

Figure 30. Length-frequency distribution for Channel Catfish sampled from Fernan Lake (2016).

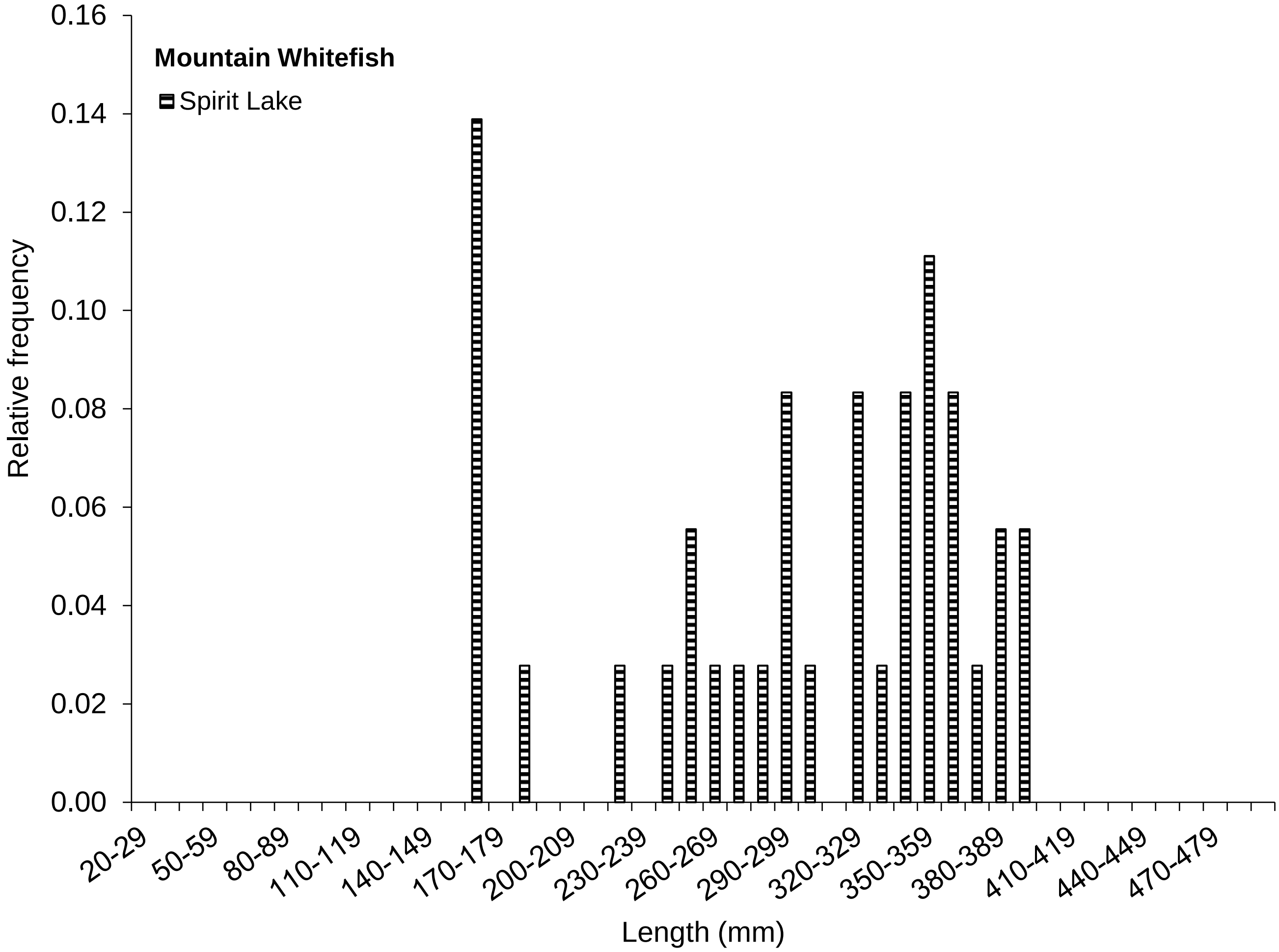

Figure 31. Length-frequency distribution for Mountain Whitefish sampled from Spirit Lake (2016).

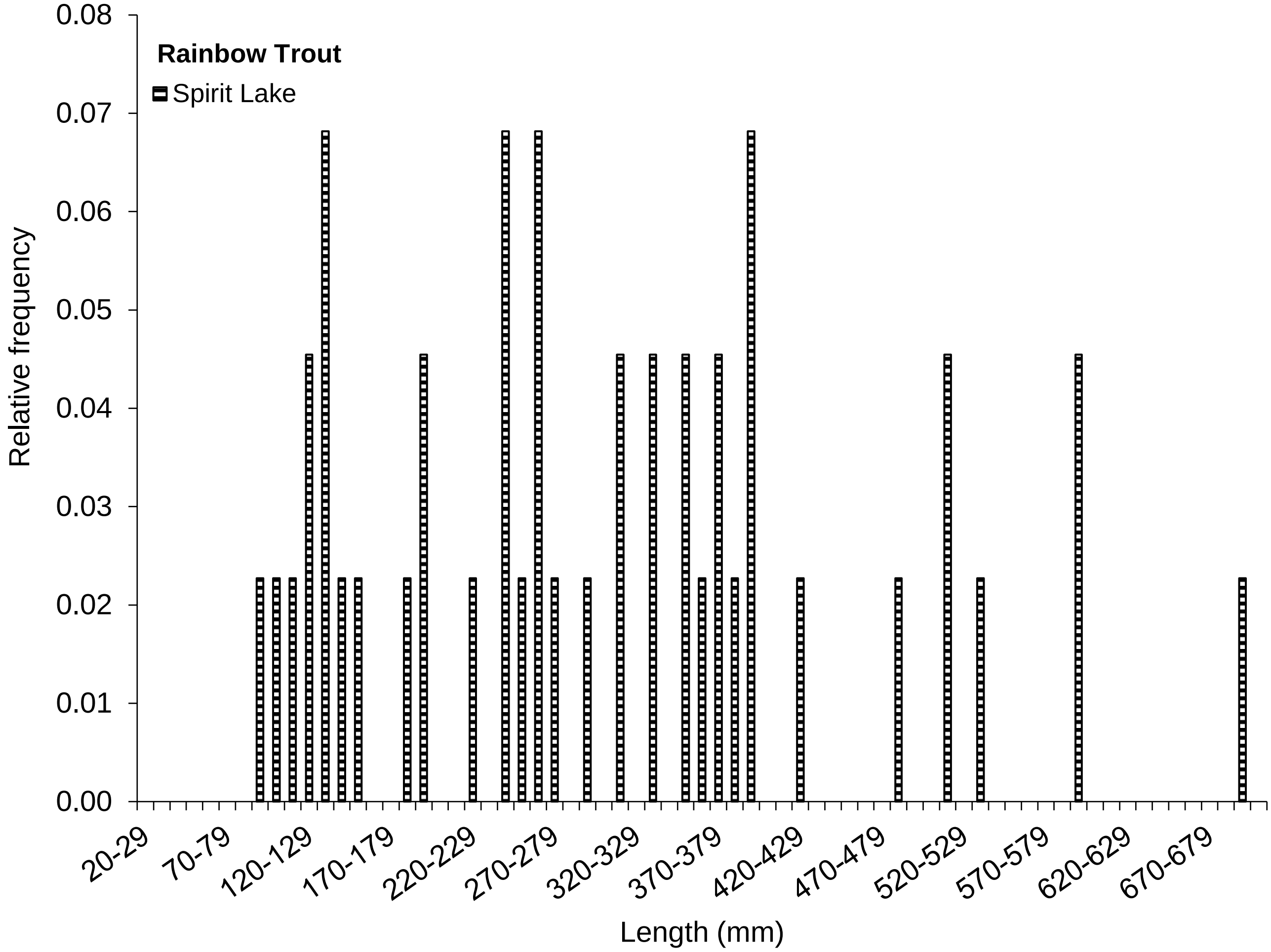

Figure 32. Length-frequency distribution for Rainbow Trout sampled from Spirit Lake (2016).

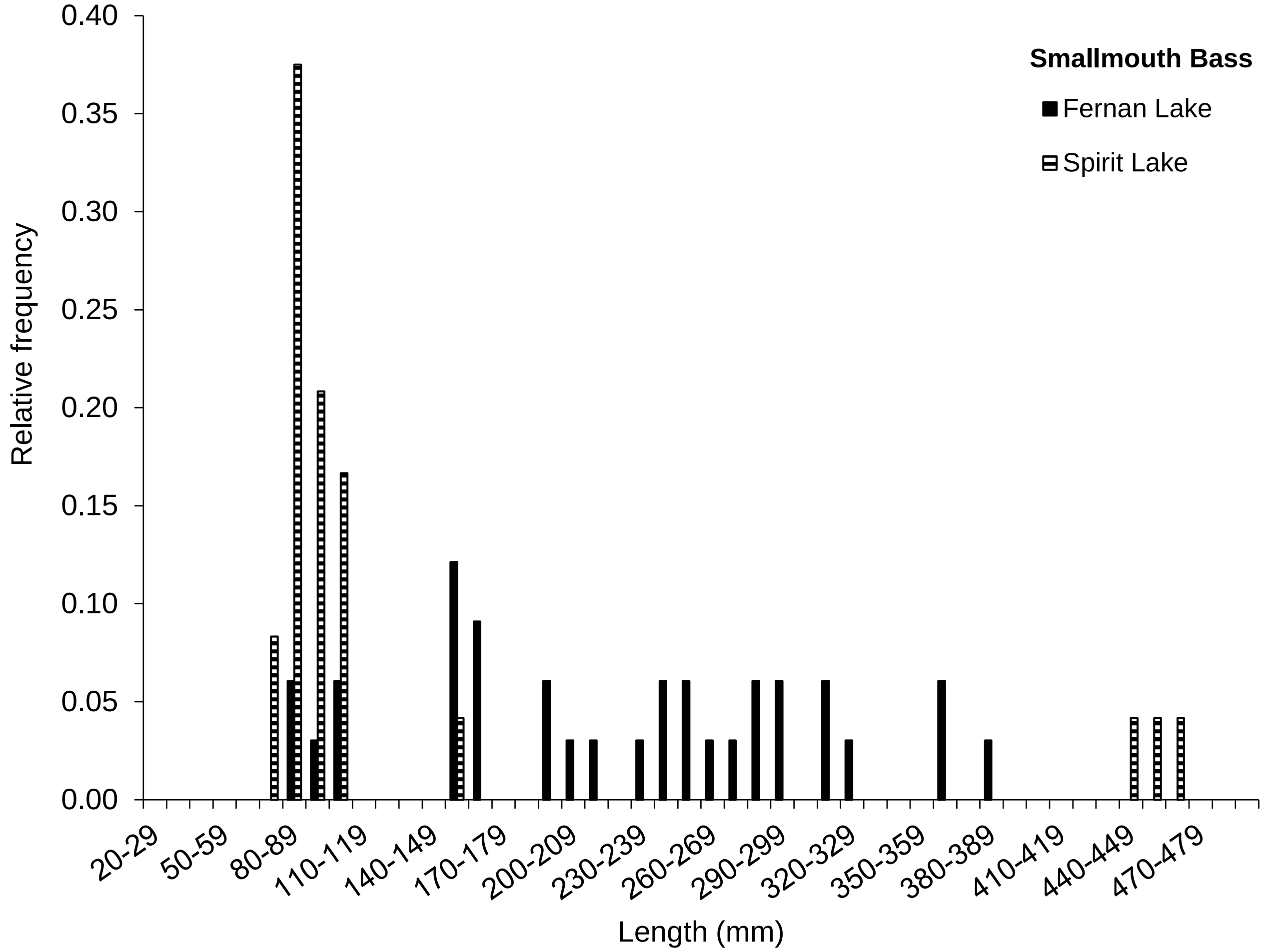

Figure 33. Length-frequency distributions for Smallmouth Bass sampled from Fernan and Spirit lakes (2016).

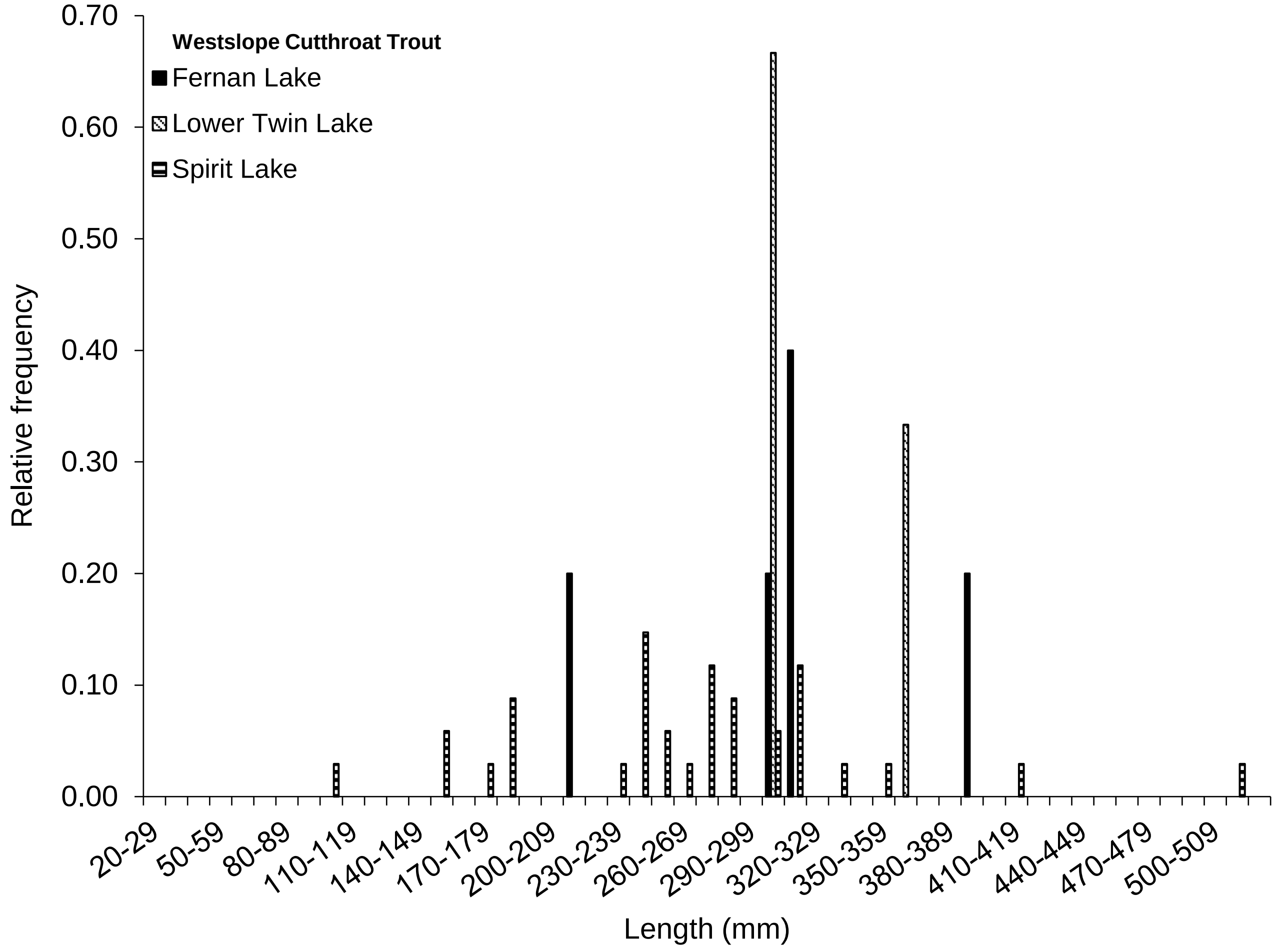

Figure 34. Length-frequency distributions for Westslope Cutthroat Trout sampled from Fernan, Lower Twin, and Spirit lakes (2016).

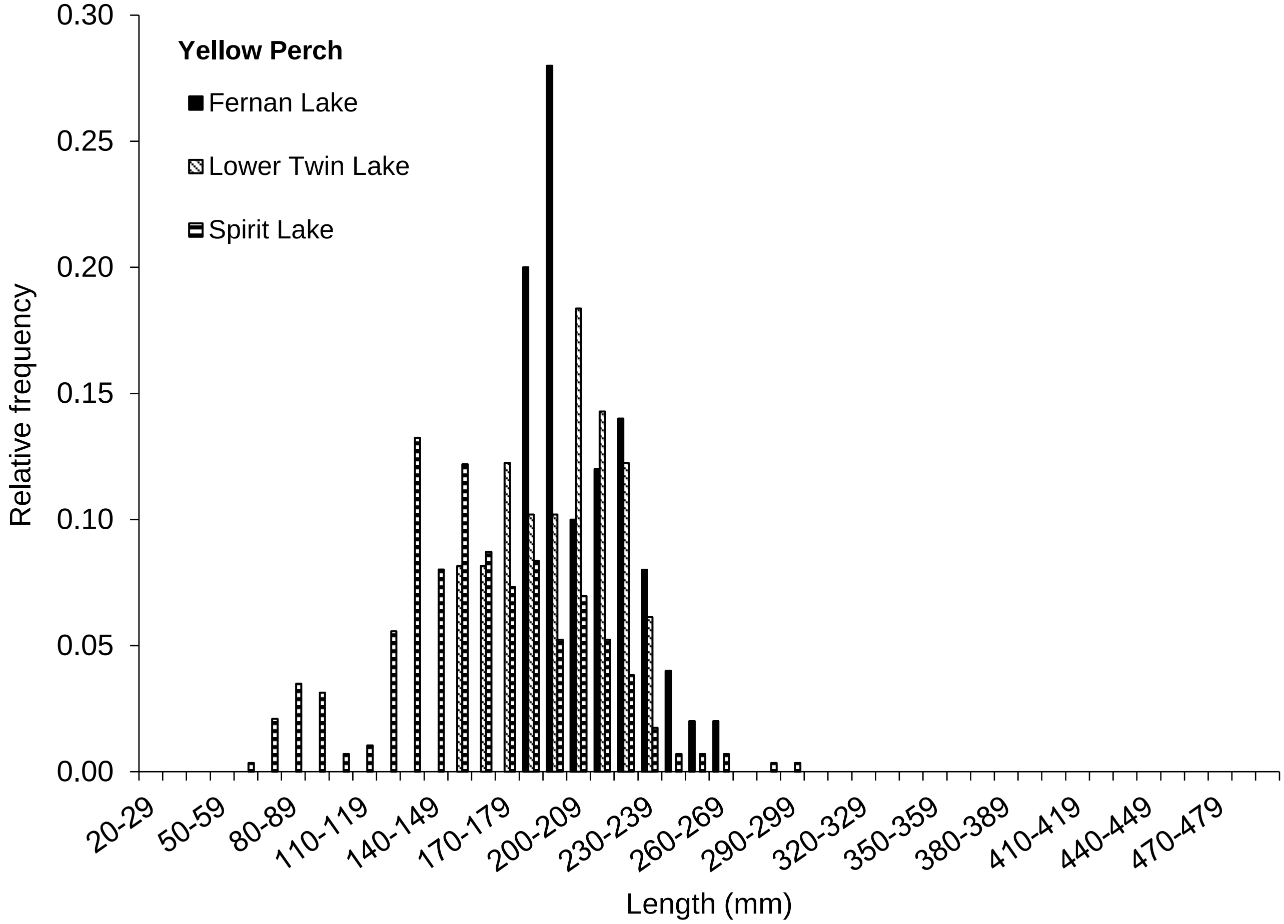

Figure 35. Length-frequency distributions for Yellow Perch sampled from Fernan, Lower Twin, and Spirit lakes (2016).

HAYDEN AND PRIEST LAKES MYSID SHRIMP SURVEYS

ABSTRACT

We sampled Priest and Hayden lakes on June 6 and 7, 2016 to estimate lake-wide mysid *Mysis diluviana* densities. Mean densities of immature and adult mysids in Hayden and Priest lakes were 73 mysids/m^2 and 43 mysids/m^2, respectively. Densities estimates represented stable population trends for both waters.

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INTRODUCTION

Mysid shrimp *Mysis diluviana* have been stocked around the globe in attempts to increase the forage base for sportfish. For that reason, mysids were introduced into Hayden Lake in 1974. Mysids were also introduced into Priest Lake and Lake Pend Oreille from 1965 to 1968 with the objective of benefiting kokanee *Oncorhynchus nerka*.

In Hayden Lake, no adverse effects from mysids have been described. Black Crappie *Pomoxis nigromaculatus*, Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*, and Rainbow Trout *Oncorhynchus mykiss* are all known to consume mysids at some level. Mysids are generally considered to be a benefit to the fishery, though the impacts on fish growth have not been definitively assessed.

In Priest Lake, mysids were credited with increasing kokanee growth (Irizarry 1974), but were ultimately the major factor in the subsequent collapse of the fishery. The kokanee fishery collapsed by 1976 as a result of predation from increasing Lake Trout *Salvelinus namaycush* abundance, which occurred because mysids increased juvenile Lake Trout survival. The resulting Lake Trout fishery in Priest Lake largely replaced fisheries for kokanee and Westslope Cutthroat Trout (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 2010 (Wahl et al. 2015). The collapse of mysids in Lake Pend Oreille prompted an investigation of the densities of mysids in other northern Idaho lakes. Observed declines in abundance could have major effects on the food web and the resulting sport fisheries. This chapter includes results from our investigations on mysid densities in Hayden and Priest lakes in 2016.

METHODS

We sampled mysid shrimp to estimate density in Priest and Hayden lakes on June 6 and 7, 2016, 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 to the surface. If, in the field, a selected site was not actually 46 m deep we looked for the desired depth range in close proximity to the site or made a tow from the maximum depth available if no deeper zone was present. A 1-m hoop net with 1,000 micron mesh net and a 500 micron bucket was used for all tows. Area of the net's 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 nets mouth. We reported arithmetic mean density and 80% confidence intervals around each estimate.

RESULTS

Density of immature and adult mysids in Hayden Lake varried between sampled locations and ranged from 25 to 175 mysids/m^2 (Table 1), with a mean of 73 ± 15 mysids/m^2 (Figure 1). Mean density of immature and adult mysids from Priest Lake was estimated at 43 ± 21 mysids/m^2 (Figure 1) and ranged from 1 to 219 mysids/m^2 (Table 2). Mean densities generally represented continuation of a stable population trend for mysids in both waters (Figure 1).

DISCUSSION

Our surveys continued to build upon relatively new efforts to describe regional trends in mysid abundance (Ryan et al 2014, Watkin et al. 2018, Ryan et al. 2018). Although available data on mysids was limited, our data suggests densities in both Hayden and Priest lakes were low relative to other regional waters (i.e., Lake Pend Oreille; Wahl et al. 2016). We recommend continued monitoring of mysid abundance in Hayden and Priest lakes to establish a longer time series that eventually should help to understand whether recently observed densities represent a population decline similar to that observed in Lake Pend Oreille. We also recommend periodic monitoring of fish communities in these waters to better understand of the impact mysid densities have on regional fisheries.

