FISHERY MANAGEMENT INVESTIGATIONS

IDAHO DEPARTMENT OF FISH AND GAME
FISHERY MANAGEMENT ANNUAL REPORT

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PANHANDLE REGION

2019

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June 2023
IDFG 23-105

TABLE OF CONTENTS

POPULATION CHARACTERISTICS AND DYNAMICS OF BLACK BASS IN CHACOLET LAKE AND BENEWAH LAKE 1
- ABSTRACT 1
- INTRODUCTION 2
- METHODS 2
  - Fish Sampling 2
  - Hard Structure Processing 3
  - Data analysis 3
- RESULTS 4
- DISCUSSION 5
- MANAGEMENT RECOMMENDATIONS 7

LAKE COEUR D'ALENE CHINOOK SALMON EVALUATIONS 15
- ABSTRACT 15
- INTRODUCTION 16
- OBJECTIVES 17
- STUDY AREA 18
- METHODS 18
  - Spawner abundance 18
  - Performance of supplemental Chinook Salmon 18
- RESULTS 19
- DISCUSSION 19
- MANAGEMENT RECOMMENDATIONS 20

LAKE COEUR D'ALENE AND SPIRIT LAKE KOKANEE EVALUATIONS 25
- ABSTRACT 25
- INTRODUCTION 26
- OBJECTIVES 27
- STUDY AREA 27
  - Lake Coeur d'Alene 27
  - Spirit Lake 27
- METHODS 28
- RESULTS 29
  - Lake Coeur d'Alene 29
  - Spirit Lake 29
- DISCUSSION 29
  - Lake Coeur d'Alene 29
  - Spirit Lake 30
- MANAGEMENT RECOMMENDATIONS 31

SPOKANE BASIN WILD TROUT MONITORING 39
- ABSTRACT 39
- INTRODUCTION 40
- OBJECTIVES 41
- STUDY AREA 41
- METHODS 41
- RESULTS 42
  - Coeur d'Alene River Basin 42
  - St. Joe River 43
- DISCUSSION 43
- MANAGEMENT RECOMMENDATIONS 45

BULL TROUT REDD COUNTS 53

ABSTRACT 53
INTRODUCTION 54
METHODS 54
RESULTS AND DISCUSSION 54
  Priest Lake 54
  St Joe 55
  Kootenai River Core Area 55
MANAGEMENT RECOMMENDATIONS 56
HATCHERY RAINBOW TROUT EVALUATIONS 61
ABSTRACT 61
INTRODUCTION 62
STUDY AREA 62
  Cocolalla Lake 62
  Fernan Lake 63
METHODS 64
RESULTS 64
  Cocolalla Lake 64
  Fernan Lake 64
DISCUSSION 65
MANAGEMENT RECOMMENDATIONS 66
HAYDEN LAKE INVESTIGATIONS 68
ABSTRACT 68
INTRODUCTION 69
OBJECTIVES 70
METHODS 70
  Rainbow Trout Stocking Evaluation 70
  Kokanee Monitoring 70
  Mysid Monitoring 71
RESULTS 71
  Rainbow Trout Stocking Evaluation 71
  Kokanee Monitoring 71
  Mysid Monitoring 71
DISCUSSION 71
MANAGEMENT RECOMMENDATIONS 72
LAKE PEND OREILLE SMALLMOUTH BASS INVESTIGATIONS 76
ABSTRACT 76
INTRODUCTION 77
OBJECTIVES 78
METHODS 78
RESULTS 79
DISCUSSION 80
MANAGEMENT RECOMMENDATIONS 83
PRIEST RIVER POPULATION MONITORING 89
ABSTRACT 89
INTRODUCTION 90
METHODS 90
RESULTS 91
DISCUSSION 92
MANAGEMENT RECOMMENDATIONS 94
PRIEST LAKE FISHERY INVESTIGATIONS 102
ABSTRACT 102