MANAGEMENT RECOMMENDATIONS

1. Continue monitoring mysids in regional lakes
2. Complete periodic monitoring of fish communities in waters with mysids to better understand the impact of mysid densities on regional fisheries

Table 18. Mysid density estimates from Hayden Lake on June 7, 2016. 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 19. Mysid density estimates from Priest Lake on June 6, 2016. 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	20	16	35
2	509162	5392132	31	44	75
3	510996	5390163	81	37	117
4	510469	5387060	65	27	92
5	509056	5384168	168	21	188
6	510983	5381069	51	69	120
7	506795	5379120	83	11	93
8	509038	5377626	105	22	127
9	511004	5378149	44	219	263
10	510983	5373105	46	10	56
11	508934	5372141	48	22	70
12	511896	5382095	17	0	17

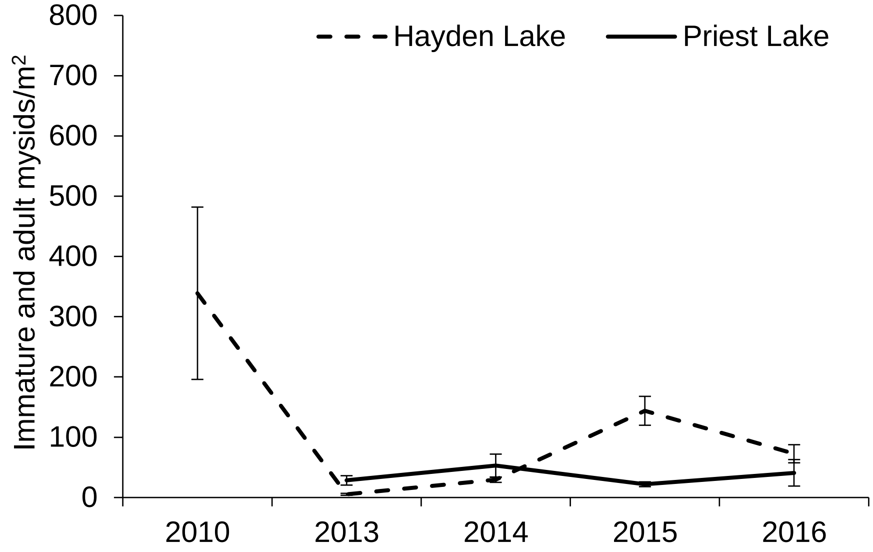

Figure 36. Estimated mean densities of immature and adult mysids of from Hayden and Priest lakes from 2010 through 2016. Error bars represent 80% confidence intervals.

LAKE COEUR D'ALENE AND SPIRIT LAKE KOKANEE EVALUATIONS

ABSTRACT

We estimated age-specific abundance, density, and population characteristics of kokanee *Oncorhynchus nerka* in Lake Coeur d'Alene and Spirit Lake to monitor population trends. A modified midwater trawl was used to sample kokanee during July 31 to August 2, 2016. We estimated a total abundance of 2,967,710 and 378,428 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 2016, but the relatively low abundance of age-0 fish which suggested poor strength of the 2016 year-class. Overall, estimated abundance decreased by around 6.4 million fish from 2015, largely due to the relatively low abundance of age-0 and -1 fish. Mean total length of adult kokanee in Lake Coeur d'Alene was 254 mm, which meets the longstanding management objective. We documented a considerable decline in 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 = 207 mm) indicating improved growth. Recruitment has been relatively low, suggesting that the trends in growth, and subsequently size structure, will continue to improve. However, we found that the 2016 year-class was relatively weak, a pattern consistent with Lake Coeur d'Alene. Overall, brood years 2014–2016 have produced weak year-classes relative to the preceding 10 years. We recommend continued monitoring of the Lake Coeur d'Alene kokanee population 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 other sportfish. 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 the 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 1992).

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

During 2016, kokanee were sampled from Spirit Lake and Lake Coeur d'Alene on July 31 and August 1–2, 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 m × 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 five 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. 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.

Kokanee spawner length and age structure was estimated to evaluate growth objectives. Spawning adults were sampled on December 6, 2016 using a sinking experimental gill net (46.0 m × 1.8 m with panels of 50, 64, 76, 88, and 100-mm stretch-measure mesh). The net was set for ~20 minutes near Higgens Point in Wolf Lodge Bay. 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.

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 summarized 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

We sampled a total of 592 kokanee by trawling in Lake Coeur d'Alene during August 1–2, 2016. We estimated a total abundance of 2,967,710 kokanee and density of 270 kokanee/ha. Age-specific abundance was estimated in order to make prior year comparisons and to provide insight on recruitment of adults to the fishery. We estimated abundances of approximately 690,000 age-0, 730,000 age-1, 2.4 million age-2, and 1,306,550 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 27–248 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).

Spawning kokanee varied in length from 225–284 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 256 mm (SD = 8.7) and 241 mm (SD = 8.2) for male and female kokanee, respectively. Overall mean TL was 255 mm (SD = 9.7). Mean TL of kokanee spawners in 2016 was slightly higher than in 2015, and males met the adult length objective (Figure 7).

Spirit Lake

We sampled a total of 211 kokanee by trawling in Spirit Lake on July 31, 2016. We estimated a total abundance of 378,428 kokanee. We estimated abundances of 11,940 age-0, 28,332 age-1, 307,544 age-2, and 30,612 age-3 kokanee based on trawling (Table 2). We estimated a total density of around 649 kokanee/ha and a density of 53 age-3 kokanee/ha (Table 2). Relatively few 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.

Kokanee sampled during trawling varied in length from 44–219 mm TL (Figure 8; mean = 185 [SD = 27.1]) 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 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 2016. In the past, the population has been negatively affected by adverse environmental conditions, namely spring

flooding (Maiolie and Fredericks 2013); however, stable conditions in recent history have improved the population. Abundance of young-of-year kokanee, as indexed by trawling, appears to be lower than normal and about four-fold below the 10-year mean. 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 several relatively weak year-classes will actually benefit the fishery by improving growth, and as a result, length-at-age of adults.

We documented adult spawner size that fell within the desired range and was near the most recent 20 year average (Figure 9). Our mean length estimate in 2016 (TL = 254 mm) was only slightly above the minimum bound of the desired range, but we believe that the majority of adult kokanee in the population are still reasonably desirable 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, however, 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 2016, overall kokanee abundance has declined substantially compared to our most recent surveys. This pattern has likely been influenced by relatively poor recruitment and apparently high mortality of adults from age-2 to age-3 during 2015–2016. 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 207 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 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.

MANAGEMENT RECOMMENDATIONS

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

Table 20. Estimated abundance of kokanee made by midwater trawl in Lake Coeur d'Alene, Idaho, from 1979–2016.

	Age class				
Year	Age-0	Age-1	Age-2	Age-3/4	Total
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 21. Estimated abundance of kokanee made by midwater trawl in Spirit Lake, Idaho, from 1981–2016.

Year	Age class				Total	Age-3/ha
	Age-0	Age-1	Age-2	Age-3		
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

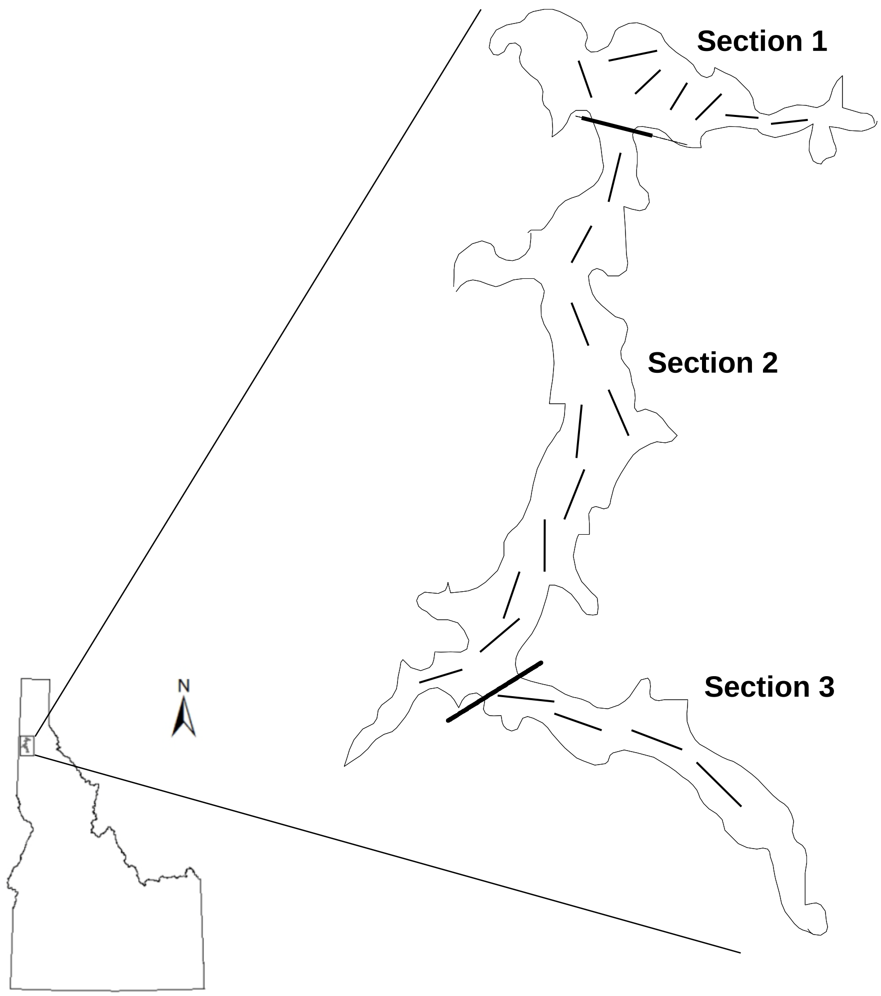

Figure 37. Approximate location of historical trawling transects used to estimate abundance of kokanee in Lake Coeur d'Alene, Idaho.

Figure 38. Approximate location of historical trawling transects used to estimate abundance of kokanee in Spirit Lake, Idaho.

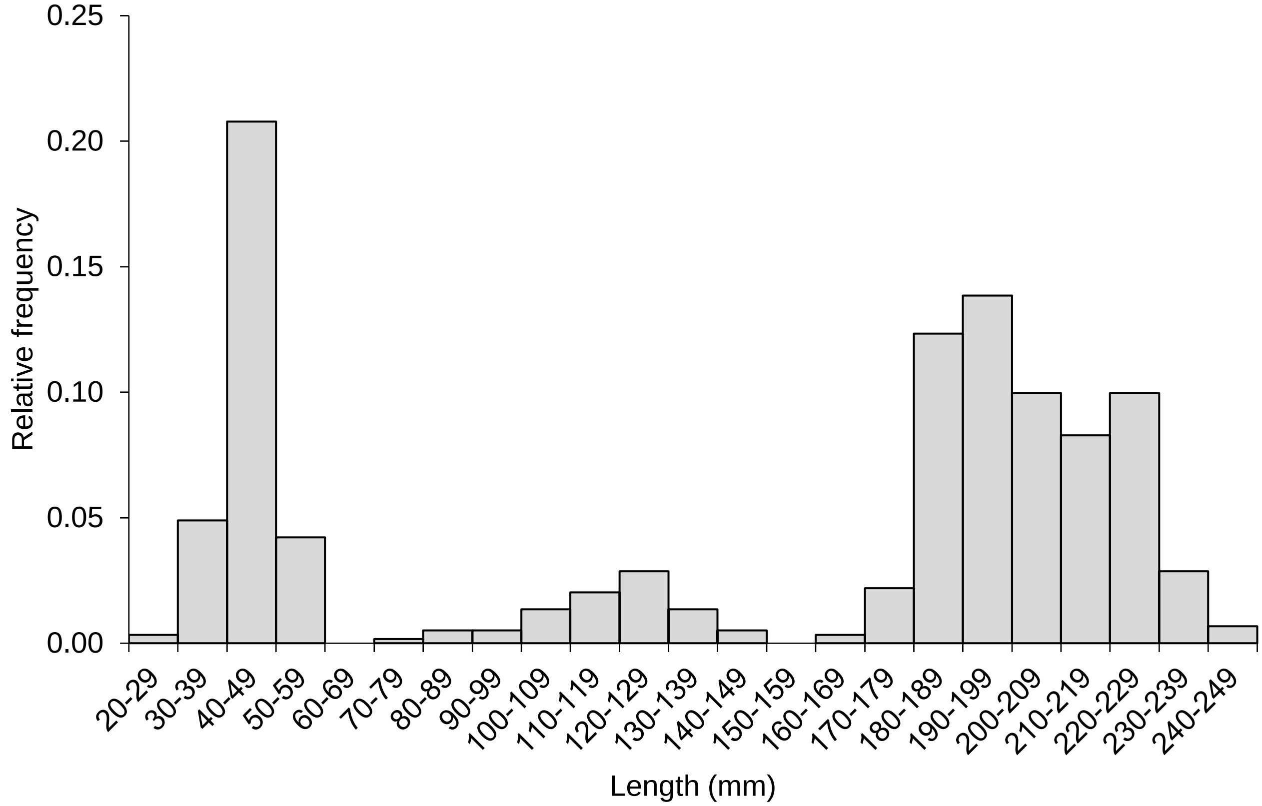

Figure 39. Length-frequency distribution for kokanee sampled using a modified-midwater *n* = 592 trawl from Lake Coeur d'Alene, Idaho (August 1–2, 2016).

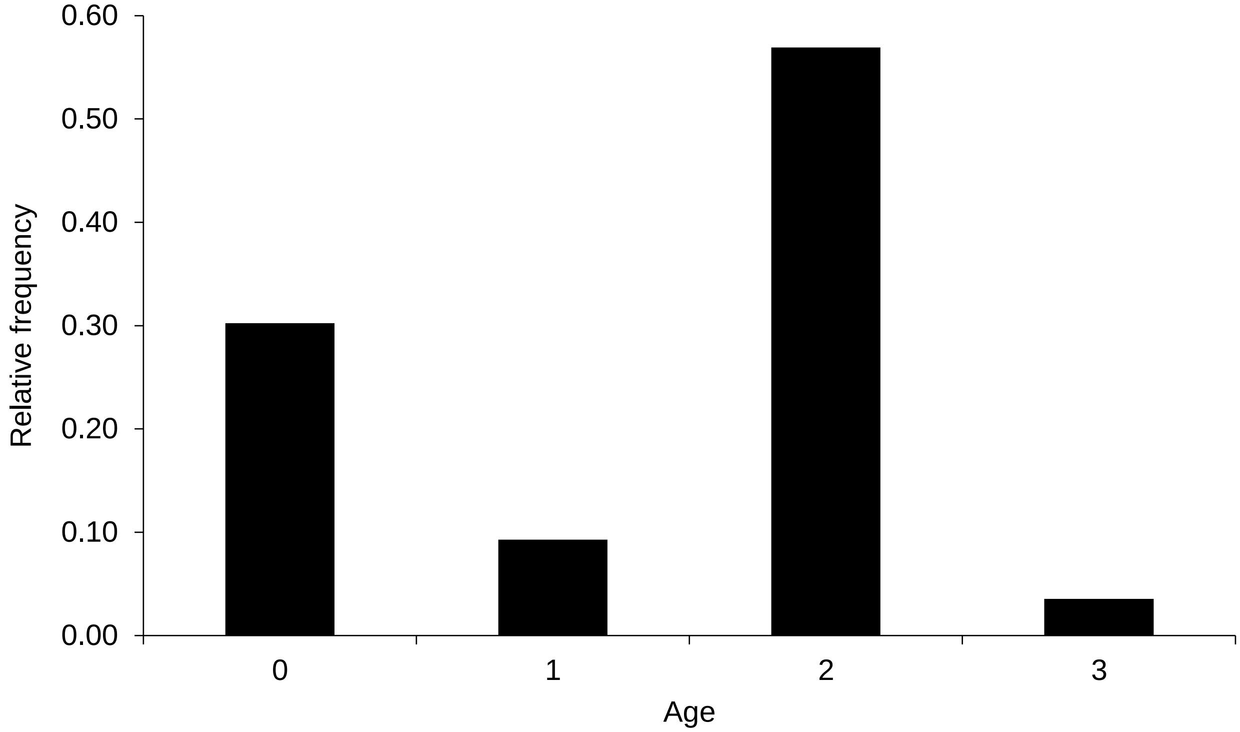

Figure 40. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (August 1–2, 2016).

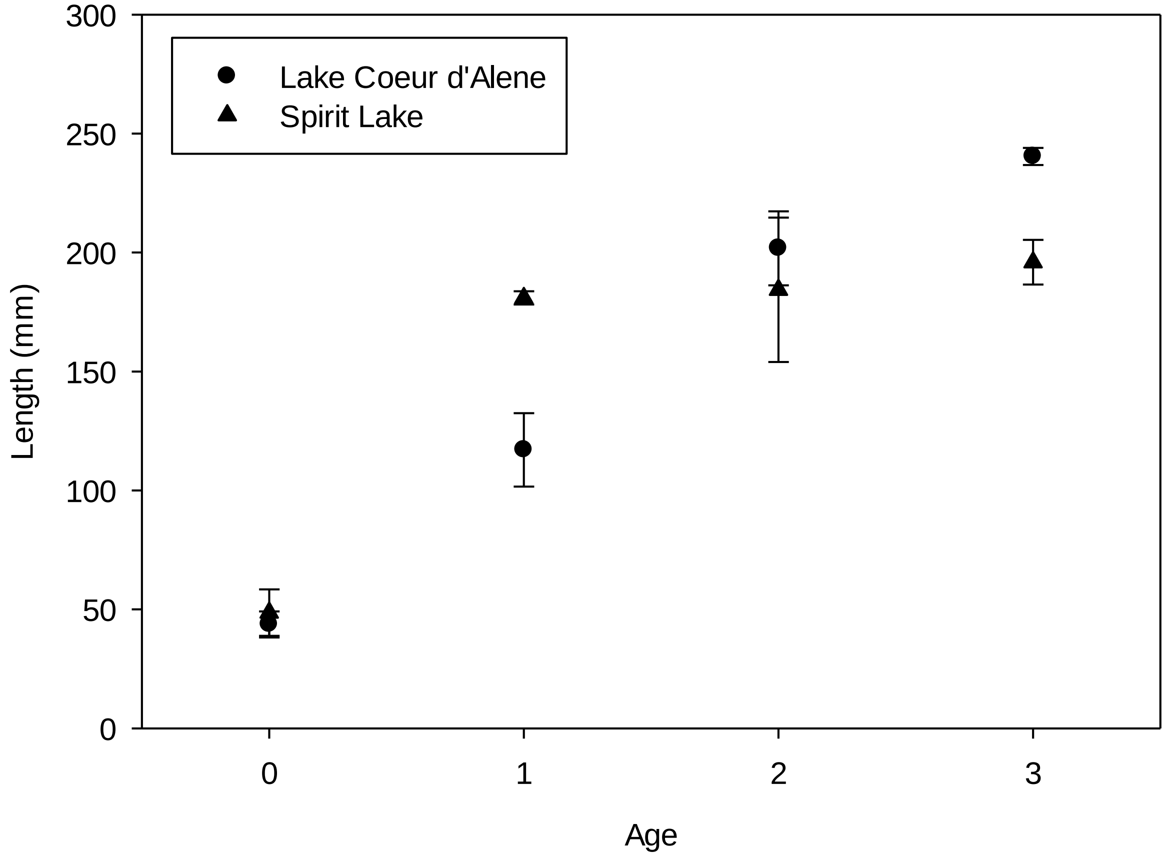

Figure 41. Mean length-at-age of kokanee sampled from Lake Coeur d’Alene and Spirit Lake, Idaho (2016).

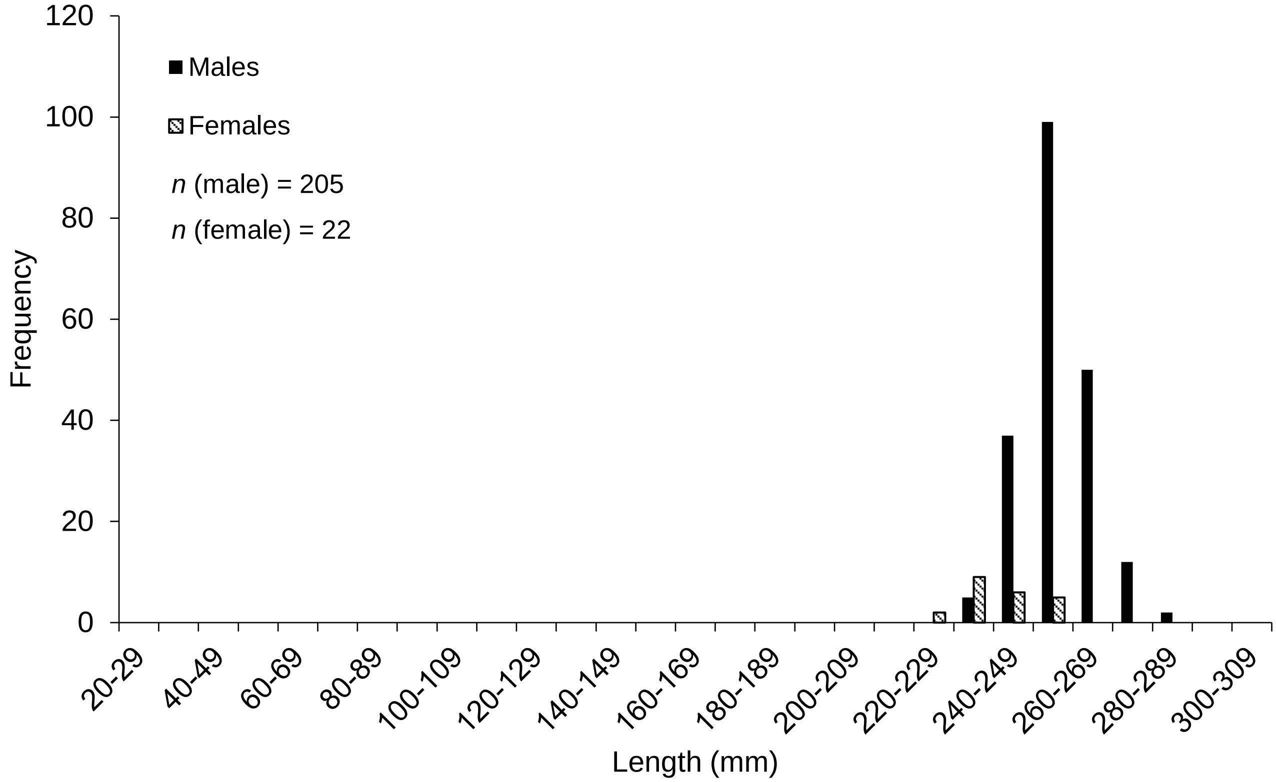

Figure 42. Length-frequency distribution for male and female kokanee sampled from Lake Coeur d'Alene, Idaho (December 6, 2016).

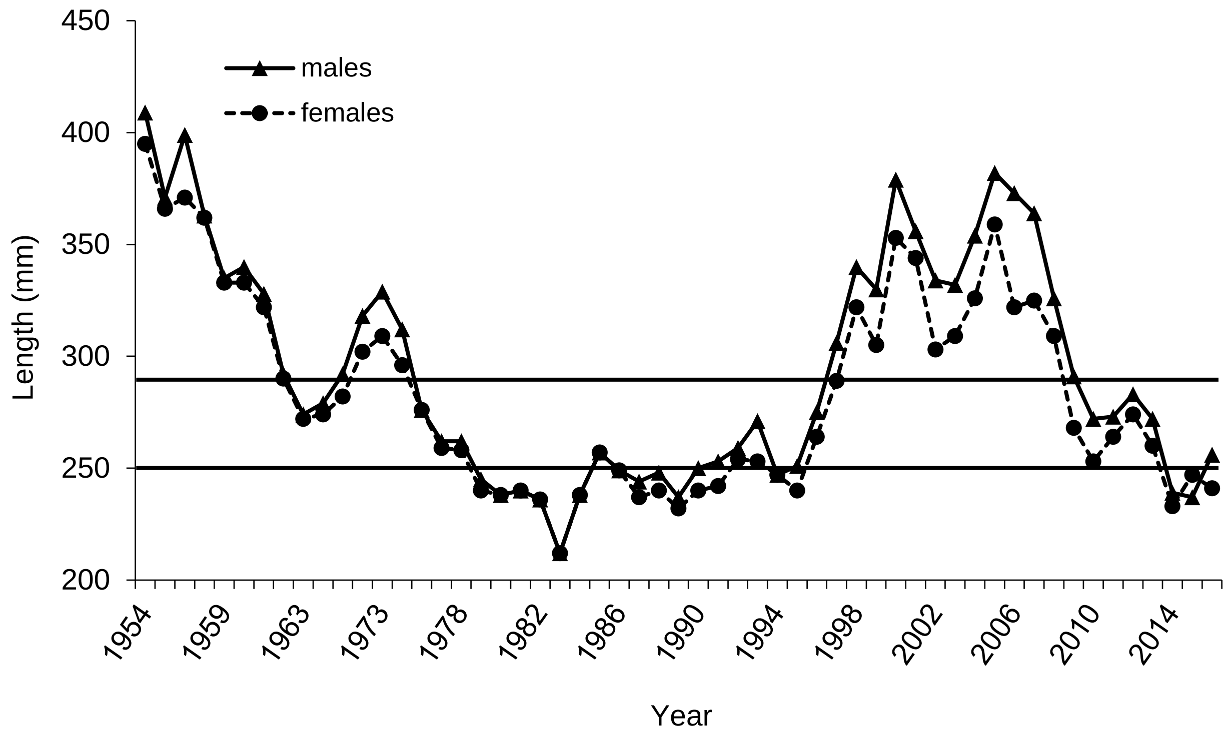

Figure 43. Mean total length of mature male and female kokanee sampled near Higgens Point in Lake Coeur d'Alene, Idaho (1954–2016). Horizontal lines indicate the upper and lower limit of the adult length management objective (250–280 mm).

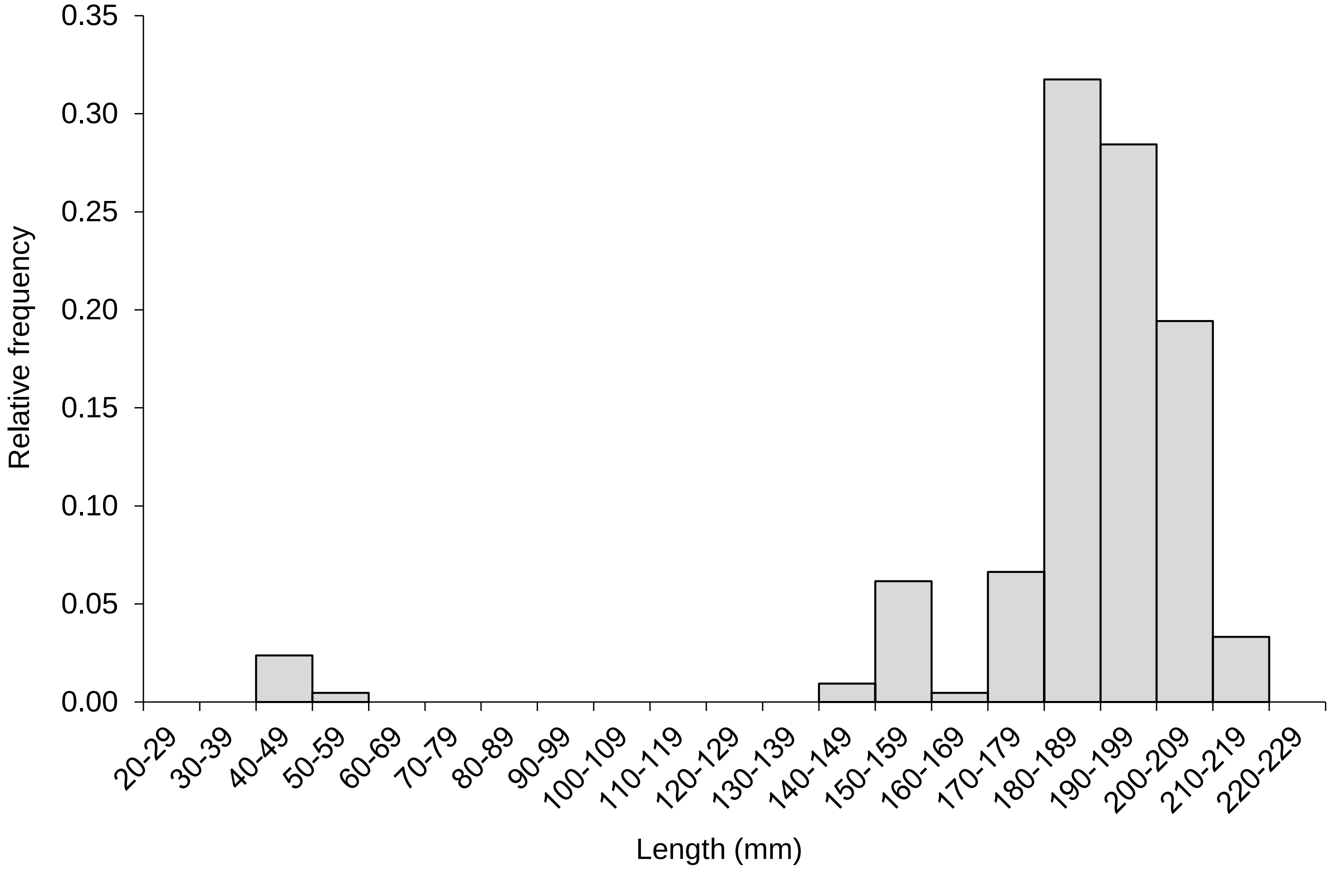

Figure 44. Length-frequency distribution for kokanee sampled using a modified-midwater *n* = 211 trawl from Spirit Lake, Idaho (July 31, 2016).

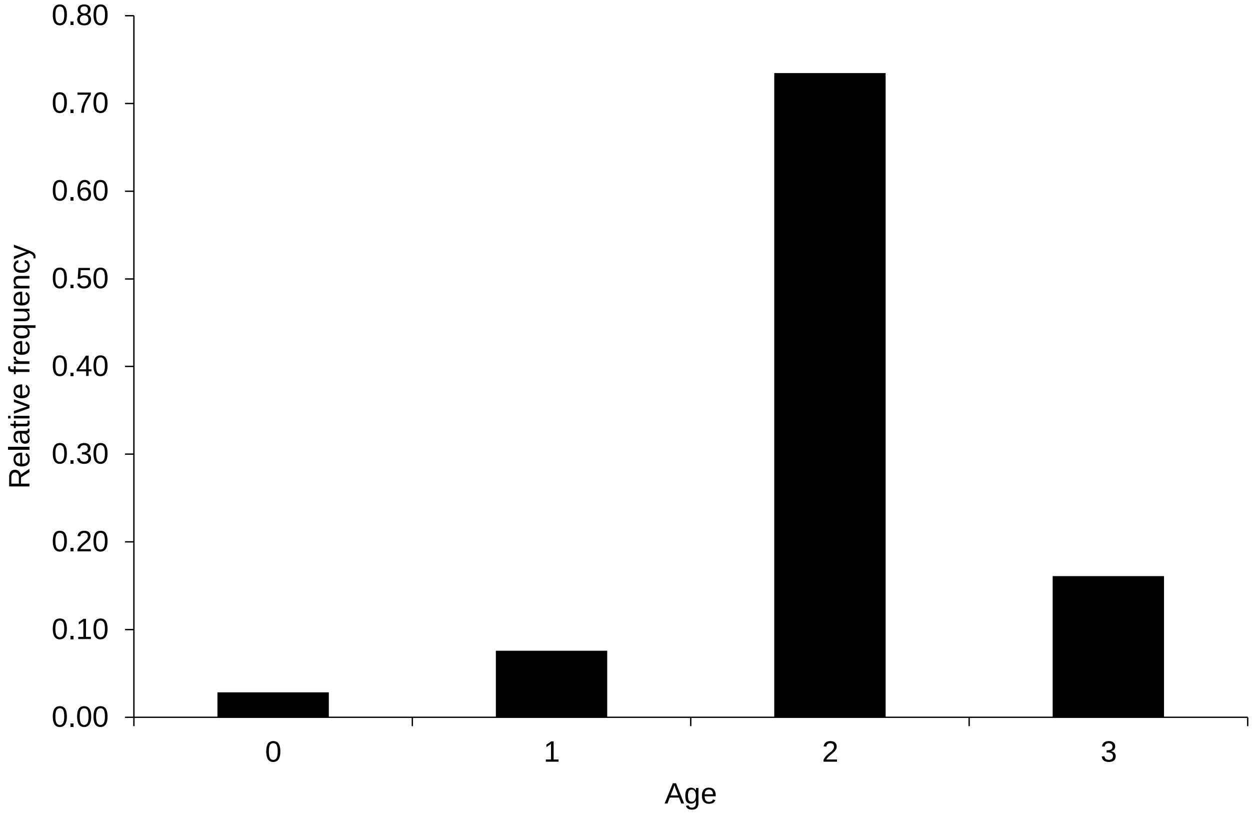

Figure 45. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (July 31, 2016).

HATCHERY TROUT STOCKING EVALUATIONS

ABSTRACT

In 2016, we continued evaluating hatchery trout stocking in Panhandle Region waters. Evaluations included estimation of the relative return of fingerling Rainbow Trout *Oncorhynchus mykiss* and Westslope Cutthroat Trout *Oncorhynchus clarkii* stocked in Hayden and Cocolalla lakes and estimation of angler use of catchable-size Rainbow Trout in Hayden, Avondale, Freeman, and Mirror lakes. We described the relative contribution of stocked fingerling trout as a 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 detected in Hayden Lake, but no one stocking group was well represented. Rainbow Trout were not observed in Cocolalla Lake. In contrast, Westslope Cutthroat Trout were relatively abundant in Cocolalla Lake (0.7 fish/net). Estimated angler exploitation of catchable size Rainbow Trout in regional lakes varied from 0% at Freeman Lake to 39% at Mirror Lake. We estimated use of Rainbow Trout stocked in Hayden Lake to be low (≤ 6%) in all trials. Use of Rainbow Trout stocked in Avondale Lake was 15% and represented an increase from estimates in prior years. Based on our observations, we recommend discontinuing stocking catchable-size Rainbow Trout stocking in Hayden Lake, but recommend evaluation of fingerling Rainbow Trout stocking should continue. Increasing fingerling Rainbow Trout stocking density in Hayden Lake is recommended to increase the probability of detection in future evaluations. We recommend discontinuation of Rainbow Trout fingerlings in Cocolalla Lake with a corresponding increase in stocking of Westslope Cutthroat Trout fingerlings to provide additional opportunity. An angler survey of Cocolalla Lake was recommended to better understand angler use and species contributions to the fishery. We recommend continued stocking of catchable size Rainbow Trout in Avondale Lake and Mirror Lake. We also recommend continued stocking of catchable size Rainbow Trout in Freeman Lake, but suggest stocking should occur in early spring in combination with an investigation of opportunities to reduce nearshore vegetation growth that currently limits angling opportunity in the 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 trout performance and associated angler exploitation is completed to ensure these resources are used effectively.

In 2016, 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. 2013b, Ryan et al. 2014, Watkins et al. 2018, Ryan et al. 2018). Evaluations included investigations on timing, size, and origin of stocked Rainbow Trout and Westslope Cutthroat Trout fingerlings. We also investigated potential influences of zooplankton quality and quantity on survival of stocked fishes.

In 2016, we also estimated exploitation of catchable-size (hereafter catchable) Rainbow Trout stocked in Hayden, Avondale, Freeman, and Mirror lakes to determine how anglers were utilizing hatchery products. Freeman and Mirror lakes have long histories of catchable Rainbow Trout stocking to provide fishing opportunities. 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) or unknown (Mirror Lake). Catchable Rainbow Trout have been stocked in Hayden Lake infrequently. However, small groups of catchable fish have been stocked in recent years with an interest in improving Rainbow Trout angling opportunities in the lake. Catchable Rainbow Trout were recently stocked in Avondale Lake, including fall outplants in 2015 and 2016, in an effort to establish a quality winter ice fishery close to the urban center of Coeur d’Alene.

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. Measure zooplankton quality and quantity to assess forage availability for stocked fingerling trout.

4. Estimate exploitation of catchable Rainbow Trout stocked in select 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. Twelve net nights were fished in each lake from April 18 through 21, 2016. Net set locations were randomly selected throughout the lake (Table 3), and all nets were fished overnight. We reported mean catch per unit effort

(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. We anticipated encountering multiple stocking groups, including Hayspur triploid Rainbow Trout fingerlings stocked in June 2012 (76 mm to 152 mm, no mark), Troutlodge triploid Rainbow Trout catchables stocked in June 2012 (> 152 mm, no mark), Hayspur triploid Rainbow Trout fingerlings stocked in October 2013 (≥ 152mm, no mark), Hayspur triploid Rainbow Trout fingerlings stocked in September 2014 (≥ 152mm, 50% adipose clip marked), and Hayspur triploid Rainbow Trout fingerlings stocked in September 2015 (≥ 152mm, 50% adipose clip marked; Table 1). Although marks were not available to distinguish every stocking group, length differences were anticipated to allow coarse identification.

In Cocolalla Lake, we assumed the presence of multiple size classes of trout could be used to distinguish stocking cohorts. Troutlodge triploid Kamloops Rainbow Trout fingerlings (< 76 mm) were stocked in April of 2012 and 2013 (Table 2). Hayspur triploid Rainbow Trout fingerlings were stocked in April 2014 and 2015 (Table 2). No marked Rainbow Trout had been stocked in the lake prior to our survey. We also looked for the presence of Westslope Cutthroat Trout that originated from Cabinet Gorge Hatchery as fingerlings stocked during 2012 through 2015 (Table 2).

We monitored zooplankton quality and quantity to describe the availability of forage for stocked hatchery products. Zooplankton were sampled on August 9 and 11, 2016 from Cocolalla and Hayden lakes. We sampled zooplankton using a set of three 0.5 m hoop-style plankton nets in 153 µm, 500 µm, and 750 µm mesh sizes. A single tow of each mesh size was taken at three randomly selected locations on Cocolalla Lake and six randomly selected locations on Hayden Lake. Tow depths ranged from seven to eight meters on Cocolalla Lake. All six tows on Hayden Lake were 10 meters deep. The samples were preserved in denatured ethyl alcohol at a concentration of 1:1 (sample volume: alcohol). After approximately ten days in alcohol, phytoplankton were filtered from the samples through a 153 µm mesh screen. Remaining zooplankton in each sample were blotted dry and weighed to the nearest gram (wet weight).

We summarized zooplankton quality and quantity using the zooplankton productivity ratio method (ZPR) and the zooplankton quality index (ZQI) as defined by Teuscher (1999). The ZPR was calculated as the ratio of sample weights from the 750 µm and 500 µm mesh samples (750:500 µm), representing preferred to usable size zooplankton. The ZQI also incorporated sample weights from 750 µm and 500 µm mesh samples and included estimated ZPR. The ZQI was calculated as:

$$ZQI = ((500\ \mu m + 750 \mu m)\ ZPR)$$

Total density of zooplankton was described as the weight of collected zooplankton in the 153 µm net corrected for sample tow depth (g/m). Values were reported as means representing all sampled sites.

Catchable Rainbow Trout Evaluations

Exploitation of catchable-sized hatchery Rainbow Trout was evaluated in Hayden Lake, Freeman Lake, Avondale Lake, and Mirror Lake. To estimate exploitation rates we tagged and released catchable Rainbow Trout with individually numbered T-bar style tags (Floy, Inc.). Tags

were inserted at an angle into the dorsal musculature just below the dorsal fin of each fish. Hayden Lake was stocked with 1,590, 1,710, and 1,535 Rainbow Trout in April, May, and June of 2016, respectively. We tagged approximately 9% of each group released. In Freeman Lake, groups of 810, 1,080, and 287 Rainbow Trout were stocked in April, May, and June of 2016, respectively. We tagged 75 fish in each Freeman Lake release group. Mirror Lake was stocked with approximately 1,080 Rainbow Trout in May, June, and October of 2016. We tagged 100 fish in the May and June release groups. Approximately 2,000 Rainbow Trout were stocked in Avondale Lake in September 2016, including 193 tagged fish. Each tag was printed with the IDFG “Tag You’re It” phone number for reporting. No reward was offered for tag returns. Angler tag returns were collected by phone, online (IDFG website), and in person at the IDFG Panhandle Regional Office. Tag reports collected through July 2018 were included in the estimates of exploitation.

Exploitation rates on catchable Rainbow Trout were estimated using tag returns as described by Meyer et al. (2012) using the IDFG “Tag You’re It” analysis application. Tag returns were corrected for tag loss (3.7%), tagged fish mortality (.8%), and reporting rate (43.3%). Exploitation was estimated for one year at-large and greater than one year at-large where feasible.

RESULTS

Hayden Lake

We caught six Rainbow Trout (0.5 fish/net ± 0.2; 80% CI) representing three age classes in Hayden Lake (Table 4). By size (300 mm and 329 mm) and fin condition (i.e. rough or absent fins), we determined two fish were stocked as catchables in April 2016. We caught one adipose-clipped Rainbow Trout (284 mm TL) and one non-clipped fish (252 mm TL) that both were considered to be 2015 fingerlings. We also caught two Rainbow Trout (373 mm, 394 mm) estimated to originate from the 2014 fingerling outplant. Surface water temperature during the gill net survey was 15.6 °C.

In addition to Rainbow Trout, gill nets caught Black Crappie *Pomoxis nigromaculatus*, Bluegill *Lepomis macrochirus*, Brown Bullhead *Ictalurus nebulosus*, kokanee, Largemouth Bass *Micropterus salmoides*, Northern Pike *Esox lucius*, Pumpkinseed *Lepomis gibbosus*, Smallmouth Bass *Micropterus dolomieu*, and Tench *Tinca tinca* (Table 4) The CPUE was highest for Black Crappie and Bluegill. Kokanee CPUE (0.4 ± 0.2, 80% CI) declined from observed catch rates in 2013 (CPUE; 2.5 ± 1.9), 2014 (CPUE; 1.9 ± 0.5), and 2015 (CPUE; 1.6 ± 0.8) (Ryan et al. 2014, Watkins et al. 2018, Ryan et al. 2018).

Average zooplankton density for Hayden Lake was 0.10 g/m (± 0.01, 80% CI; Table 6). We estimated average ZPR and ZQI at 0.31 (± 0.09, 80% CI) and 0.06 (± >0.02, 80% CI), respectively (Table 5).

Anglers reported catching Rainbow Trout from Hayden Lake that represented all three catchable Rainbow Trout stocking events in 2016 within the first year at-large (Table 7). Four tagged fish were harvested and reported by anglers from the April 2016 stocking event. Anglers reported catching six tagged fish from the May 2016 stocking event, of which four were harvested. Three tagged fish were caught and reported by anglers from the June 2016 stocking event, of which two were harvested. Year one adjusted angler exploitation and total use of Rainbow Trout was estimated at an average of 4% and 7%, respectively. No tagged Rainbow Trout stocked in 2016 were reported as caught or harvested beyond one year at-large.

Cocolalla Lake

No Rainbow Trout were caught from Cocolalla Lake (Table 6). We caught an average of 0.7 Westslope Cutthroat Trout per net. Gill nets also captured 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*, and a Rainbow x Westslope Cutthroat Trout Hybrid (Table 5). Peamouth and Channel Catfish were the most abundant fishes in our survey. Brown Trout and Brook Trout were the most abundant salmonids in our survey. Surface water temperature during the gill netting was approximately 12 °C.

Average zooplankton density from Cocolalla Lake was 0.13 g/m (± 0.05, 80% CI; Table 5). We estimated average ZPR and ZQI at 0.68 (± 0.11) and 0.37 (± 0.15), respectively. We found warm water temperatures down to approximately eight m in Cocolalla Lake during August zooplankton surveys (Figure 1). Although temperatures cooled with depth, dissolved oxygen levels were low below eight m and suggested trout habitat was limited.

Freeman Lake

No tags were reported by anglers from April, May, or June stocking events of Freeman Lake in 2016 (Table 7). We concluded that few, if any, Rainbow Trout stocked in 2016 were caught or harvested, suggesting poor survival or very low fishing effort.

Avondale Lake

Anglers reported catching 20 of the tagged Rainbow Trout stocked during September 2016 in Avondale Lake (Table 7). Sixteen of the reported fish were caught and 14 harvested in the first year post-stocking. Year one adjusted use and exploitation were estimated at 20% and 18%, respectively. An additional four tagged Rainbow Trout were caught and reported in the second year at-large. Adjusted use and exploitation including tags reported in year two were estimated at 25% and 23%, respectively.

Mirror Lake

Anglers reported catching Rainbow Trout from Mirror Lake that represented both the May and June stocking events in 2016 (Table 7). Sixteen tagged fish from the May stocking event were caught and reported by anglers. An additional 26 tagged fish from the June stocking event were caught and reported by anglers. Anglers reported harvesting 15 and 26 of the fish caught from these stocking events, respectively. Year one adjusted angler use and exploitation of Rainbow Trout stocked in May was 39% and 36%, respectively. Year one adjusted angler use and exploitation of Rainbow Trout stocked in June was 63%, respectively. Anglers also reported harvesting Rainbow Trout stocked in 2016 during the second year at-large. Estimated exploitation for combined-year tag returns from May and June stocking events were 41% and 65%, respectively.

DISCUSSION

Hayden Lake

Rainbow Trout collected in our 2016 survey, although few in number, represented the most robust sample in a series of surveys since 2013 (Ryan et al. 2014, Watkins et al. 2018, Ryan et al. 2018). The detection of Rainbow Trout originating as fall fingerlings from Cabinet Gorge Hatchery suggested there may be benefits to survival influenced by the hatchery of origin. However, the level of certainty in this conclusion was limited due in part to the size of the sample collected (i.e., four fish). In addition, the number of fish collected may reflect fingerling stocking rates. Rainbow Trout stocking rates from 2014 and 2015 were considered low at approximately 23 fish per hectare. To improve confidence in our conclusions, we recommend stocking rates of fall fingerlings originating from Cabinet Gorge hatchery be increased in 2017 to increase the likelihood that detectable abundances are present. In addition, we recommend increasing the number of gill net sets in future surveys to improve our ability to detect targeted fish.

Zooplankton quality and quantity in Hayden Lake continued to suggest available forage for planktivorous fishes was poor. Based on these results, the expected return of put-and-grow trout stocking should be tempered, especially relative to Rainbow Trout that appear to experience high post-stocking mortality.

Our evaluation suggested that angler use of catchable Rainbow Trout stocked in Hayden Lake was low. Estimated use was 8% or less over all tagging groups in our evaluation. Exploitation of catchable Rainbow Trout stocked in Hayden Lake in 2016 did not appear to be influenced by when fish were released. Estimated use varied only 3% between April, May, and June stocking events. Our conclusions were consistent with a similar evaluation conducted in 2015 (Ryan et al. 2018). Although we observed consistently low angler use in our work, a 2011 evaluation estimated angler use of catchable Rainbow Trout was considerably greater in Hayden Lake (i.e. 20%; Ryan Hardy, IDFG, personal communication). We are uncertain as to the cause of high variability in exploitation rates. However, based on low exploitation of hatchery products in multiple recent evaluations, the potential presence of Rainbow Trout from fingerling stocking efforts, and other fishery opportunities in this water (i.e., kokanee, multiple warmwater species) we recommend discontinuing catchable stocking.