INTRODUCTION....103
METHODS....104
  Acoustic Kokanee Survey....104
  Shoreline Kokanee Count....105
  Mysid Survey....105
RESULTS....105
  Acoustic Kokanee Monitoring....105
  Shoreline Kokanee Count....105
  Mysid Survey....106
DISCUSSION....106
MANAGEMENT RECOMMENDATIONS....107
PRIEST AND UPPER PRIEST LAKES MANAGEMENT PUBLIC OPINION SURVEY....113
ABSTRACT....113
INTRODUCTION....114
METHODS....114
RESULTS....115
DISCUSSION....116
MANAGEMENT RECOMMENDATIONS....117
APPENDICES....124
LAKE TROUT MANAGEMENT IN UPPER PRIEST LAKE....127
ABSTRACT....127
INTRODUCTION....128
OBJECTIVE....128
STUDY SITE....128
METHODS....129
RESULTS....130
DISCUSSION....130
MANAGEMENT RECOMMENDATIONS....131
BONNER LAKE BURBOT STOCKING EVALUATION....135
ABSTRACT....135
INTRODUCTION....136
METHODS....136
RESULTS....137
DISCUSSION....137
MANAGEMENT RECOMMENDATIONS....137
ROSE LAKE NORTHERN PIKE POPULATION EVALUATION....140
ABSTRACT....140
INTRODUCTION....141
OBJECTIVES....141
STUDY AREA....141
METHODS....142
RESULTS....143
DISCUSSION....143
MANAGEMENT RECOMMENDATIONS....144
LITERATURE CITED....146

LIST OF TABLES

Table 1. Sample size (n), mean catch-per-unit-effort (CPUE = fish/h of electrofishing, ±1 SE), total length (mm; Minimum–Maximum [Min–Max]) statistics, proportional size distribution (PSD), total annual mortality (A), recruitment coefficient of determination (RCD), recruitment variability index (RVI), annual angler exploitation (µ ± 90% C.I.) and angler use (± 90% C.I.) for Largemouth Bass and Smallmouth Bass sampled during 2019 in Benewah and Chatcolet lakes (pooled). 8

Table 2. Chinook Salmon redd counts in the Coeur d'Alene (CDA) River drainage, St. Joe River, and Wolf Lodge Creek, Idaho, 1990-2019..................................21

Table 3. Estimated abundance of kokanee made by midwater trawl in Lake Coeur d'Alene, Idaho, from 1979–2019. 32

Table 4. Estimated abundance of kokanee made by midwater trawl in Spirit Lake, Idaho, from 1981–2019. 33

Table 5. Bull Trout redd counts by stream and count transect from the Upper Priest River, Idaho. Redd counts were reported for 2019. Average redd counts were reported for the previous 10-year period (2009-2018) and the period from 1993 through 2018. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row. 57

Table 6. Bull Trout redd counts by stream and count transect from the St. Joe River, Idaho. Redd counts were reported for 2020. Average redd counts were reported for the previous 10-year period (2010-2019) and the period from 1992 through 2019. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row. 58

Table 7. Bull Trout redd counts by stream and count transect from tributaries to the Kootenai River, Idaho. Redd counts were reported for 2019. Average redd counts were reported for the previous 10-year period (2009-2018) and the period from 2001 through 2018. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row. 60

Table 8. Rainbow Trout stocked, proportion tagged, adjusted exploitation (*µ*; ± 80% C.I.), and adjusted total use (± 80% C.I.) by stocking month from Cocolalla Lake and Fernan Lake, Idaho. 67

Table 9. History of Rainbow Trout stocking in Hayden Lake, Idaho from 2011 through 2019. Information provided includes year and season of stocking, hatchery of origin, strain, size, number of fish stocked, and marks present on stocked fish to identify stocking group. 73