Rainbow Trout fingerlings were again stocked in Hayden Lake in the fall of 2016. A batch thermal mark was created on the otoliths of 2016 fish to facilitate separation of year classes (John Rankin, IDFG, personal communication). In addition, catchable Rainbow Trout were stocked during the spring in 2016. Continued evaluation of the contribution of hatchery products is recommended given the uncertain success of these efforts.

Cocolalla Lake

We continued to see poor return on Rainbow Trout fingerlings in our 2016 gill net survey of Cocolalla Lake. Our observations were consistent with lake-wide survey results from Cocolalla Lake in 2008 and 2015 (Fredericks et al. 2009, Ryan et al. 2018). The information from these two survey efforts suggested stocking fingerling Rainbow Trout does not benefit the Cocolalla Lake fishery. As such, we recommend discontinuing Rainbow Trout fingerling stocking starting in 2017. We expect the contribution of other fishes (i.e., Westslope Cutthroat Trout, Brown Trout, Brook Trout) will continue to provide quality angling opportunities in the lake.

Our metric for evaluating the relative contribution of Rainbow Trout in the Cocolalla Lake fishery remained coarse. Although our survey suggested Rainbow Trout were poorly represented, we could not confirm whether Rainbow Trout were present in the recreational fishery at some level or how other trout species may contribute to fishery. We recommend an angler survey, evaluating angler use and species-specific catch rates, be completed to provide relevant information on what anglers desire and encounter in this fishery. We anticipate information gained from an angler survey would help refine fishery management expectations.

Westslope Cutthroat Trout continued to be found in moderate abundance in surveys of Cocolalla Lake, suggesting stocked cutthroat fingerlings survive at higher rates than Rainbow Trout. Rainbow x Westslope Cutthroat Trout hybrids were also observed, although at lower abundance than previously found (Ryan et al. 2018). The presence of hybrid trout further supported previous suggestions that our catch of Westslope Cutthroat Trout may be influenced by wild recruitment. Westslope Cutthroat Trout destined to be stocked in 2017 were batch thermal marked to facilitate better separation of hatchery and wild recruitment in future years. In addition, we recommend increasing stocking rates of Westslope Cutthroat Trout in 2017 to ensure quality angling opportunities remain in Cocolalla Lake in the absence of Rainbow Trout.

Avondale Lake

Estimated exploitation on Rainbow Trout stocked in Avondale in 2016 suggested return to anglers improved from previously estimated levels. Specifically, angler use increased more than 11% since a 2015 evaluation (Ryan et al. 2018). Our estimate was representative of a moderate level of angler use relative to other hatchery-supported Rainbow Trout fisheries in the Panhandle Region. Exploitation of stocked Rainbow Trout in Panhandle area lakes has been estimated to vary widely from 0% to over 70% (Fredericks et al 2011, Maiolie et al 2013a). Observed improvement in angler use likely represented a combination of factors, including expanded angler knowledge of the opportunity and an extended winter ice fishery season in 2016-17. Based on angler use of Rainbow Trout from Avondale Lake, we recommend continued stocking of Rainbow Trout to support this fishery.

Our evaluation demonstrated a portion of the Rainbow Trout stocked in Avondale Lake survived beyond one year, extending the productivity of the fishery. In addition to returned tags beyond one year at–large, we also received miscellaneous angler reports of large carryover size Rainbow Trout being caught in the fishery. General observations of Panhandle Regional fisheries suggest survival of more than one year for hatchery Rainbow Trout is low, making our observation somewhat unique.

Freeman Lake

Our evaluation of Rainbow Trout stocked in Freeman Lake suggested angler exploitation was low or absent in this fishery. This result was consistent with the most recent prior estimate of angler use on the fishery. Ryan et al. (2018) found angler exploitation on fall stocked Rainbow Trout in this fishery was also very low (1%). This evaluation, in combination with the previous fall evaluation, also provided a better understanding of the seasonality of angler use. Specifically, there did not appear to be a seasonal influence on angler exploitation of Rainbow Trout.

The mechanisms effecting angler use of Rainbow Trout in this fishery have not been clearly described. However, short-term survival of stocked Rainbow Trout was not likely the

primary cause of poor return to anglers. A survey of the Freeman Lake fish community in 2016 indicated Rainbow Trout were present and available to anglers at the time of this evaluation (see Panhandle Regional Lowland Lakes Investigations 2016 chapter in this report). Although fish were present and available, we observed lake conditions in June 2016 that may influence angling opportunities for Rainbow Trout. Specifically, heavy littoral vegetation was observed surrounding the lake and extending a long distance from the shoreline. This condition potentially impeded casting and retrieving lures or bait. However, we did not measure angler effort on Freeman Lake during the time period of our evaluation and cannot describe how effort may have influenced our estimates.

Our results were not consistent with previous estimates of angler use for the Freeman Lake Rainbow Trout fishery. Fredericks et al. (2011) estimated angler exploitation on Rainbow Trout to be 17% in 2011. Mechanisms affecting differences in use estimates over time have also not been clearly described. As such, we were unable to define the cause of any changes in use or speculate on how use may vary over time.

Freeman Lake is the only location where hatchery Rainbow Trout are stocked in the general area surrounding the communities of Oldtown and Priest River, Idaho. Use of hatchery products are typically balanced between providing angler opportunity and maximizing return on a region-wide scale. Angler use of hatchery products at the level described in our evaluation of Freeman Lake would typically suggest stocking should be discontinued and hatchery products used elsewhere in the region. However, based on the limited availability of opportunity provided to anglers in this area, we recommend continued stocking or Rainbow Trout in Freeman Lake. We recommend stocking be focused on early spring when access may be least impacted by littoral vegetation growth. In addition, options for controlling vegetation growth in the vicinity of primary shoreline access points should be investigated as a potential method for improving angler access and subsequently use of Rainbow Trout.

Mirror Lake

Estimated exploitation rates on catchable Rainbow Trout from Mirror Lake represented high returns on hatchery trout. Based on our interpretation, we recommend catchable Rainbow Trout stocking in Mirror Lake continue at current rates.

Similar to our observation from Avondale Lake, anglers returned tags from Rainbow Trout stocked in Mirror Lake beyond one year at-large. This observation demonstrated a portion of the Rainbow Trout stocked in Mirror Lake survived beyond one year, extending the productivity of the fishery. As previously noted, this occurrence is somewhat unique within the scope of hatchery supported Rainbow Trout fisheries in the Panhandle Region.

MANAGEMENT RECOMMENDATIONs

1. Discontinue stocking catchable Rainbow Trout in Hayden Lake.

2. Increase stocking rate of Rainbow Trout fingerlings in Hayden Lake to in an attempt to increase detection probability of these fish in future evaluations.

3. Discontinue stocking Rainbow Trout fingerlings in Cocolalla Lake.

4. Increase the stocking rate of Westslope Cutthroat Trout fingerlings in Cocolalla Lake to provide additional fishing opportunity.

5. Complete an angler survey of the Cocolalla Lake fishery to improve understanding of angler use and how existing fish species contribute to the fishery.

6. Continue stocking catchable Rainbow Trout at current rates in Avondale Lake.

7. Continue stocking catchable Rainbow Trout at current rates in Freeman Lake with an emphasis on early–spring stocking.

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

9. Continue stocking catchable Rainbow Trout in Mirror Lake at current rates.

Table 22. History of Rainbow Trout stocking in Hayden Lake, Idaho from 2011 through 2016.

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	

Table 23. History of Westslope Cutthroat Trout and Rainbow Trout fingerling stocking in Cocolalla Lake, Idaho from 2011 through 2016.

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 for 2017

Table 24. Locations sampled during Rainbow Trout stocking evaluations on Hayden and Cocolalla lakes from April 19-21, 2016.

Water	Net	Date Set	Z	Easting	Northing	Datum
Hayden Lake	1	4/20/2016	11	522772	5294598	WGS84
Hayden Lake	2	4/20/2016	11	523260	5292755	WGS84
Hayden Lake	3	4/20/2016	11	523972	5292092	WGS84
Hayden Lake	4	4/20/2016	11	522053	5291365	WGS84
Hayden Lake	5	4/20/2016	11	521856	5290966	WGS84
Hayden Lake	6	4/20/2016	11	523155	5290505	WGS84
Hayden Lake	7	4/21/2016	11	523715	5289573	WGS84
Hayden Lake	8	4/21/2016	11	521118	5290489	WGS84
Hayden Lake	9	4/21/2016	11	520141	5290684	WGS84
Hayden Lake	10	4/21/2016	11	518603	5290165	WGS84
Hayden Lake	11	4/21/2016	11	518460	5289736	WGS84
Hayden Lake	12	4/21/2016	11	518989	5288812	WGS84
Cocolalla Lake	1	4/18/2016	11	528685	5331912	WGS84
Cocolalla Lake	2	4/18/2016	11	529436	5331235	WGS84
Cocolalla Lake	3	4/18/2016	11	528919	5330927	WGS84
Cocolalla Lake	4	4/18/2016	11	529005	5330537	WGS84
Cocolalla Lake	5	4/18/2016	11	528166	5330510	WGS84
Cocolalla Lake	6	4/18/2016	11	528130	5330020	WGS84
Cocolalla Lake	7	4/19/2016	11	528734	5329824	WGS84
Cocolalla Lake	8	4/19/2016	11	527995	5329545	WGS84
Cocolalla Lake	9	4/19/2016	11	528239	5329531	WGS84
Cocolalla Lake	10	4/19/2016	11	528188	5329225	WGS84
Cocolalla Lake	11	4/19/2016	11	528485	5329165	WGS84
Cocolalla Lake	12	4/19/2016	11	527952	5329040	WGS84

Table 25. Species, minimum and maximum total length, catch (number), and catch rate (CPUE) from 2016 Hayden Lake gill netting completed to evaluate Rainbow Trout stocking.

Species	Catch	CPUE ± 80% C.I.	Min	Max
Black Crappie	50	4.2 ± 4.0	111	303
Bluegill	38	3.2 ± 1.4	55	195
Brown Bullhead	3	0.3 ± 0.3	247	292
Rainbow Trout	6	0.5 ± 0.2	252	394
Kokanee	5	0.4 ± 0.2	282	304
Largemouth Bass	3	0.3 ± 0.2	155	354
Northern Pike	24	2.0 ± 0.7	398	1010
Pumpkinseed	13	1.1 ± 0.6	99	178
Smallmouth Bass	1	0.1 ± 0.1	383	383
Tench	17	1.4 ± 0.6	335	477

Table 26. Zooplankton ZPR and ZQI indices and density estimates by year from Hayden and Cocolalla lakes.

Water	Year	ZPR	ZQI	Density
Hayden Lake	2010	0.93	0.28	0.66
	2011	0.74	0.22	0.30
	2014	0.81	0.09	0.01
	2015	0.43	0.03	0.07
	2016	0.31	0.06	0.10
Cocolalla Lake	2011	0.24	0.48	4.33
	2015	0.95	0.42	0.40
	2016	0.68	0.37	0.13

Table 27. Species, minimum and maximum total length, catch (number), and catch rate (CPUE) from 2016 Cocolalla Lake gill netting completed to evaluate Rainbow Trout and Westslope Cutthroat Trout stocking.

Species	Catch	CPUE ± 80% C.I.	Min TL	Max TL
Black Crappie	4	0.3 ± 0.3	245	273
Brook Trout	16	1.6 ± 0.6	213	337
Brown Bullhead	1	0.1 ± 0.1	289	289
Brown Trout	18	1.5 ± 0.4	171	512
Channel Catfish	81	6.8 ± 4.8	324	561
Largescale Sucker	7	0.6 ± 0.6	484	569
Longnose Sucker	16	1.3 ± 0.9	362	441
Peamouth	59	4.9 ± 1.5	204	351
Rainbow Cutthroat Hybrid	1	0.1 ± 0.1	465	465
Rainbow Trout	0			
Westslope Cutthroat Trout	8	0.7 ± 0.3	326	450

Table 28. Catchable Rainbow Trout exploitation summary from lakes evaluated in 2016. Summary includes the number of Rainbow Trout released by date, total number released, number of fish tagged, number of tags returned, number of tags returned reported as harvested and released, and adjusted exploitation estimate (± 90% CI).

Lake	Release Date	Fish Stocked	Tags Out	Tags Returned	Harvested/ Released	Exploitation (%)
Avondale	Sep-16	2000	191	16	14/1*	17.7 ± 9.5
Hayden	Apr-16	1590	149	4	4/0	6.5 ± 5.6
	May-16	1710	150	6	3/2*	4.8 ± 4.7
	Jun-16	1535	132	3	1/2	1.8 ± 3.0
Freeman	Apr-16	810	75	0	--	--
	May-16	1080	75	0	--	--
	Jun-16	287	75	0	--	--
Mirror	May-16	1079	100	16	15/1	36.3 ± 18.7
	Jun-16	1080	100	26	26/0	62.9 ± 27.6

*excludes fish harvested only because they were tagged

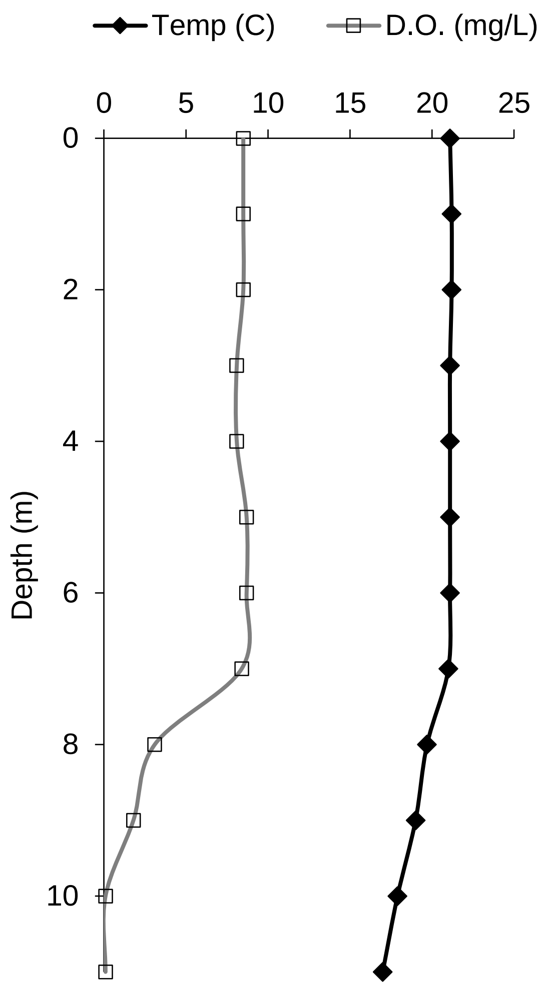

Figure 46. Dissolved oxygen (DO) and temperature profiles from Cocolalla Lake in August 2016.

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 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., Fernan Lake, Lower Twin Lake, Spicer Pond, Steamboat Pond) to better understand utilization of hatchery trout in those fisheries. We sought to update previous assessments of return-to-creel with the ultimate goal of maintaining effective distribution of catchables around the region. In lowland lakes receiving "magnum" (mean = 305 mm TL) catchables, we estimated return-to-creel rates varying from 10–25% in Lower Twin Lake and 11–23% in Fernan Lake for various release groups during the primary angling season. Return-to-creel of standard-sized catchables (mean = 254 mm) in catch-out ponds varied from 4% (Steamboat Pond; July stocking) to 28% (Spicer Pond; April stocking). In general, earlier stocking events resulted in higher return-to-creel for both lowland lakes and catch-out ponds, but the number of months at-large was greater for later stocking events. Our estimates are within the range of variability of past estimates of return-to-creel with regard to both lowland lakes and catch-out ponds in the Panhandle Region. However, return-to-creel of catchables in Steamboat Pond continues to be poor compared to nearby waters.

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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 et al. 2011) that raise and stock sportfish 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 around the state, 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 agency 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, there has been an increased need for regional fishery management programs 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). 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 two lowland lakes and catch-out ponds that receive stockings throughout the angling season (i.e., April–September). The daily bag limit for trout species is six fish in all of the waters included in this study.

OBJECTIVES

1. Evaluate return-to-creel rates of hatchery catchables in Fernan Lake, Lower Twin Lake, Spicer Pond, and Steamboat Pond.

STUDY AREA

Fernan Lake

Fernan Lake is located in Kootenai County immediately east of the city of Coeur d'Alene. It has historically been classified as an oligotrophic water body, but eutrophication has led to recent increases in its productivity. The lake has a surface area of 171 ha and elevation of 647 m. Fernan Creek is the primary tributary to the lake, entering on the east end of the lake. Fernan Lake is one of the Panhandle Region's most popular lowland lakes and supports a mixed fishery for both warmwater and coldwater species.

Lower Twin Lake

Lower Twin Lake is located in Kootenai County approximately 11 km north of Rathdrum, Idaho. The lake has a surface area of 158 ha, elevation of 704 m, mean depth of 6.9 m, and maximum depth of 19.1 m. Lower Twin Lake is part of a complex comprised of two unique lentic water bodies; Upper and Lower Twin lakes are connected via a small channel. Fish Creek is the largest tributary in the system, entering Upper Twin Lake on the western shoreline. Water exits the system via Rathdrum Creek at the southern end of Lower Twin Lake.

Spicer Pond

Spicer Pond is a small catch-out pond located in Benewah County approximately 2 km southeast of St. Maries, Idaho between Highway 3 and the St. Maries River. The pond has a surface area of 0.4 ha and elevation of 655 m. Spicer Pond is owned by the IDFG and managed as a Family Fishing Water. The fish community has low diversity, being composed only of Brown Bullhead *Ameiurus nebulosus* and stocked Rainbow Trout (seasonally). Spicer Pond is a relatively new water body and was built and filled in late 2013. As such, Spicer Pond does not have a history of fish stocking and catchable return-to-creel has never been evaluated.

Steamboat Pond

Steamboat Pond is a small catch-out pond located about 22 km north of Kingston, Idaho in Shoshone County. The pond is owned by the IDFG and managed as a Family Fishing Water. The pond has a surface area of 1 ha and elevation of 681 m. Steamboat Pond was built and filled in 2002, and first stocked with catchables in 2003. An evaluation of return-to-creel of Steamboat pond catchables was conducted in 2013; the study concluded that annual angler exploitation was low, necessitating a follow-up survey (Liter and Fredericks 2011).

METHODS

Angler exploitation of catchables was evaluated monthly (May–September) 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,

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

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 (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 ~150 catchables per stocking group (i.e., month), and a total of 1,048 tagged Rainbow Trout was released into lowland lakes (i.e., Fernan and Lower Twin lakes) during the study. Anglers reported catching 93 tagged catchables in lowland lakes receiving "magnum" catchables (Table 1). We estimated adjusted exploitation rates varying from 10 – 26%. Tag returns by release group declined from April–June in Fernan Lake; however, returns were more consistent in Lower Twin Lake (Table 1; Figure 1). Tag returns from the September release group in Lower Twin Lake were anomalous to this pattern and displayed the lowest return-to-creel of all stocking groups in lowland lakes (Figure 1). In general, tagged fish were at-large for no longer than four months (Figure 2). The majority of fish were caught after being at-large for 0–2 months in Fernan Lake, but the time at-large was more evenly distributed from 0–4 months in Lower Twin Lake (Figures 2). We documented catchables overwintering in both systems and being caught the following spring; only fish from May (Fernan Lake), June (Fernan and Lower Twin lakes), and September (Lower Twin Lake) resulted in fish overwintering (Figures 1 and 2). Most catchables reportedly caught in lowland lakes were harvested and not released (Table 1).

We tagged a total of 250 standard (i.e., mean TL = 254 mm) catchables stocked into catch-out ponds. After one year at-large, 19 tags had been returned; all were reportedly harvested except one (Table 1). Angler exploitation varied from 4 – 24% and total use varied from 4 – 28% between both ponds. Angler exploitation was similar for both stocking groups in Spicer Pond, but showed a declining trend from May–July in Steamboat Pond (Figure 1). In general, Spicer Pond showed higher return-to-creel of catchables than Steamboat Pond. The total number of months at-large varied from 0–1 month in Spicer Pond and 0–2 months in Steamboat Pond (Figure 3). Around 80% of the catchables stocked in Spicer Pond were caught during the month they were stocked; all of the catchables stocked into Steamboat Pond were caught during the month they were stocked with the exception of the May stocking group (Figure 3).

DISCUSSION

Exploitation of "magnum" catchables in our study followed patterns incongruent to other waters around the state (Cassinelli 2016), but the rates fail to meet the statewide objective (μ = 40%) for put-and-take Rainbow Trout fisheries (IDFG 2013a). Both waters receiving "magnum" catchables (i.e., Fernan Lake, Lower Twin Lake) displayed mean annual exploitation rates of ~17% and maximum exploitation rates of ~25%, which varied by release month between waters. With respect to Fernan Lake, annual exploitation during 2016 was 13% lower than during 2010 for catchables stocked during the same time period. Conversely, annual exploitation rates for catchables stocked into Lower Twin Lake were similar or slightly higher than the last survey (Liter and Fredericks 2013). This difference in exploitation observed in Fernan Lake is disconcerting because the principle of "magnum" catchable stocking suggests that exploitation rates should be higher than that of standard catchables (i.e., catchables stocked during 2010). Magnum catchable principles further suggest that higher exploitation allows fewer fish to be stocked, but ultimately leads to similar total harvest by anglers. Stocking densities have been highly variable for Fernan Lake over the past 15 years making it difficult to understand the relationship between catchable size, stocking density, and exploitation; however, further tagging evaluations may elucidate patterns that can inform allocation of catchables in this lake.

Both Fernan and Lower Twin lakes displayed total return rates well below that of similar-size systems around the state (e.g., Lost Valley Reservoir, Warm Lake, Sage Hen Reservoir; Cassinelli 2016). In fact, even much larger water bodies such as Blackfoot Reservoir, Mackay

Reservoir, and Lucky Peak Reservoir routinely display higher return-to-creel rates of catchables than lowland lakes in the Panhandle Region. However, relative to the history of catchable harvest in our study lakes, the exploitation rates estimated from fish stocked during 2016 were not notably different and should be considered acceptable. We acknowledge that our previous efforts to evaluate catchable Rainbow Trout exploitation may have conditioned some anglers to the "Tag You're It!" reporting process, inducing some bias in our current study. Particularly for Fernan Lake where many anglers routinely fish for catchables and likely encounter more than one tag over time, our future evaluations may benefit by including reward tags to better estimate tag reporting rates and increase the precision of exploitation estimates.

Results of our evaluation of standard catchable return-to-creel in catch-out ponds were somewhat mixed. Consistent with a recent evaluation, catchable Rainbow Trout stocked in Steamboat Pond continue to return very poorly (Liter and Fredericks 2011). Estimated annual angler exploitation across stocking events was 8%, unchanged from the 2012 study. In contrast, Spicer Pond produced an annual exploitation rate of 25%. Liter and Fredericks (2011) evaluated angler exploitation of catchables in four regional catch-out ponds having similar characteristics to both of our study ponds; the authors reported annual exploitation rates varying from 4.5% (Calder Pond) to 57.5% (Day Rock Pond; mean = 21.5%). With this understanding, we should consider Steamboat Pond to be underperforming, and Spicer Pond adequately performing, per Panhandle Region baseline.