Table 10. Catch (*n*), catch rate, mean total length (TL), and length spread by species from a gill net survey used to evaluate Rainbow Trout stocking in Hayden Lake, Idaho during April 2019. 74
Table 11. Kokanee catch (*n*) by age from suspended gill nets fished in Hayden Lake, Idaho in July 2019. Associated metrics include length range observed and proportion identified as hatchery-origin. 74
Table 12. Catch (*n*) and catch rate (CPUE ± 80% C.I.) of Smallmouth Bass by zone and associated length of caught fish (TL = total length) from an electrofishing survey of Lake Pend Oreille, Idaho in June 2019. 84
Table 13. Tag allocation and tag returns associated with estimation of exploitation on Smallmouth Bass in Lake Pend Oreille, Idaho from June 2019 through May 2020. Tag encounters listed include those from fish harvested, caught and released, and harvested only because they were tagged (BT Harvested). 84
Table 14. Site location (river km), area surveyed, and counts of primary species observed from snorkel surveys of the Priest River, Idaho in June 2019. 95
Table 15. Site location (river km), area surveyed and counts of primary species observed from snorkel surveys of the Priest River, Idaho in August 2019. 96
Table 16. Site location (river km), area surveyed, and counts of primary species observed from snorkel surveys of coldwater transects in the Priest River, Idaho in August 2019. 97
Table 17. Mean density (fish/100 m^2) by species, sample period, and transect type from June and August snorkel surveys of the Priest River, Idaho. Numbers in parentheses represent one standard error about mean density estimates. Mean density values in bold represent significantly greater values in density comparisons. 97
Table 18. Acoustic kokanee survey results from Priest Lake, Idaho on August 7, 2019. 108
Table 19. Kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 to 2019. 109
Table 20. Mysid density estimates from Priest Lake on May 28, 2019. Densities were listed by sample location (UTM, zone 11, WGS84) and life stage (young-of-year (YOY) and combined immature/adult). 110
Table 21. Proposed Priest Lake fishery management alternatives summarizing management actions and related details. 118
Table 22. Proportional survey responses by survey method to questions asked in a 2017-2018 opinion survey used to estimate angler preferences for fishery management of Priest Lake and Upper Priest Lake, Idaho. 120
Table 23. Gill net effort and Lake Trout (LKT) catch by gill net mesh size in Upper Priest Lake, Idaho in 2019. Total length ranges of Lake Trout caught were reported by associated gill net mesh sizes. 132
Table 24. Bonner Lake Burbot sampling locations from April 2019. 138
Table 25. Bonner Lake Burbot stocking history. 138

LIST OF FIGURES

Figure 1. Bass species composition within each sampling unit in both Chatcolet Lake (numbers) and Benewah Lake (letters). Pie chart size represents relative abundance of bass sampled and pie chart locations represent the start of each sampling unit. 9

Figure 2. Length-frequency distributions for Smallmouth Bass (top panel) and Largemouth Bass (bottom panel) sampled from Benewah and Chatcolet lakes. 10

Figure 3. Length-at-age and von Bertalanffy growth functions for Smallmouth Bass (top panel) and Largemouth Bass (bottom panel) sampled from Benewah and Chatcolet lakes (pooled)....................11

Figure 4. Mean (±1 SD) back-calculated length at age and relative growth index (RGI; numbers above symbols) for Largemouth Bass and Smallmouth Bass sampled in Benewah Lake and Chatcolet Lake (pooled). 12

Figure 5. Mean relative weight (±95% C.I.) by length category for Largemouth Bass (top panel) and Smallmouth Bass (bottom panel) sampled from Benewah and Chatcolet lakes (pooled). Dashed line represents standard weights....................13

Figure 6. Estimates from Studentized residuals from catch curve regressions for Largemouth Bass and Smallmouth Bass from Chatcolet and Benewah lakes (pooled). Dashed lines represent the 80th and 20th percentiles. Positive residuals above the 80th percentile line represent strong year classes and negative residuals below the 20th percentile represent weak year classes....................14

Figure 7. Location of Lake Coeur d'Alene, Idaho. The black dot represents the location where juvenile hatchery Chinook Salmon were released. 23

Figure 8. Number of Chinook Salmon redds counted during sampling of index reaches in the Coeur d'Alene River and St. Joe River from 1990–2019. 24

Figure 9. Approximate location of historical trawling transects used to estimate abundance of kokanee in Lake Coeur d'Alene, Idaho. 34

Figure 10. Approximate location of historical trawling transects used to estimate abundance of kokanee in Spirit Lake, Idaho....................35

Figure 11. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (August 3–4, 2019). 36

Figure 12. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (August 3–4, 2019). 36

Figure 13. Length-frequency distribution for male and female spawning kokanee sampled from Lake Coeur d'Alene, Idaho (December 6, 2019). 37

Figure 14. Mean total length of mature male and female kokanee sampled near Higgens Point in Lake Coeur d'Alene, Idaho (1954–2019). Horizontal lines indicate the upper and lower limit of the adult length management objective (250–280 mm). 37

Figure 15. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (August 2, 2019). 38

Figure 16. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (August 2, 2019). 38

Figure 17. Location of 44 index reaches sampled using snorkeling in the Coeur d'Alene River, Idaho during July 22–24, 2019. 46
Figure 18. Location of 35 index reaches sampled using snorkeling in the St. Joe River, Idaho during July 29–30, 2019. 47
Figure 19. Density and 10-year average of Westslope Cutthroat Trout observed during snorkeling in the Coeur d'Alene River basin (1973–2019). 48
Figure 20. Density and 10-year average of Westslope Cutthroat Trout larger than 305 mm TL observed during snorkeling in the Coeur d'Alene River basin (1973–2019). 48
Figure 21. Density and 10-year average of Rainbow Trout observed during snorkeling in the Coeur d'Alene River basin (1973–2019). 49
Figure 22. Density and 10-year average of Mountain Whitefish observed during snorkeling in the Coeur d'Alene River basin (1973–2019). 49
Figure 23. Density and 10-year average from the current year of Westslope Cutthroat Trout observed during snorkeling in the St. Joe River (1969–2019). 50
Figure 24. Density and 10-year average from current year of Westslope Cutthroat Trout larger than 305 mm TL observed during snorkeling in the St. Joe River (1969–2019). 50
Figure 25. Density and 10-year average from current year of Rainbow Trout observed during snorkeling in the St. Joe River (1969–2019). 51
Figure 26. Density and 10-year average from current year of Mountain Whitefish observed during snorkeling in the St. Joe River (1969–2019). 51
Figure 27. Length-frequency distributions of Westslope Cutthroat Trout observed during snorkeling in the Coeur d'Alene River basin and St. Joe River (2019). 52
Figure 28. Mean density of immature and adult mysids in Hayden Lake, Idaho by year from 2010 through 2019. Error bars represent 80% confidence intervals. 75
Figure 29. Sampling zones and electrofishing sites for a Smallmouth Bass survey conducted on Lake Pend Oreille, Idaho in June 2019. 85
Figure 30. Length-frequency of Smallmouth Bass caught by electrofishing from Lake Pend Oreille, Idaho in June 2019. 85
Figure 31. Mean length-at-age of Smallmouth Bass caught by electrofishing from Lake Pend Oreille, Idaho in June 2019. 86
Figure 32. Catch frequency by age of Smallmouth Bass caught in electrofishing samples of Lake Pend Oreille, Idaho in June 2019. Figure includes an associated catch curve used to estimate annual mortality in the population. 86
Figure 33. Length-frequency of tagged Smallmouth Bass collected from electrofishing samples in June 2019 and gill-net samples in April 2019 from Lake Pend Oreille, Idaho. 87
Figure 34. Proportion of Smallmouth Bass tagged by size class in Lake Pend Oreille, Idaho in 2019 and associated estimates of adjusted exploitation. Size classes include stock (180-279 mm; TL), quality (280-349 mm), preferred (350-429 mm), and memorable/trophy (≥ 430 mm). 87