There are a variety of factors that are known to influence the relative performance of put-and-take fisheries, some of which can result in poor angling experiences. Such factors are typically associated with fish survival (Barnes et al. 2009) or angler use. In most cases, catch-out ponds are strategically developed in locations with easy access and where angling use is known to be high. Spicer Pond has seasonally poor water quality that negatively influences its aesthetics and habitat suitability. We are currently aware of these problems and their potential to affect fish survival and angling participation at Spicer Pond. It is thought that improvements in water quality may improve seasonal longevity of catchables and encourage additional angling activity. Unfortunately, the factors influencing poor return-to-creel rates of catchables in Steamboat Pond are not understood. The majority of catch-out ponds around the Panhandle Region are located near rural communities in the upper Spokane River Basin where lentic fishing opportunities are limited or where current angling regulations preclude wild trout harvest. As such, most catch-out ponds have similar characteristics and should produce comparable return-to-creel rates of catchables simply based on proximity to waters with comparable opportunity. However, IDFG has reported widely variable return-to-creel rates among water bodies that are located in close geographic proximity to one another. For example, Lucky Friday Pond and Day Rock Pond are both located within 10 miles of Wallace, Idaho; however, Day Rock Pond displayed return-to-creel rates nearly double that of Lucky Friday Pond in a recent evaluation (Liter and Fredericks 2011). Steamboat Pond is also located near several small towns in the Silver Valley area, yet displays poor return-to-creel rates. Anomalous to this pattern, Liter and Fredericks (2011) reported that Clee Creek Pond also displayed poor return-to-creel of catchable Rainbow Trout. Interestingly, both Clee Creek and Steamboat ponds lie along the North Fork Coeur d'Alene River where recreational traffic is much higher than the upper Silver Valley. While this does not necessarily explain the observed differences in these fisheries, it does elucidate some potential differences between the angling clientele in each general area. For instance, the North Fork Coeur d'Alene River is a quality catch-and-release Westslope Cutthroat Trout *O. clarki lewisi* fishery that receives considerable effort from specialized anglers, and the SF Coeur d'Alene River sees little angling attention. However, there is a high amount of additional recreation traffic along the North Fork Coeur d'Alene River corridor, but the contribution it makes to consumptive angling is unknown. Steamboat Pond does not appear to have any major habitat issues that could negatively affect

survival of catchables. In addition, it has been thought that Steamboat Pond's close proximity to Silver Valley communities and many recreational campgrounds along the North Fork Coeur d'Alene River would make it a popular angling resource, but this has not been well-supported. It may benefit the IDFG to reduce catchable stocking in Steamboat Pond, particularly during May and June when annual exploitation rates are very low.

Catch-out ponds are managed to provide simple, quality angling to nearly any member of the public. In fact, one of the primary objectives of catchable stocking in ponds is to provide angling opportunities for beginners, youths, disabled anglers, and families (IDFG 2013a). If the pond characteristics do not meet the needs of the local angling clientele, they may not warrant use of IDFG's hatchery products. Our results show that the longevity of catchables is very short (≤ 2 months) in Panhandle Region catch-out ponds, necessitating the wise immediate use of available hatchery products. This is in contrast to lowland lakes which can support catchables long after the primary angling season. With the increase in awareness and scrutiny of how IDFG's hatchery products are utilized, this should remain a primary focus of catchable management.

MANAGEMENT RECOMMENDATIONS

1. Discontinue fall stocking in Lower Twin Lake if efforts to publicize fall catchable Rainbow Trout stocking do not improve return-to-creel rates.

2. Perform follow-up evaluation in Fernan Lake to understand the relationship among stocking density, catchable size, and exploitation.

3. Publicize catchable Rainbow Trout fishing opportunity in Steamboat Pond.

4. Perform follow-up evaluations of Steamboat Pond and other nearby catch-out ponds to better understand if management efforts improve return-to-creel of catchable Rainbow Trout.

Table 29. Summary information from catchable Rainbow Trout study conducted during 2016–2017. Included is the number of Rainbow Trout tagged, harvested, and released in each release group during 2016. Values associated with fish harvested and released are for one year at-large.

	Release month				
Disposition	April	May	June	July	September
			Fernan Lake		
Tagged	150	150	150	--	--
Harvested	19	11	8	--	--
Released	0	2	0	--	--
			Lower Twin Lake		
Tagged	150	151	150	--	148
Harvested	13	13	18	--	7
Released	1	3	1	--	0
			Spicer Pond		
Tagged	50	50	--	--	--
Harvested	6	6	--	--	--
Released	1	0	--	--	--
			Steamboat Pond		
Tagged	--	50	50	50	--
Harvested	--	3	2	1	--
Released	--	0	0	0	--

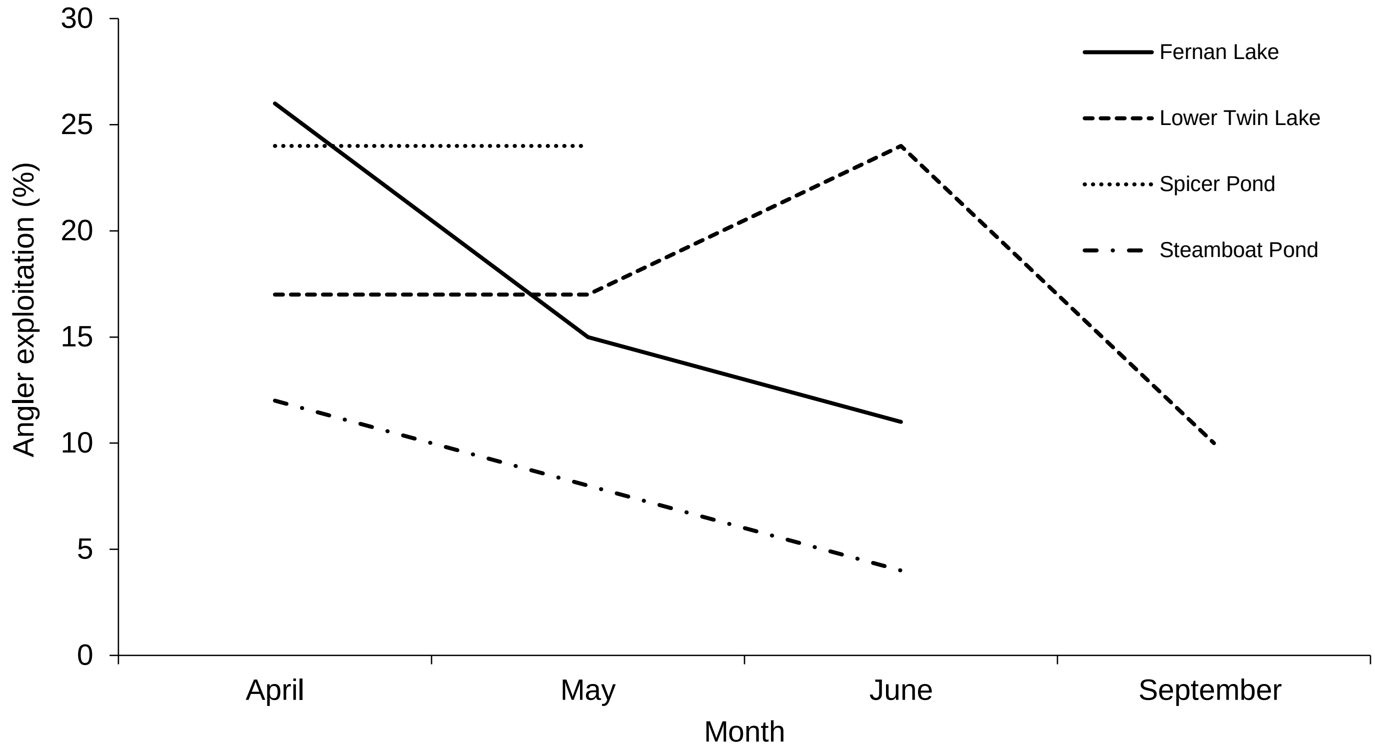

Figure 47. Annual angler exploitation summarized by release month for catchable Rainbow Trout in Fernan and Lower Twin lakes and Spicer and Steamboat ponds during 2016–2017.

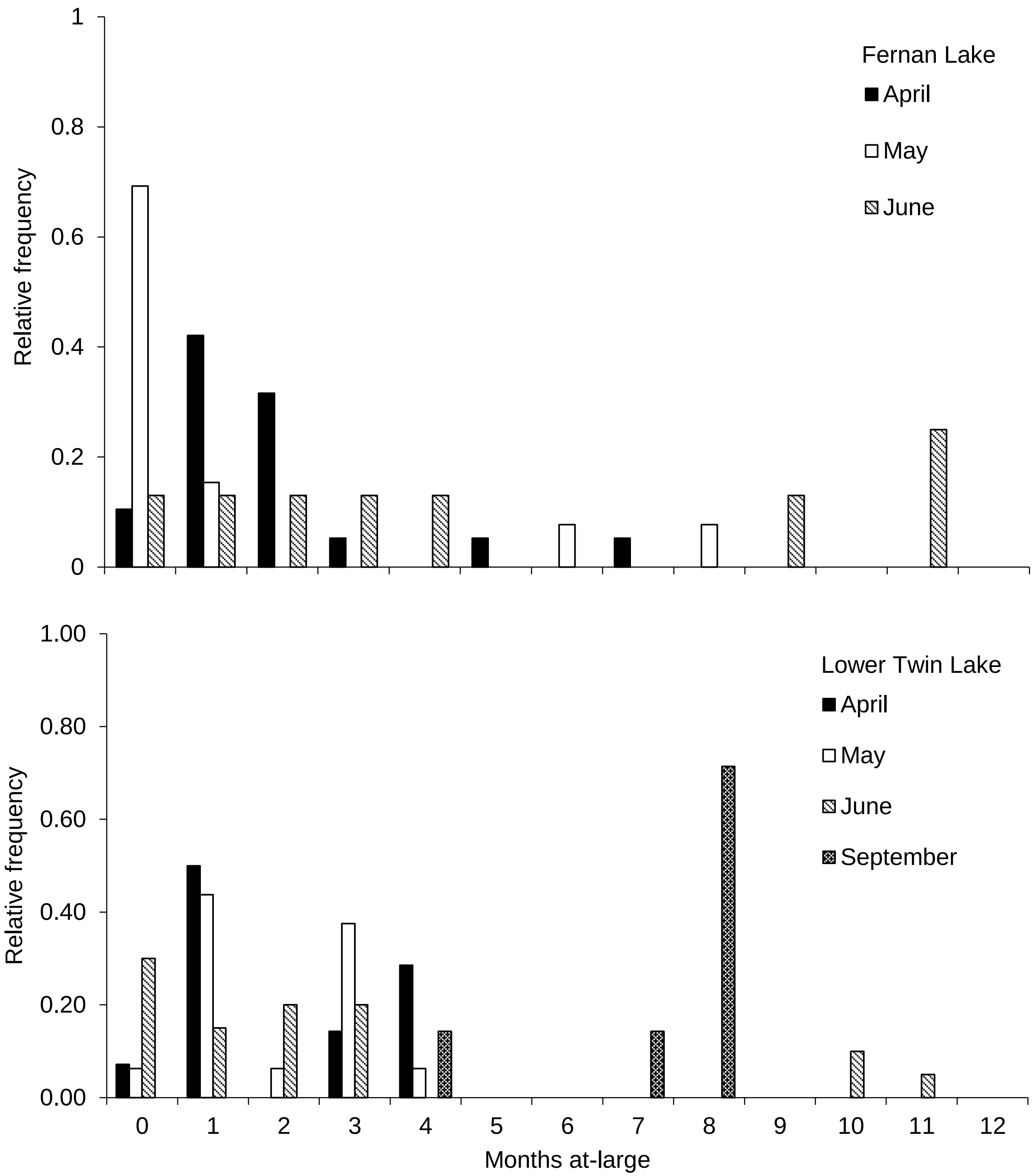

Figure 48. Months at-large for catchable Rainbow Trout stocked during April–September 2016 in Fernan and Lower Twin lakes.

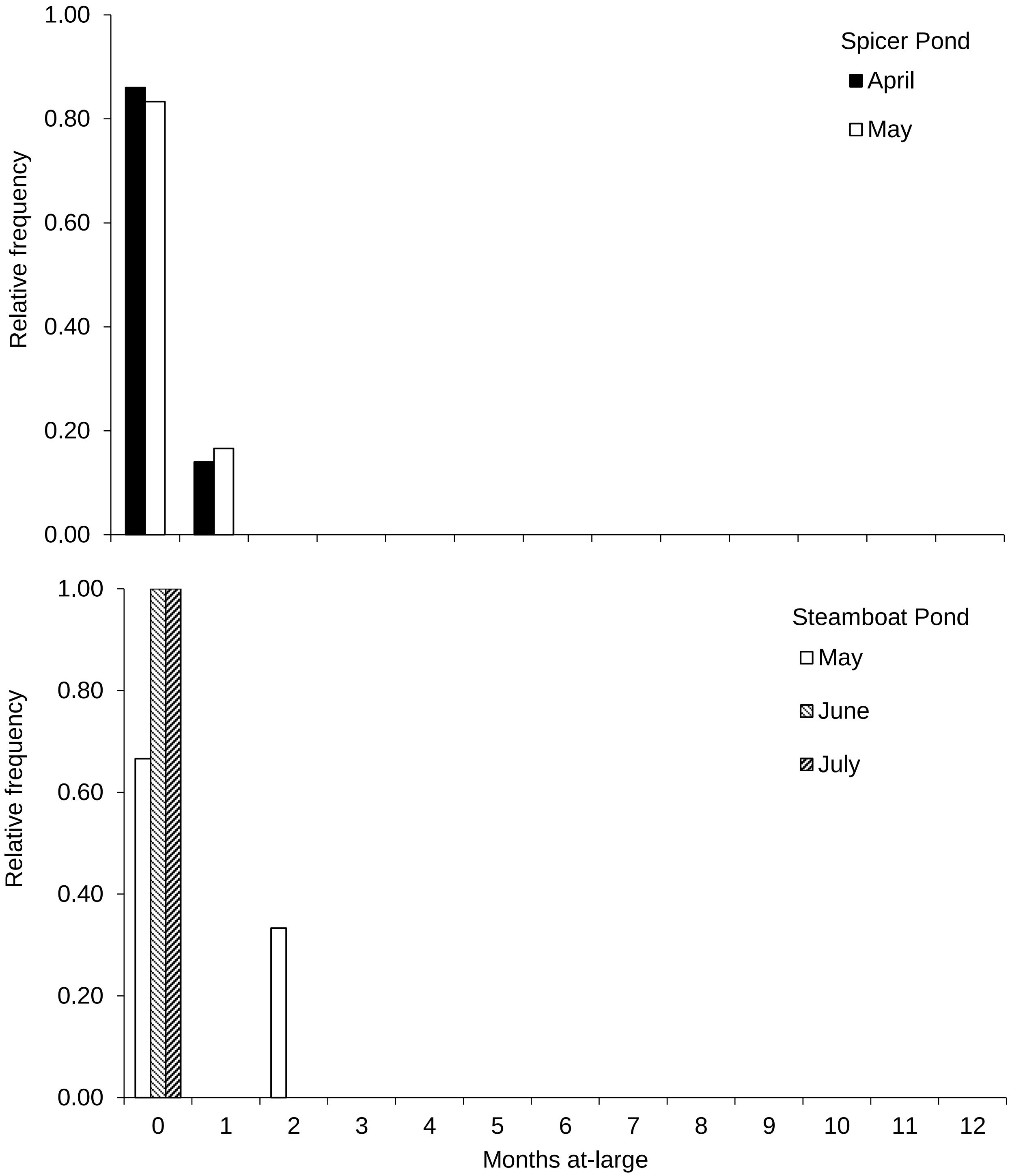

Figure 49. Months at-large for catchable Rainbow Trout stocked during April–July 2016 in Spicer and Steamboat ponds.

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 25–August 3, 2016, 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 0.51 fish/100 m^2 in the North Fork Coeur d'Alene River (including Teepee Creek), 0.64 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 1.41 fish/100 m^2 in the St. Joe River. For Westslope Cutthroat Trout ≥ 300 mm in total length, we estimated densities of 0.16 fish/100 m^2 in the North Fork Coeur d'Alene River, 0.08 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 0.40 fish/100 m^2 in the St. Joe River. Densities of Rainbow Trout *O. mykiss* remain relatively low 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 system. 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 continue to improve. 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; Muhlfeld et al. 2009).

Concerns about the rangewide status of Westslope Cutthroat Trout have resulted in two petitions for listing under the U.S. Endangered Species Act (ESA 1973, as amended) in 1997 and 2001. Subsequent evaluations of extant populations determined that the relatively broad distribution and persistence of isolated populations in Oregon, Washington, and Canada did not warrant protection under the ESA (U.S. Federal Register 1998, 2003). However, the U.S. Forest Service and Bureau of Land Management regard Westslope Cutthroat Trout as a sensitive species, and the Idaho Department of Fish and Game (IDFG) has designated it as a Species of Greatest Conservation Need (IDFG 2006; IDFG 2013b). 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 non-consumptive use (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 2013a). 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 2013a). 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 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 25–August 3, 2016 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; inches) of all salmonid species. All snorkelers

obtained training on observation techniques and protocol by an experienced individual prior to conducting the survey. Transects have been 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

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

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 300 mm length (Neumann and Allen 2007; Neumann et al. 2012).

RESULTS

North Fork Coeur d’Alene River

A total of 631 Westslope Cutthroat Trout, 78 Rainbow Trout, and 1,409 Mountain Whitefish was observed among the 44 sampling sites in the North Fork Coeur d’Alene River drainage. In addition, we observed 72 Largescale Sucker *Catostomus macrocheilus* and 168 Northern Pikeminnow *Ptychocheilus oregonsis*. We also noted adult and juvenile Redside Shiner *Richardsonius balteatus* and Longnose Dace *Rhinichthys cataractae*. Mean total density of Westslope Cutthroat Trout was 0.51 fish/100 m^2 in the North Fork Coeur d’Alene River (including Teepee Creek) and 0.64 fish/100m^2 in the Little North Fork Coeur d’Alene River (Figure 3). Mean density of Westslope Cutthroat Trout ≥ 300 mm was 0.16 fish/100 m^2 in the North Fork Coeur d’Alene River and 0.08 fish/m^2 in the Little North Fork Coeur d’Alene River (Figure 4). For Westslope Cutthroat Trout during 2016, the mean estimates of total density and density of fish ≥ 300 mm were lower than the 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 0.04 fish/ 100 m^2 and 0.16 fish/100m^2 in the Little North Fork Coeur d’Alene River (Figure 5). Mean total density of Mountain Whitefish was 1.02 fish/100 m^2 in the North Fork Coeur d’Alene River and 0.03 fish/100 m^2 in the

Little North Fork Coeur d'Alene River (Figure 6). We estimated a RSD of 47 for the Coeur d'Alene River Basin (Figure 11).

St. Joe River

A total of 801 Westslope Cutthroat Trout, 38 Rainbow Trout, and 998 Mountain Whitefish was observed among the 35 sampling sites in the St. Joe River. In addition, we observed 162 Largescale Sucker, 265 Northern Pikeminnow. Four Bull Trout *S. confluentus* were observed during 2016 sampling at sites between Prospector and Ruby creeks. Mean total density of Westslope Cutthroat Trout was 1.41 fish/100 m^2 (Figure 7). Mean density of Westlope Cutthroat Trout ≥ 300 mm was 0.40 fish/100 m^2 (Figure 8). The mean estimates total density and density of fish ≥ 300 mm during 2016 were lower than the 10-year averages of 1.82 fish/100 m^2 and 0.64 fish/100 m^2. Mean total density of Rainbow Trout and Mountain Whitefish was < 0.01 fish/ 100 m^2 and 1.11 fish/100 m^2, respectively (Figures 9 and10). Size structure of Westslope Cutthroat Trout in the St. Joe River (RSD-300 = 49) 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 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 and the IDFG manages for low abundance of Rainbow Trout in the Spokane River Basin to 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 history, a major concern among the angling public has been the effect of summer conditions and its interaction with angling-induced fish mortality. Severe drought conditions during 2015 did not appear to cause substantial direct mortality of Westslope Cutthroat Trout. Flow conditions were again low during 2016. As in 2015, we did not observe any dead Westslope Cutthroat Trout at any of our snorkel sites nor did we receive public comments about dead fish being observed during the summer and early-fall months. Although anecdotal, such observations

might indicate a negative relationship between extreme environmental conditions and Westslope Cutthroat Trout mortality. Both river systems showed declines in Westslope Cutthroat Trout density during 2016; however, current densities are only slightly below the 10-year mean, and above the overall mean. In addition, we documented declines in the density of all fish species, suggesting that declines in abundance were not species-specific. The long-term effects of severe summer drought conditions on recruitment dynamics and somatic growth are not yet understood, but will probably be revealed through continued annual monitoring.

MANAGEMENT RECOMMENDATIONS

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

2. Continue to monitor trends in fish assemblage characteristics.

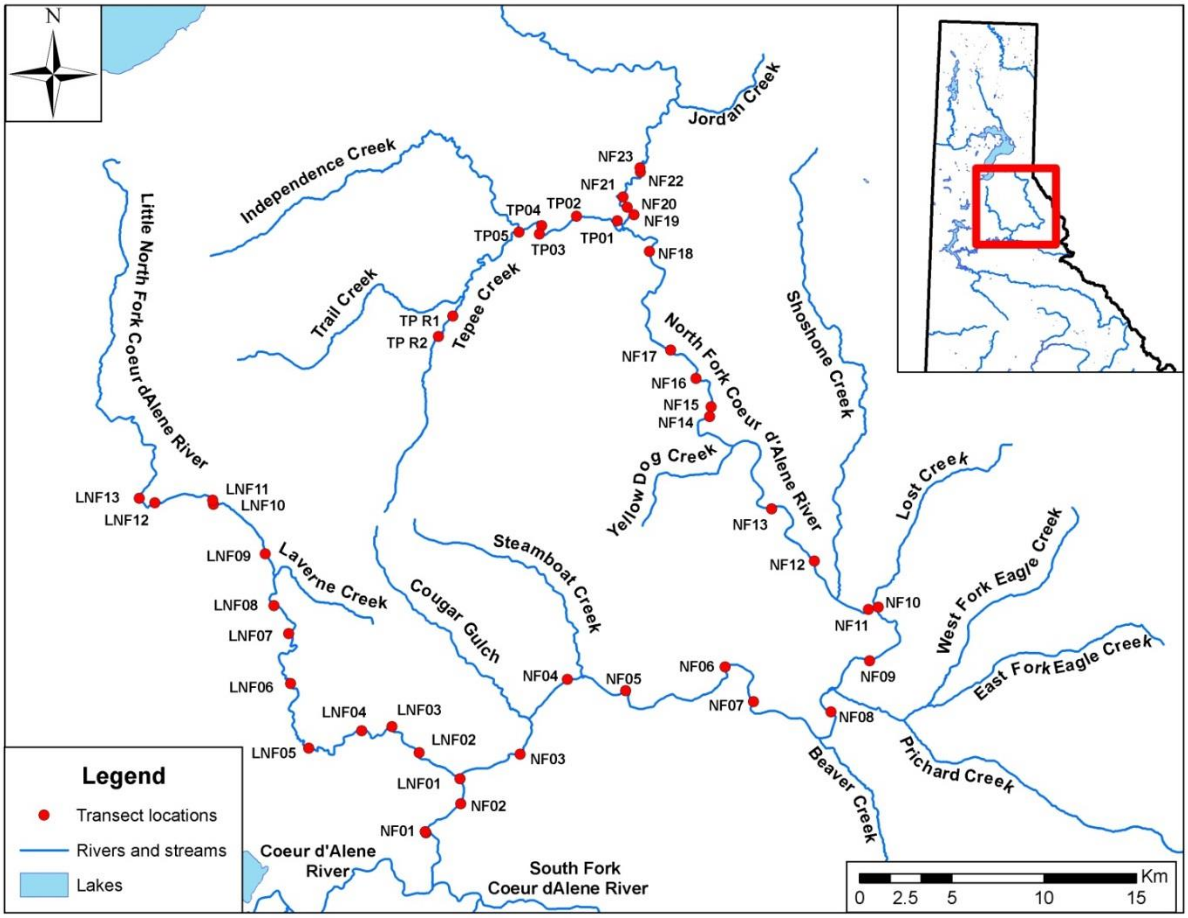

Figure 50. Location of 44 index reaches sampled using snorkeling in the Coeur d'Alene River, Idaho during August 1–3, 2016.

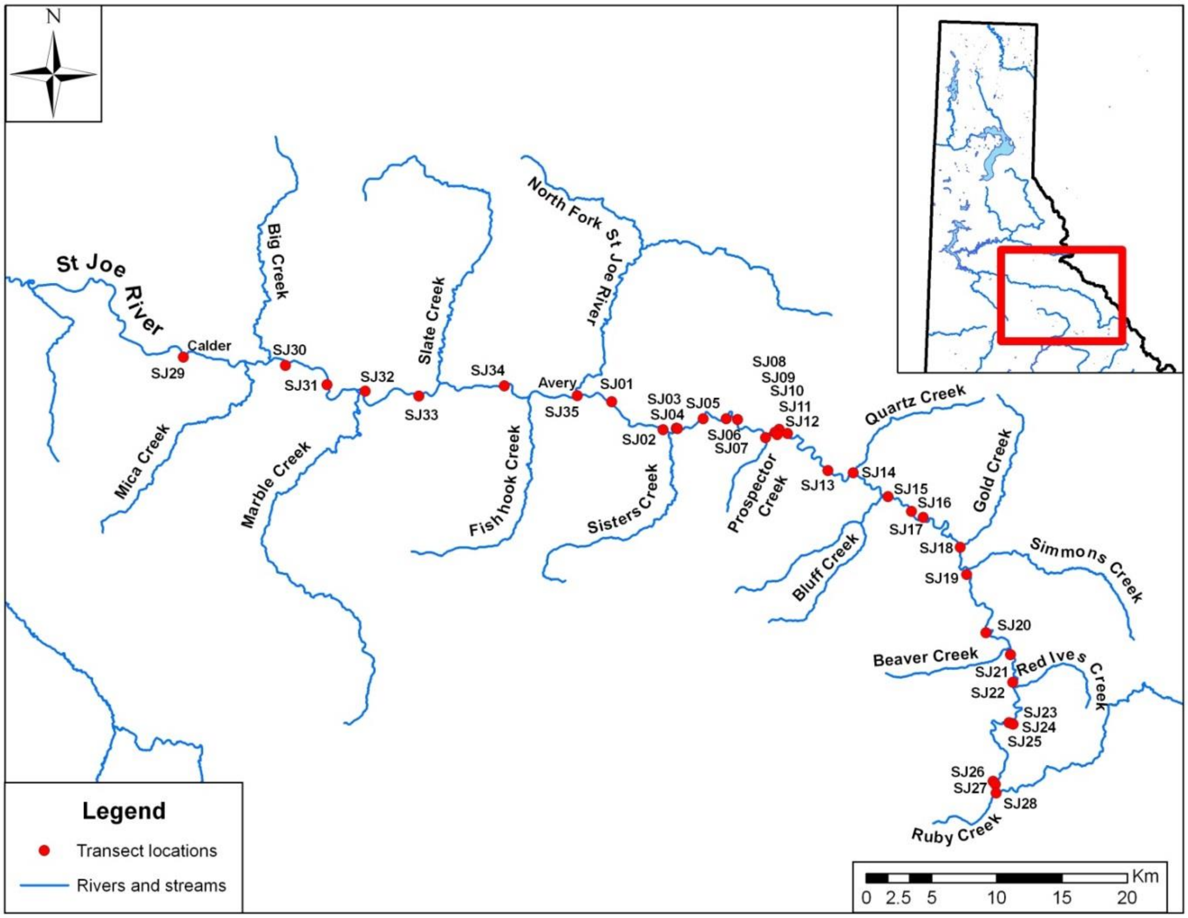

Figure 51. Location of 35 index reaches sampled using snorkeling in the St. Joe River, Idaho during July 25–27, 2016.

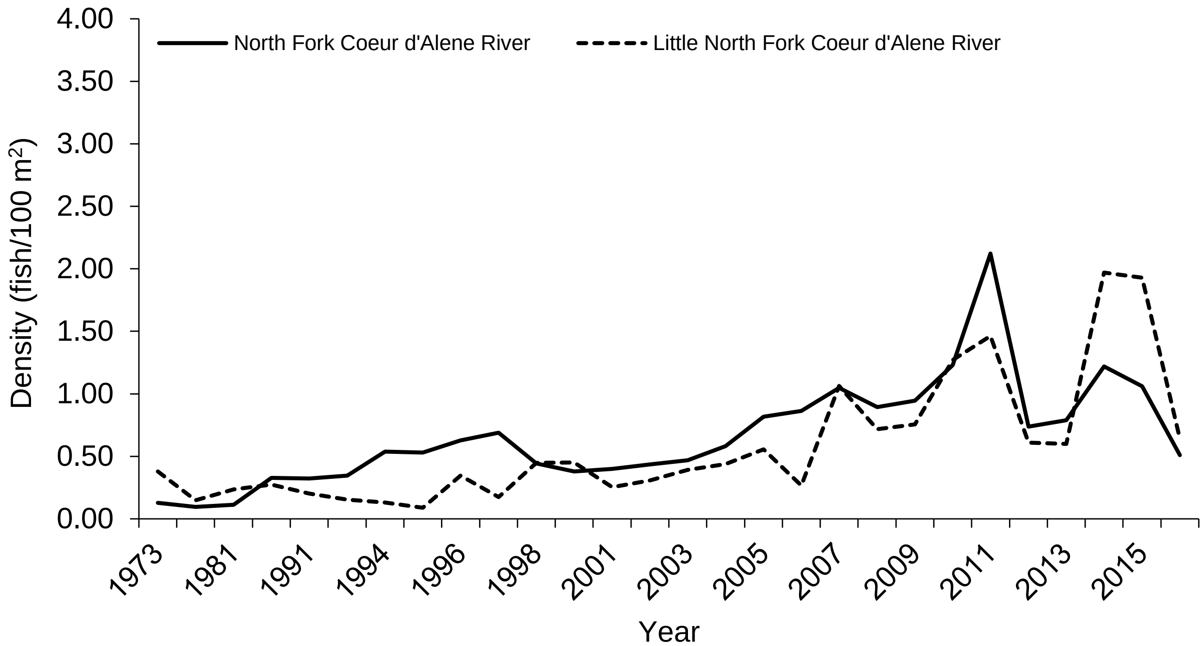

Figure 52. Mean density of Westslope Cutthroat Trout observed during snorkeling in the North Fork of the Coeur d'Alene River and Little North Fork of the Coeur d'Alene River (1973–2016).

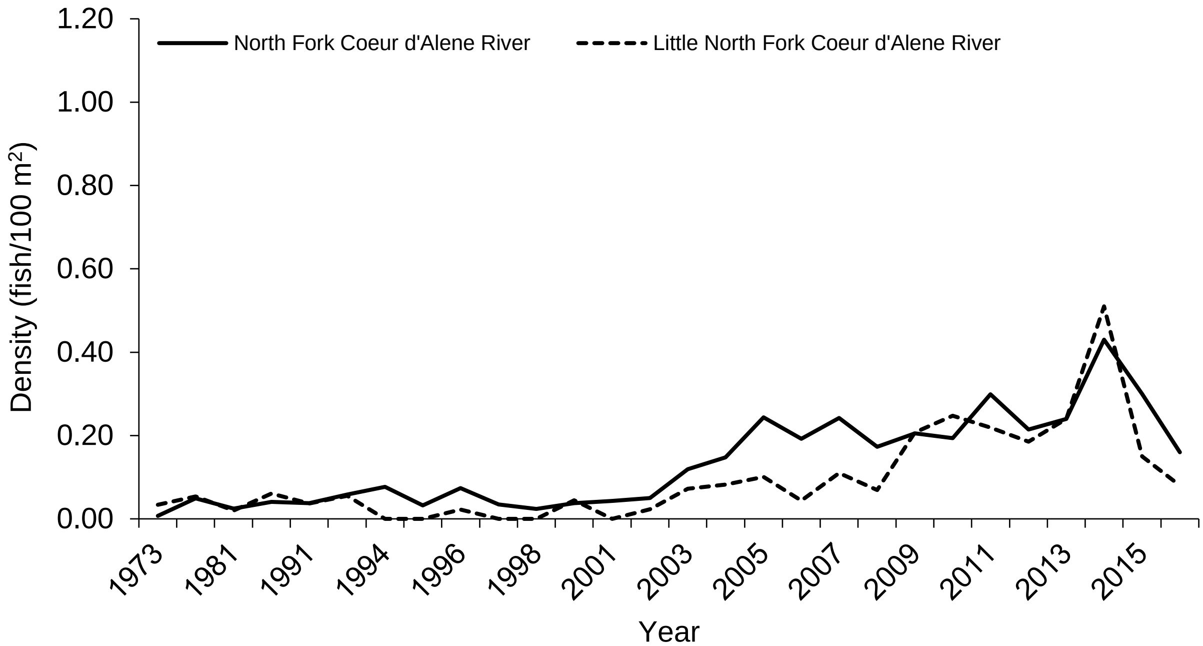

Figure 53. Mean density of Westslope Cutthroat Trout larger than 300 mm TL observed during snorkeling in the North Fork of the Coeur d’Alene River and Little North Fork of the Coeur d’Alene River (1973–2016).

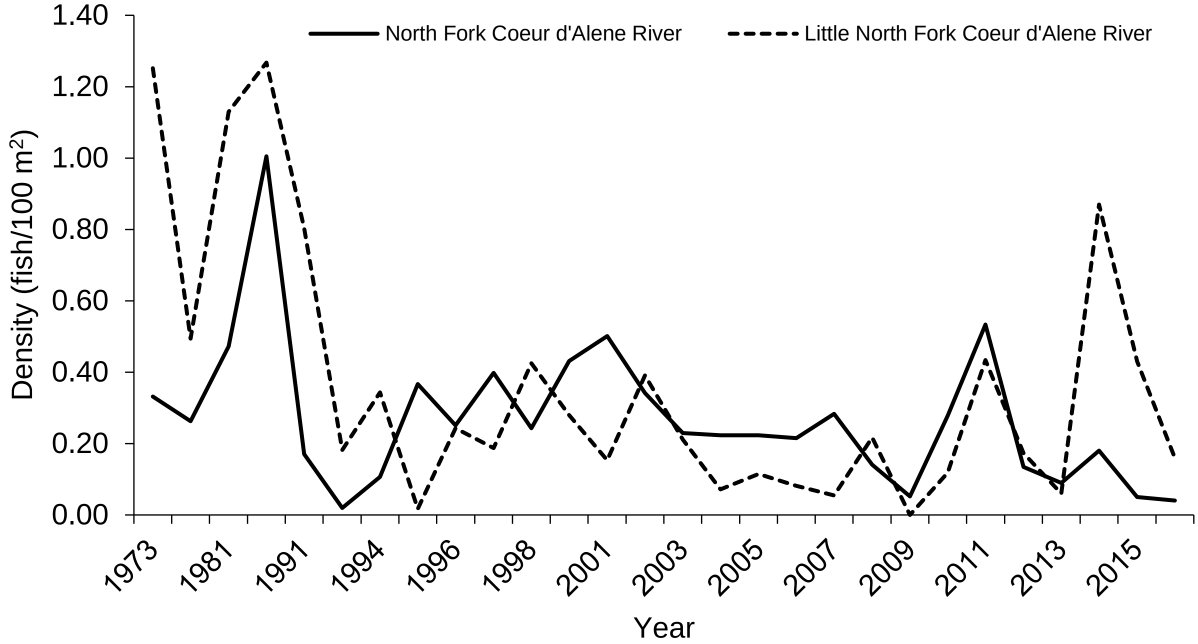

Figure 54. Mean density of Rainbow Trout observed during snorkeling in the North Fork of the Coeur d'Alene River and Little North Fork of the Coeur d'Alene River (1973–2016).

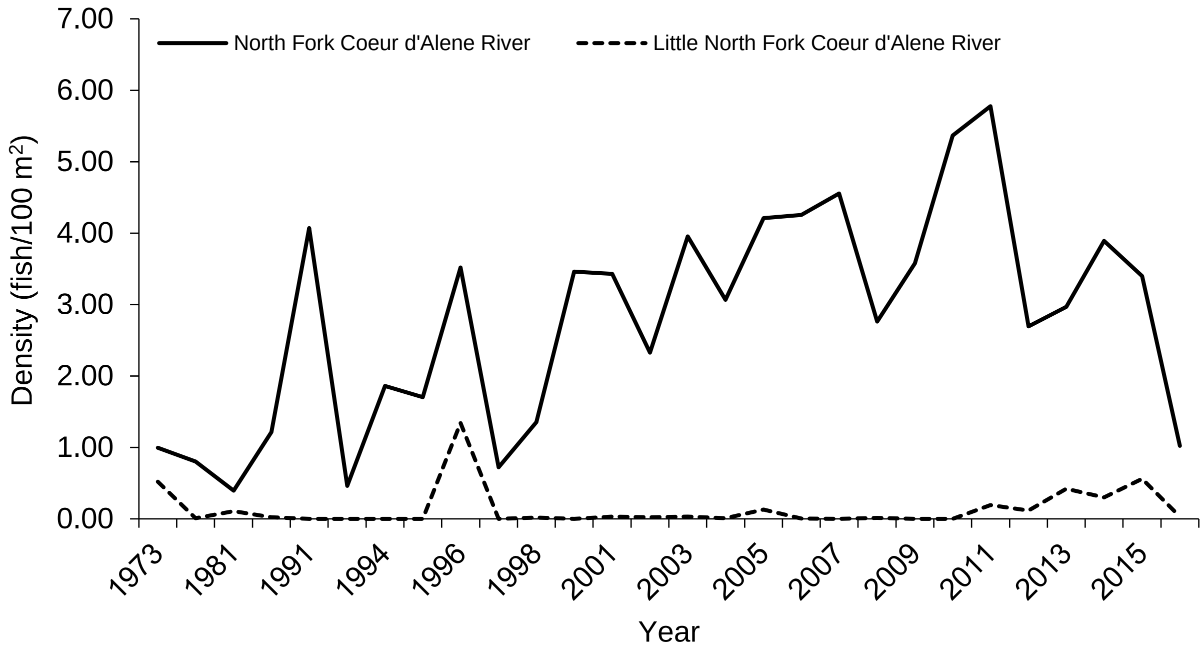

Figure 55. Mean density of Mountain Whitefish observed during snorkeling in the North Fork of the Coeur d’Alene River and Little North Fork of the Coeur d’Alene River (1973–2016).

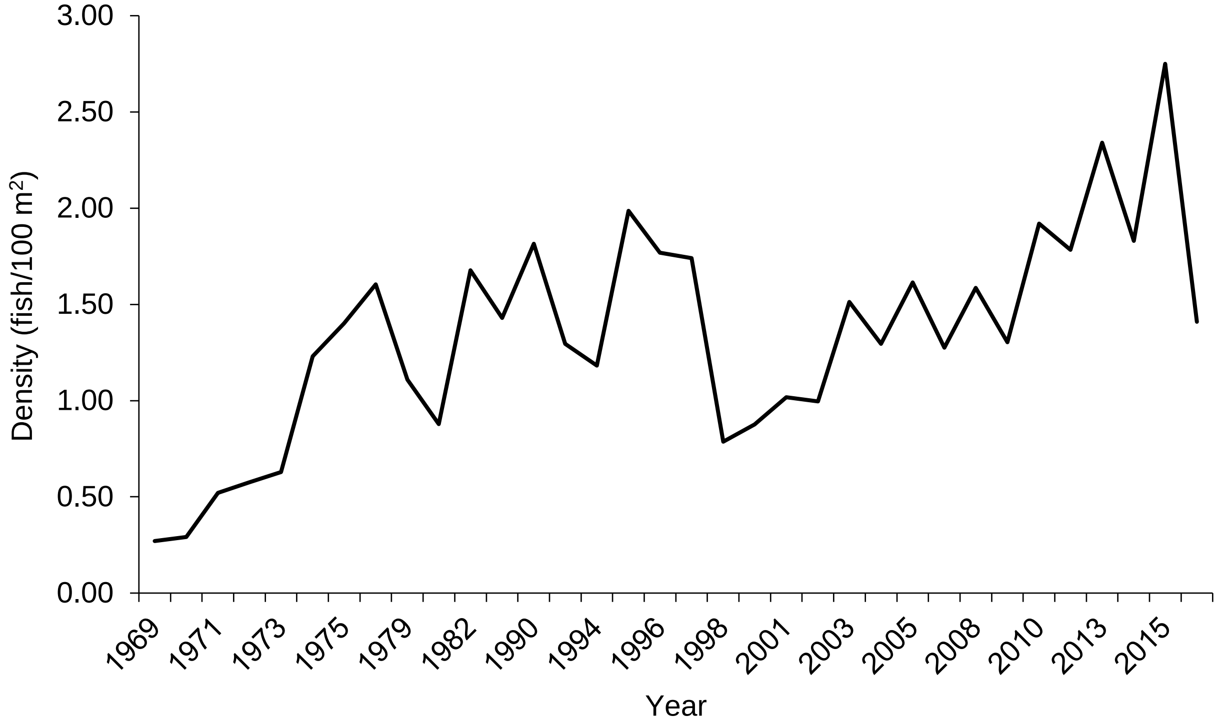

Figure 56. Mean density of Westslope Cutthroat Trout observed during snorkeling in the St. Joe River (1969–2016).

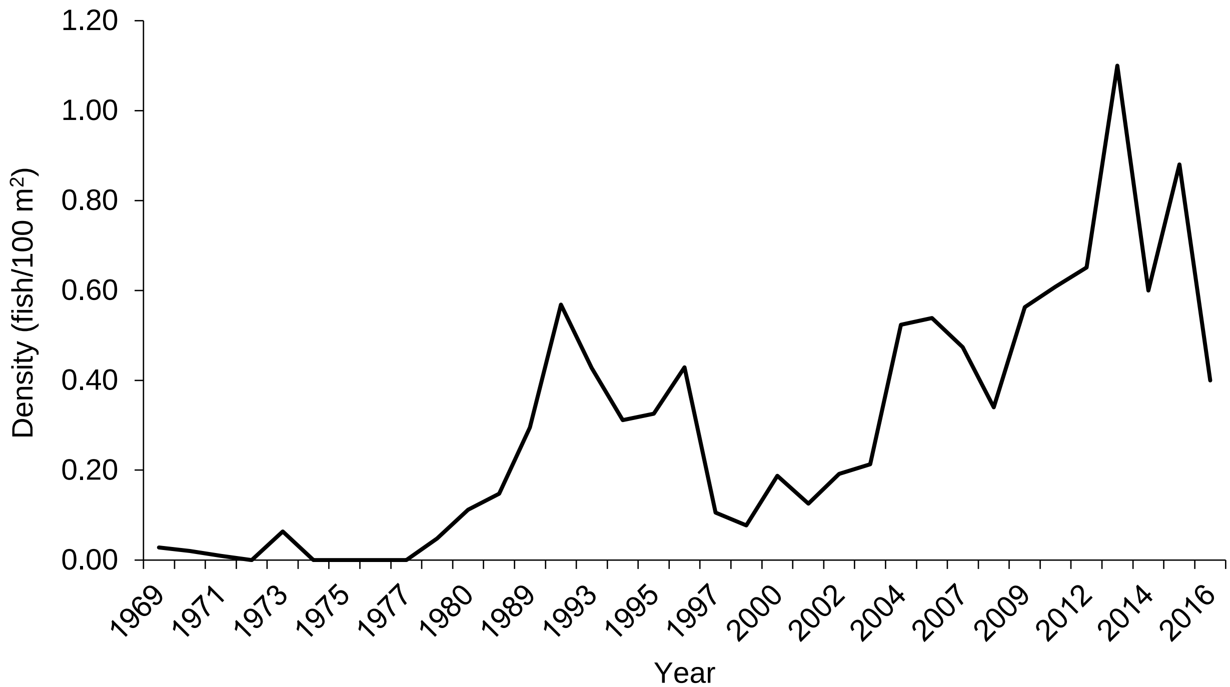

Figure 57. Mean density of Westslope Cutthroat Trout larger than 300 mm TL observed during snorkeling in the St. Joe River (1969–2016).

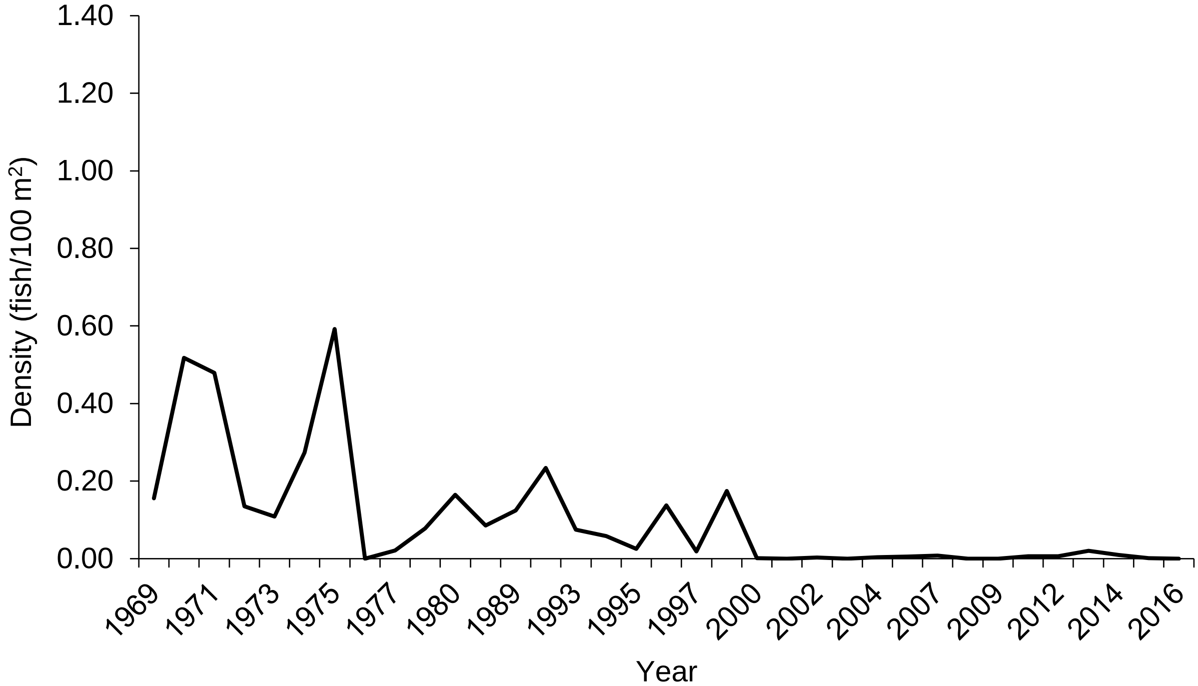

Figure 58. Mean density of Rainbow Trout observed during snorkeling in the St. Joe River (1969–2016).

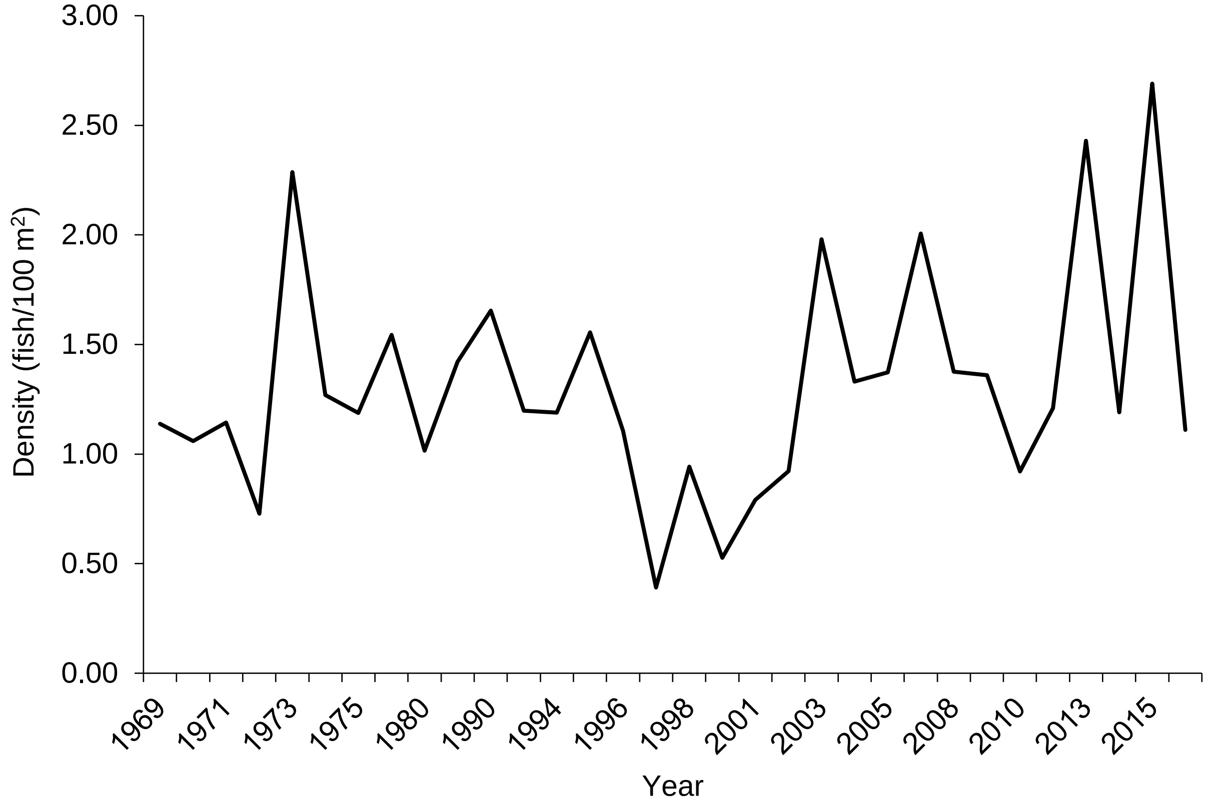

Figure 59. Mean density of Mountain Whitefish observed during snorkeling in the St. Joe River (1969–2016).

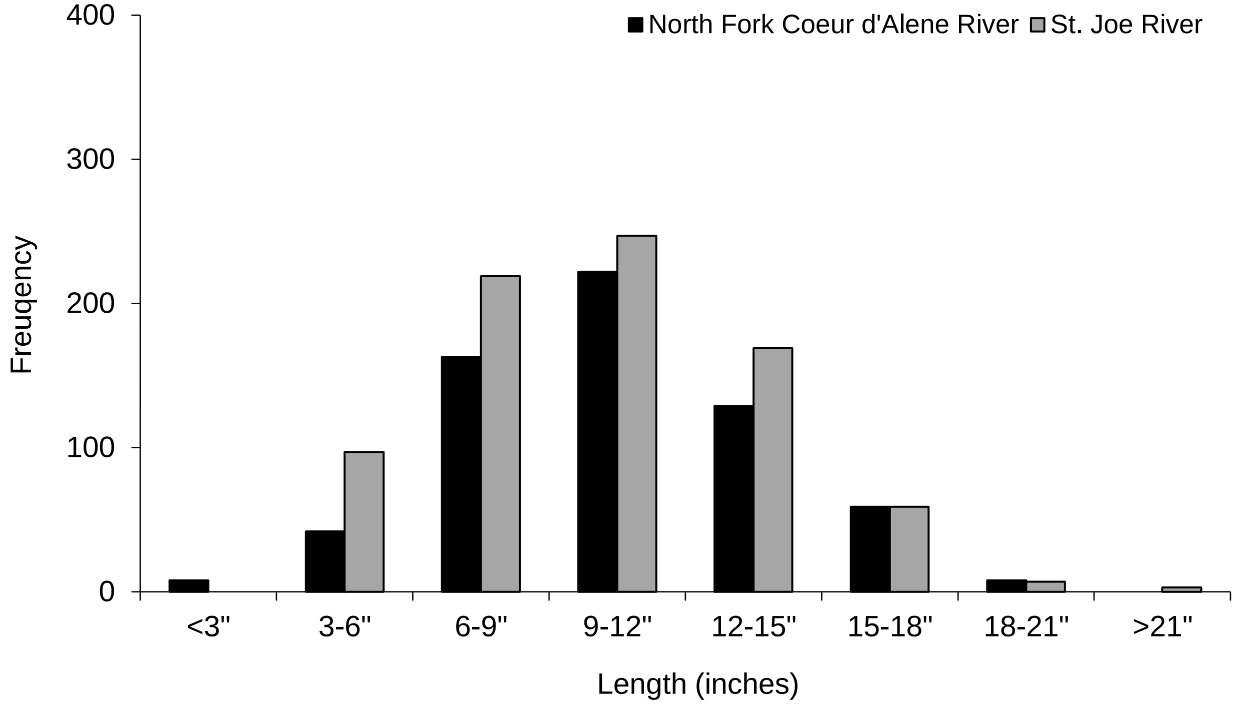

Figure 60. Length-frequency distributions of Westslope Cutthroat Trout observed during snorkeling in the North Fork Coeur d'Alene River (includes Little North Fork Coeur d'Alene River and Teepee Creek) and St. Joe River (2016).

LAKE COEUR D'ALENE CHINOOK SALMON EVALUATIONS

ABSTRACT

We evaluated escapement of Fall Chinook Salmon *Oncorhynchus tshawytscha* to assess trends in adult abundance by enumerating redds at standard index reaches of the Coeur d'Alene and St. Joe rivers. In 2016, we observed a total of 105 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 at-large. Future assessments should include annual monitoring of adult escapement and spawner age structure so that changes in abundance and age-at-maturity can be identified. Information related to population characteristics can be used to better management of the Lake Coeur d'Alene fishery.

In addition to adult abundance monitoring, we continued efforts to improve hatchery Fall Chinook Salmon performance. Similar to 2015, experimental fall outplants occurred during 2016 in Wolf Lodge Creek and Wolf Lodge Bay to evaluate relative return-to-creel. Stocking performance is anticipated to be evaluated using fishery dependent data from angler logs kept by avid Chinook Salmon anglers. We also sought to collect eggs from locally-adapted individuals that home to tributaries in the north end of Lake Coeur d'Alene. Eggs were to be used for the following year's stocking. We operated a weir on Wolf Lodge Creek near the Interstate-90 bridge to collect upstream migrants during September 14 – October 9. A total of 14 Fall Chinook Salmon was collected during weir operation, most of which were adipose-removed individuals of hatchery origin. Too few wild Chinook Salmon were available to satisfy broodstock requirements. We recommend continued monitoring of hatchery fish performance using fishery-dependent data obtained from angler records. Additionally, improving performance of hatchery products and dispersing the fall fishery should remain a priority. Efforts to improve performance should focus on utilizing locally-adapted adlfuvial 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.

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INTRODUCTION

Chinook Salmon *Oncorhynchus tshawytscha* is an anadromous Pacific salmon species historically found throughout the Columbia River Basin (Wallace and Zaroban 2013). While anadromy is the natural life history form of Chinook Salmon, 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 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. 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 stocking (or lack thereof) 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 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 attempt to emigrate 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 residentializing 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.

STUDY AREA

Lake Coeur d'Alene is a natural mesotrophic 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 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

Chinook Salmon escapement has been monitored using annual redd counts in the Coeur d'Alene and St. Joe rivers since 1990. We summarized redd abundance to provide insight on adult escapement and to monitor trends in natural production. 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, 2016 and the St. Joe index reach during October 4, 2016 using a drift boat. 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.

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 and Wolf Lodge Bay (Figure 1) on September 20, 2016. Hatchery Chinook Salmon were stocked post-smoltification 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.

RESULTS

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 2016 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 2016 (Figure 2).

Fourteen adult Chinook Salmon were trapped at the weir on Wolf Lodge Creek during September and October, of which twelve were hatchery origin individuals. Ripe eggs were not harvested due to the low observed return and paucity of wild, locally-adapted individuals.

DISCUSSION

The Chinook Salmon fishery has improved substantially over the past decade, although 2016 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. 2018). The most recent redd survey (fall 2016) showed that adult escapement was slightly above the long-term average (mean = 84.5 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-removed 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 reports are not uncommon and are received from both anglers and Washington Department of Fish and Wildlife personnel. Post-release emigration has been documented in other lentic systems in Idaho where Fall Chinook Salmon are stocked. For instance, hatchery Chinook Salmon stocked into Deadwood Reservoir in the Southwest Region have been sampled in Black Canyon Reservoir on the Payette River (Koenig et al. 2015). Additionally, hatchery Chinook Salmon stocked into Anderson Ranch Reservoir have been reported in Arrowrock Reservoir and Lucky Peak Reservoir

(Arthur Butts, personal communication). 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.

MANAGEMENT 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.

Table 30. 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	2016	2015	2014	2013	2012
	Coeur d'Alene River					
CDA 1	Cataldo to S.F. Coeur d'Alene River confluence	76	210	104	108	65
CDA 2	S.F. to L.N.F Coeur d'Alene River confluence	29	68	62	2	7
CDA 3	S.F. Coeur d'Alene River	--	10	4	14	13
	St. Joe River					
SJR 1	St. Joe City to Calder bridge	0	15	9	4	9

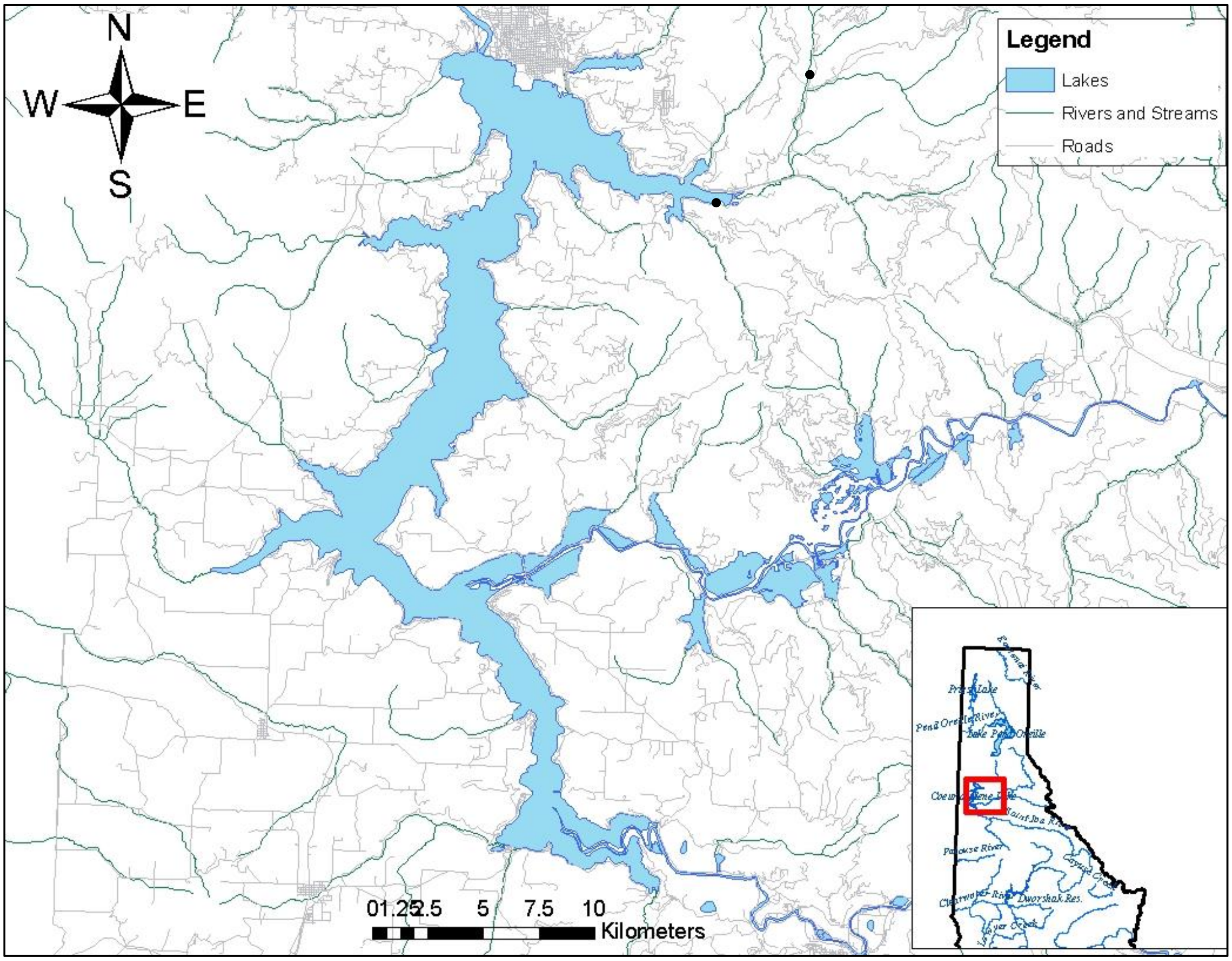

Figure 61. Location of Lake Coeur d'Alene, Idaho. The black dots represent the location of the adult trap and where juvenile hatchery Chinook Salmon were released.

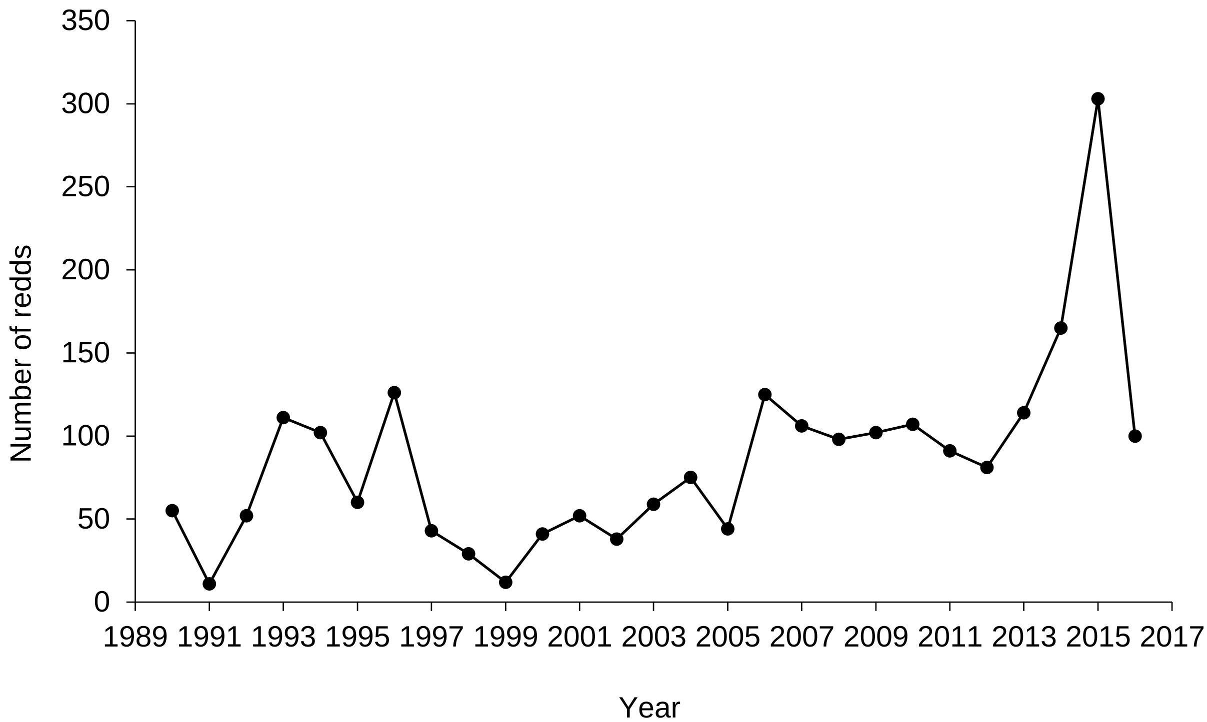

Figure 62. Number of Chinook Salmon redds counted during sampling of index reaches in the Coeur d'Alene River and St. Joe River from 1990–2016.

WINDY BAY NORTHERN PIKE MANAGEMENT

ABSTRACT

Adfluvial populations of Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* in the Lake Coeur d'Alene basin have declined in recent history. Predation by nonnative Northern Pike *Esox lucius* has been demonstrated to be a significant factor limiting the recovery of certain adlfuvial Westslope Cutthroat Trout subpopulations in the basin. Following two years of research evaluating food habitats and predation patterns of Northern Pike in Lake Coeur d'Alene, the Coeur d'Alene Tribe identified predation-related mortality as a critical factor hampering population growth of Westslope Cutthroat Trout in Lake Creek. Lake Creek enters Lake Coeur d'Alene in Windy Bay, an area that provides ample spawning habitat for Northern Pike during the spring. Northern Pike occupancy around the mouth of Lake Creek coincides with emigration of sub-adult Westslope Cutthroat Trout and immigration of adult Westslope Cutthroat Trout. Ecological overlap lends itself to high consumption rates of adlfuvial Westslope Cutthroat Trout, and thus, creates a mortality "bottleneck." In cooperation with the Coeur d'Alene Tribe, we implemented a Northern Pike management strategy that would alleviate the predation risk to migrating Westslope Cutthroat Trout, but not adversely affect the popular Northern Pike fishery. During 14 March–15 April, 2016 we captured 161 Northern Pike from Windy Bay around the inlet of Lake Creek using experimental mesh gill nets. 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 are readily available to more anglers. Mean total length of Northern Pike was 583 mm and varied from 415–941 mm. Mean catch-per-unit-effort (CPUE) across all sampling events was < 0.01 fish/net h. Catch rates decreased markedly during the removal period and were substantially lower compared to 2015. We used a simple depletion model to estimate a total subpopulation abundance of 162 Northern Pike, which was a 50.0% reduction compared to 2015. In total, 111 Northern Pike were translocated to Cougar Bay and nine of those were reportedly caught by anglers. Anglers harvested all of the reported Northern Pike, and we estimated an annual exploitation rate of 19.6%. Short-term site fidelity of Northern Pike appeared to be low and only two translocated individuals migrated back to Windy Bay after removal. We will continue this Northern Pike management strategy in Windy Bay through 2017 on a trial basis. During that time, we will continue to evaluate site fidelity of translocated Northern Pike, angler exploitation, and recolonization rates in Windy Bay.

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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 19^{th} 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 often has negative effects to the native ecosystem. Native species are often affected 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. Nonnative predators are regarded as posing the most imminent threat to fish community structure and species persistence in North America.

Examples of the negative effects of top-down 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 “Chain Lakes” along the lower Coeur d’Alene River. Since that time, Northern Pike have spread throughout the Lake Coeur d’Alene basin and have been introduced to many neighboring water bodies in the Idaho Panhandle, to which their current distribution in Idaho is limited (Ryan et al. 2014). Northern Pike are classified as a game fish species in Idaho; however, Idaho Department of Fish and Game’s (IDFG) management policy prohibits fish introductions (IDFG 2013a). Further, the policy attempts to discourage illegal fish introductions by forbidding the use of special rules (including bag limitations) and mandating catch-and-kill angling tournaments focused on illegally introduced species.

The Lake Coeur d’Alene system has the longest history of Northern Pike occupancy among all northern Idaho waters. The lake also serves as important habitat for adult adfluvial Westslope Cutthroat Trout, 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 tribal jurisdiction. 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 anglers. Angling clienteles develop around introduced sportfishes 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 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 public interest groups and 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.

OBJECTIVES

1. In cooperation with Coeur d'Alene Tribe fisheries staff, mitigate predation risk to adfluvial Westslope Cutthroat Trout through seasonal translocation of Northern Pike from Windy Bay to Cougar Bay.

2. Estimate removal efficiency of Northern Pike in Windy Bay.

3. Evaluate angler exploitation of translocated Northern Pike.

4. Evaluate site fidelity of translocated Northern Pike.

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). The headwaters of Lake Creek originate near Mica Peak and it flows in a southeasterly direction until it joins the lake. 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 headwater reaches of Lake Creek and Windy Bay are owned and managed by the state of Idaho.

METHODS

Northern Pike were sampled daily (Monday–Friday only) during March 12–April 30, 2015 using 45 × 1.8 m experimental sinking gill nets (five panels with 50, 64, 76, 88, and 100-mm stretch-measure mesh). 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 (2013). Our goal was to minimize capture mortality of Northern Pike, so gill nets were soaked for 3–4 hours before retrieval. Several overnight gill net sets were conducted on a trial basis to evaluate Northern Pike survival from nets with longer soak times. Mortality from overnight gill net sets was relatively high, so short daytime sets were used in all subsequent sampling. Catch-per-unit-effort (CPUE) was estimated as the number of Northern Pike captured per net/h. We used the DeLury depletion method to estimate the population size of Northern Pike in Windy Bay. We modelled 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).

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

Northern Pike were then transported to Cougar Bay near the north end of Lake Coeur d'Alene, approximately 22.9 air km from the capture site. Condition of translocated Northern Pike was again assessed after they had been transported to the release location; individuals in poor condition (i.e., likely to expire) were killed.

RESULTS

A total of 161 Northern Pike was captured during the five-week-long event. Of these, 111 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 Northen Pikeminnow *Ptychocheilus oregonesis*. Observed survival of Northern Pike captured was 47.4% (SE = 5.1) and 76.5% for overnight and daytime gill net sets, respectively. Although higher mortality resulted from longer soak time, the degree of gill net entanglement and handling time was thought to be the most influential factor on mortality. Overall, 56.3% of Northern Pike survived and were successfully translocated to Cougar Bay.

Catch rates for Northern Pike declined substantially over the course of the removal effort from 0.01 during the first week of removal to <0.01 during the last week and averaged 0.10 (Table 1). Total subpopulation abundance in Windy bay was estimated at 162 fish (Figure 2). Mean total length was 583 mm (415–941 mm) for all Northern Pike captured in Windy Bay, 571 (415–865 mm) for Northern Pike translocated to Cougar Bay, and 546 mm (467–735 mm) for translocated Northern Pike caught by anglers (Figure 3). Angler exploitation of translocated Northern Pike was 19.6% after one year at-large. All of the harvested fish were reportedly caught in the north portion of Lake Coeur d'Alene in the vicinity of Cougar Bay. Size structure of Northern Pike translocated to Cougar Bay was similar to that of all Northern Pike captured in the study.

DISCUSSION

The management strategy that we implemented was developed following a comprehensive evaluation of the effects of Northern Pike predation on Westslope Cutthroat Trout and extensive public input. Our strategy focuses on small scale removal and translocation that will not adversely affect the fishery at-large, while helping to conserve the local Westslope

Cutthroat population. Over the past two years, we have removed 472 Northern Pike from Windy Bay around the vicinity of the Lake Creek inlet. We estimated a total population size of 162 Northern Pike in 2016, which is an approximately 50% decrease population from the year prior. In comparison to 2015, we were able to reach critical population depletion with three weeks of effort (includes daily overnight gill net sets) and maintained low catch rates through the duration of the removal effort. In contrast, we observed an increase in catch rates late in the 2015 effort, presumably due to emigration of post-spawn Northern Pike from Lake Creek.

Site fidelity of Northern Pike in the Lake Coeur d'Alene system is poorly understood, but there is some evidence suggesting that it may be quite high. Walrath (2013) sampled various bays around Lake Coeur d'Alene and did not document movement of Northern Pike between sampling sites. Additionally, tagged Northern Pike caught by anglers in the author's study were usually caught in the general vicinity of the initial capture location. We assume that movement of Northern Pike is minimal and that they have a high affinity for particular locations that provide good habitat. However, we are unsure whether fish that are translocated many km will display high movement or strong fidelity to their capture location. Thus far, we documented immigration of three Northern Pike back to Windy Bay from the translocation site. The large majority of translocated Northern Pike reported by anglers were also caught in the general vicinity of Cougar Bay and around the Spokane River, a pattern consistent with fish translocated during 2015. Two Northern Pike were reportedly caught south of the northern pool of Lake Coeur d'Alene (i.e., south of the area near Arrow and Threemile Point), the exception being one fish reportedly caught in Mica Bay and another caught in the lower Coeur d'Alene River.

Angler exploitation of translocated Northern Pike in the 2016 release (μ = 19.60%) was lower than those translocated in 2015 (μ = 34.3%). However, the 2016 angler exploitation estimate is lower than estimates for Northern Pike population exploitation in Lake Coeur d'Alene (Walrath et al. 2015b). We suspect that the increased use of overnight gill net sets may have negatively influenced post-release survival and biased our exploitation estimate. Cougar Bay typically receives high angler use due to its close proximity to Coeur d'Alene and good shoreline access. Much of the northwest shore of Cougar Bay is owned by the Bureau of Land Management and has ample roadside parking along Highway 95. As such, many anglers make the short drive from town to target Northern Pike in Cougar Bay, likely resulting in higher annual exploitation relative to other popular angling locations (i.e., Wolf Lodge Bay, Harrison area) around the lake (J.P. Fredericks, personal communication). We are confident that translocation of Northern Pike to Cougar Bay maximizes their susceptibility to angler harvest.

Size structure of Northern Pike from our 2016 removal effort was similar to 2015. The most notable difference in size structure was the absence of Northern Pike smaller than 400 mm in the 2016 catch. We did not observe a difference in size structure between our full sample and fish translocated to Cougar Bay, suggesting that mortality from gillnetting and handling was not size related. Size structure trends will be useful for documenting Northern Pike recruitment from Windy Bay and recolonization rates.

We demonstrated the use of a relatively benign control method for a nonnative species to benefit 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. Overall, we effectively suppressed adult Northern Pike during the spring of 2015, which compliments the objectives of the Coeur d'Alene Tribe for Westslope Cutthroat Trout restoration in Lake Creek. Long term, managers will require high removal efficiency, low recolonization, and high fidelity to translocation sites for this project to be deemed effective. In addition, Coeur d'Alene Tribe fishery managers will evaluate the response of juvenile-adult returns of adfluvial Westslope Cutthroat Trout to Lake

Creek. Specifically, managers will need to document increases in Westslope Cutthroat Trout survival and abundance that can be ascribed to Northern Pike removal for the program to warrant long-term implementation.

MANAGEMENT RECOMMENDATIONS

1. Complete pilot project in 2017 under the same primary objectives.

2. Cooperate with Coeur d'Alene Tribe to understand abundance trends for adult Westslope Cutthroat Trout returning to Lake Creek in response to reduced Northern Pike abundance in Windy Bay.

Table 31. Weekly catch information for Northern Pike suppression in Windy Bay including sampling time period, gill net set type, and catch statistics.

Week	Period (dates)	*n* (captured)	*n* (translocated)	Recaptures	CPUE (fish/net h)*	Total length (mm) Mean	Total length (mm) Min–Max
2016							
1	3.14–3.18	50	32	--	0.01	615	465–941
2	3.21–3.25	64	45	--	<0.01	535	415–778
3	3.28–4.1	21	15	1 (2015)	<0.01	615	458–771
4	4.4–4.8	7	5	--	<0.01	662	417–883
5	4.11–4.15	19	14	1 (2015)	<0.01	594	472–802
Total		161	111				
2015							
1	3.12–3.20	113	93	--	0.44	564	288–1,000
2	3.23–3.27	47	43	--	0.24	588	420–850
3	3.30–4.30	59	40	--	0.10	571	329–1,020
4	4.6–4.10	33	19	--	0.04	460	254–795
5	4.13–4.16	11	10	--	0.07	592	480–947
6	4.20–4.24	30	22	--	0.11	582	410–825
7	4.27–4.30	18	7	1 (2015)	0.04	615	494–870
Total		311	234				

*Reflects both daytime and overnight gillnet soaks.

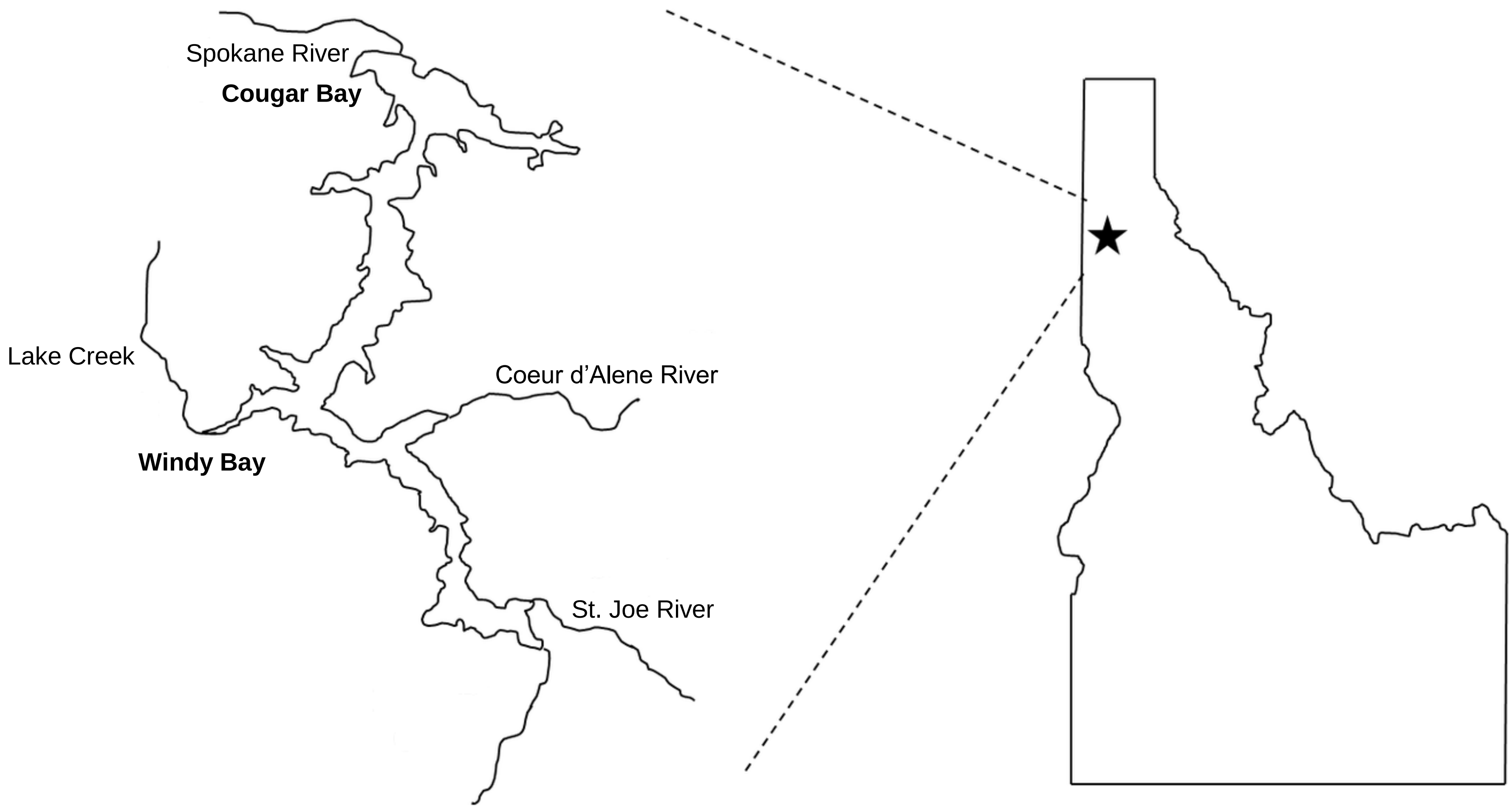

Figure 63. Map of the Lake Coeur d'Alene, Idaho and major tributaries. Capture and translocation areas are indicated by bold text.

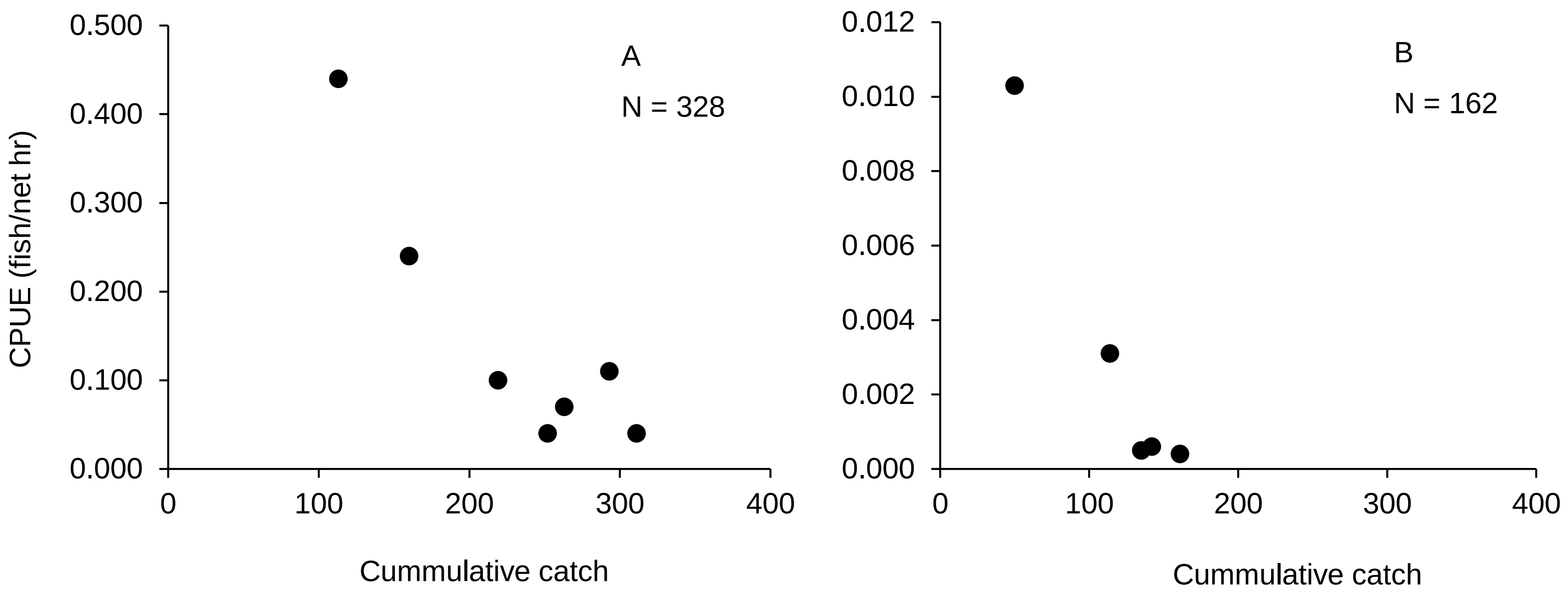

Figure 64. Relationship between catch-per-unit-effort (CPUE) and cumulative catch of Northern Pike sampled in Windy Bay, Lake Coeur d'Alene during spring removal in 2015 (panel A) and 2016 (panel B). Estimated abundance of Northern Pike in Windy Bay during each year is indicated.

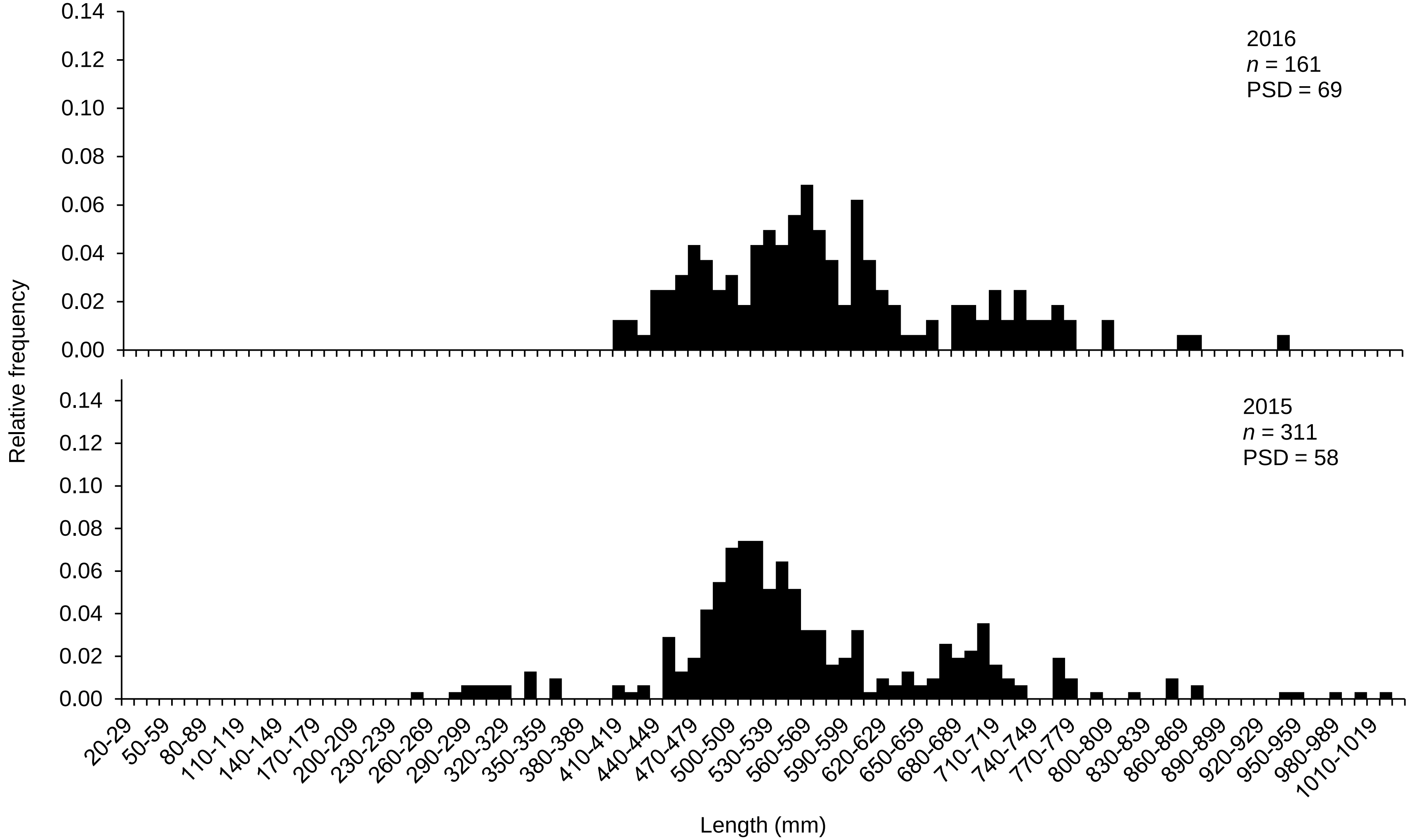

Figure 65. Length-frequency distributions for all Northern Pike sampled during 2015 (bottom panel) and 2016 (top panel).

PANHANDLE REGION BULL TROUT REDD COUNTS

ABSTRACT

In 2016, we counted Bull Trout *Salvenlinus confluentus* redds as an index of adult abundance in two major drainages in northern Idaho's Panhandle Region. A total of 76 redds were detected, including 63 redds in the Upper Priest Lake drainage, and 13 redds in the St. Joe River drainage. Although typically surveyed, the Kootenai River drainage was not counted in 2016 due to high flow conditions during October. Redd count totals from 2016 were variable relative to average counts from the previous ten-year period, but did not suggest dramatic shifts in Bull Trout abundance at the core area scale.

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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 (Bouwens et al. 2017).

STUDY SITES

Bull Trout redds were counted in headwater streams within the Upper Priest Lake and St. Joe River drainages where bull trout were known to spawn. These watersheds make up two of the four different core areas that occur in the IDFG Panhandle Region.

METHODS

We counted Bull Trout redds in selected tributaries of the Upper Priest Lake and St. Joe River drainages where migratory Bull Trout were known or believed to spawn. Although typically surveyed, the Kootenai River drainage was not counted in 2016 due to high flow conditions during October. We located redds visually by walking along standardized sections within each tributary (Ryan et al. 2014; Table 1; Table 2). Surveys were conducted by experienced redd counters or an experienced countered 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 core area. 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 29, 2016. We counted 63 redds across seven standardized (Ryan et al. 2014) stream reaches surveyed in the core area (Table 3). Overall counts increased from the previous year and were above the previous 10-year average for combined counts of 41 redds.

St Joe Core Area

St Joe River core area redd counts were completed on October 6, 2016. We surveyed standardized reaches in 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 13 redds among three index reaches in the core area (Table 4). We counted 11 redds in Medicine Creek and two redds in the St. Joe River between Heller Creek and St. Joe Lake. Total redds observed in 2016 were far below the 10-year average for index streams. Redd counts in the three index streams have been in a steep decline since 2008 (Table 4). This is a notable conservation concern because a continued decline will put this population at risk of extirpation.

The number of streams surveyed per year in the St. Joe River core area has varied considerably over time. Interpretation of total count values should be done cautiously. We recommend focusing future efforts primarily on index streams to better understand trends in redd abundance.

MANAGEMENT RECOMMENDATIONS

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

2. Continue to balance the frequency and location of surveys with the availability of time and intended use of collected data.

3. Focus future efforts in the St. Joe basin primarily on index streams to better understand trends in redd abundance

Table 32. 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 33. Bull Trout redd survey stream reaches for St. Joe River surveys in 2016.

Stream	Reach description	Downstream location		Upstream location	
		latitude	longitude	latitude	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 34. Bull Trout redd counts by year from tributaries in the Upper Priest Lake drainage, Idaho from 1993 through 2016. Redd surveys were not completed on all stream reaches in all years from 1993 through 2006. As such, averaged redd counts for surveys completed between these years may include fewer completed counts.

Stream	Transect description	Avg. 1993 -2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Upper Priest River	Falls to Rock Cr.	13	5	14	5	17	10	36	34	58	25	17
	Rock Cr. to Lime Cr.	1	0	0	2	4	1	0	7	8	12	34
	Lime Cr. to Snow Cr.	6	1	5	10	3	1	3	6	9	13	11
	Snow Cr. to Hughes Cr.	4	1	2	4	0	7	2	2	0	1	0
	Hughes Cr. to Priest Lk	0	--	--	--	0	0	0	--	--	--	--
Rock Cr.	Mouth to F.S. trail 308	0.4	0	0	0	1	0	0	--	--	--	--
Lime Cr.	Mouth upstream 1.2 km	0.3	0	0	0	0	0	0	--	--	--	--
Cedar Cr.	Mouth upstream 3.4 km	0.3	0	0	0	0	0	0	--	--	--	--
Ruby Cr.	Mouth to waterfall	0	0	0	0	0	--	--	--	--	--	--
Hughes Cr.	Trail 311 to trail 312	1	0	0	0	0	0	0	--	--	--	--
	F.S. road 622 to Trail 311	1	0	0	5	0	7	5	0	3	0	0
	F.S. road 622 to mouth	2	0	0	3	11	3	2	1	2	3	1
Bench Cr.	Mouth upstream 1.1 km	0.4	0	0	0	0	0	0	--	--	--	--
Jackson Cr.	Mouth to F.S. trail 311	0	0	0	0	0	0	0	--	--	--	--
Gold Cr.	Mouth to Culvert	3	0	1	5	6	2	4	3	1	0	0
Boulder Cr.	Mouth to waterfall	0	0	0	0	0	--	0	--	--	--	--
Trapper Cr.	Mouth upstream 5.0 km upstream from East Fork	2	0	0	0	0	--	0	--	--	--	--
Caribou Cr.	Mouth to old road crossing	0.2	--	--	--	0	--	--	--	--	--	--
All stream reaches combined		31	7	22	34	42	31	52	53	81	54	63

Table 35. 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 2006. As such, averaged redd counts for surveys completed between these years may include fewer completed counts.

Stream name	Avg 1992 - 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Aspen Cr.	0	--	--	--	--	--	--	--	--	--	--
Bacon Cr.	0	--	--	0	--	--	0	--	0	--	--
Bad Bear Cr.	0	--	--	--	--	--	--	--	--	--	--
Bean Cr.	7	--	--	1	--	--	1	0	--	--	--
North Fork Bean Creek	0	--	--	--	--	--	19	8	0	--	--
Unnamed tributary to N.Fk. Bean	0	--	--	--	--	--		3	--	--	--
Beaver Cr.	0	0	0	0	3	--	0	--	--	--	--
Bluff Cr.- East Fork	0	--	--	--	--	--	--	--	--	--	--
California Cr.	1	0	0	2	--	--	0	--	--	0	--
Cascade Creek	0	--	--	--	--	--	2	--	--	--	--
Copper Cr.	0	0	0	--	--	--	--	--	--	--	--
Entente Cr.	0	--	--	--	--	--	--	--	--	--	--
Fly Cr.	0	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	0	3	9	5	5	--	0	11	--
Indian Cr.	0	--	--	--	--	--	--	--	--	--	--
Medicine Cr.	35	55	71	41	48	35	20	20	17	4	11
Mill Cr.	0	--	--	--	--	--	9	6	--	--	--
Mosquito Cr.	1	--	--	--	--	--	--	--	--	--	--
My Cr.	0	--	--	--	--	--	0	--	--	--	--
Pole	0	--	--	--	--	--	0	--	--	--	--
Quartz Cr.	0	--	--	--	--	--	--	--	--	--	--
Red Ives Cr.	0	1	1	--	2	4	0	--	0	0	--
Ruby Cr.	3	--	--	--	--	--	0	--	--	--	--
Sherlock Cr.	1	0	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 35 (continued)

Stream name	Avg 1992 - 2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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	6	8	1	5	7	4	1	0	7	2
Three Lakes Creek	0	--	--	--	--	--	--	--	--	--	--
Timber Cr.	0	--	--	--	--	--	--	--	--	--	--
Tinear Cr.	0	--	--	--	--	--	2	5	--	--	--
Wampus cr	0	--	--	--	--	--	--	--	--	--	--
Washout cr.	1	--	--	--	--	--	--	--	--	--	--
Wisdom Cr	7	32	27	8	1	1	5	1	0	0	0
Yankee Bar	1	0	0	--	--	--	--	--	--	1	--
Total - Index Streams	49	93	106	50	54	43	29	22	17	11	13
Total - All Streams	57	94	113	57	69	52	69	44	17	26	13
Number of streams counted	14	11	12	15	8	5	18	8	8	9	3

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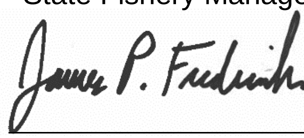

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