Figure 35. Proportional catch by length of Smallmouth Bass from Lake Pend Oreille, Idaho in electrofishing samples in June 2019 and gill net samples in October 2017. 88
Figure 36. Locations of standard monitoring transects (IDFG 2011-2019) and coldwater transects (KNRD CW) surveyed in 2019 on the Priest River, Idaho. 98
Figure 37. Relative frequency by length group (mm) of fish observed in snorkel surveys of standard transects on the Priest River, Idaho in June and August 2019 and targeted sites designated as coldwater transects, also surveyed in August 2019. 99
Figure 38. Estimated density of all salmonids by transect from June and August 2019 snorkel surveys of the Priest River, Idaho. River kilometer zero represents the confluence of the Priest River and Pend Oreille River. 100
Figure 39. Mean density (fish/100 m^2) of primary species observed in snorkel surveys of standard transects on the Priest River, Idaho in June and August 2019 and targeted sites designated as coldwater transects, also surveyed in August 2019. Error bars represent one standard error about mean density estimates. 100
Figure 40. Mean density (fish/100 m^2) of primary species observed in snorkel surveys of standard transects on the Priest River, Idaho in August 2011 and 2019. Error bars represent one standard error about mean density estimates. 101
Figure 41. Standard transects on Priest Lake, Idaho used in an acoustic survey of kokanee abundance on August 7, 2019. 111
Figure 42. Kokanee density estimates from Priest Lake, Idaho acoustic surveys from 2012 through 2019. 111
Figure 43. Adult kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 through 2019 and corresponding length of male kokanee spawners. 112
Figure 44. Estimated mean densities of immature and adult mysids in Priest Lake from 2013 through 2019. Error bars represent 80% confidence intervals. No survey was conducted in 2018. 112
Figure 45. Proportional survey response by survey method gauging angler experience fishing Priest Lake, Idaho from a 2017-2018 opinion survey used to estimate angler preferences for management of the Priest Lake fishery. 122
Figure 46. Proportional survey response by survey method gauging angler preference for proposed fishery management alternatives of Priest Lake, Idaho from a 2017-2018 opinion survey. 122
Figure 47. Proportional survey response by survey method gauging angler preference for proposed fishery management alternatives of Priest Lake, Idaho from a 2017-2018 opinion survey. Responses represent preferences for new management direction from those survey participants who indicated they desired a different management alternative than the status quo. 123
Figure 48. Average daily Lake Trout catch rates (± 80% CI) by year from combined standard gill net mesh sizes (51, 64 , and 76 mm) fished in Upper Priest Lake, Idaho between 2010 and 2019. 133

Figure 49. Average daily Lake Trout catch rate (Lake Trout/box (± 80% CI) by mesh size from all standardized gill nets fished in Upper Priest Lake, Idaho from 2014 to 2019. 133
Figure 50. Size structure of Lake Trout sampled in Upper Priest Lake, Idaho in 2019. 134
Figure 51. Average daily Bull Trout catch rate (Bull Trout/box ± 80% CI) from all mesh sizes fished in Upper Priest Lake, Idaho from 2007 to 2019. Confidence intervals were only estimated for years in which gill nets mesh and effort were standardized. 134
Figure 52. Burbot CPUE and average total length (TL) from spring sampling efforts in 2017, 2018, and 2019 on Bonner Lake, Idaho. Catch in all years was represented primarily by the 2015 cohort. 139
Figure 53. Length-frequency distribution for Northern Pike sampled from Rose Lake in April 2019. 145

LIST OF APPENDICES

Appendix A. Opinion survey used to gauge angler preferences for fishery management of Priest Lake and Upper Priest Lake, Idaho in 2017-2018. 124

POPULATION CHARACTERISTICS AND DYNAMICS OF BLACK BASS IN CHACOLET LAKE AND BENEWAH LAKE

ABSTRACT

In collaboration with the Idaho Department of Fish and Game, the Coeur d'Alene Tribe initiated a project to improve survival of adfluvial Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* by reducing Northern Pike *Esox lucius* abundance in the southern end of Lake Coeur d'Alene, which includes Chatcolet and Benewah lakes. There are concerns about population-level impacts to Largemouth Bass *Micropterus salmoides* and Smallmouth Bass *Micropterus dolomieu* due to incidental netting mortality. In addition, the population-level response of these species to reduced Northern Pike abundance is of interest. In June 2019, we sampled Largemouth Bass and Smallmouth Bass in Chatcolet and Benewah lakes to evaluate population characteristics, dynamic rate functions, and angler exploitation to provide a baseline for future comparisons. Largemouth Bass mean CPUE was 26.5 fish/h and size structure was good (PSD = 73). Fish were long-lived (max = 17 years) and had moderate growth (age at 305 mm = 3.9 years). Annual mortality was 38% with moderately stable recruitment (RVI = 0.46; RCD = 0.90). Estimated exploitation was 3.4% (±4.9% 90% C.I) and use was 41.4% (±19.5% 90% C.I). Smallmouth Bass mean CPUE was 23.8 fish/h, and size structure was good (PSD = 45). Fish were long-lived (max = 11 years) and slow growing (age at 280 mm = 4.3 years). Annual mortality was 62% with stable recruitment (RVI = 0.85; RCD = 0.81). Estimated exploitation and use was 6.7% (±9.8% 90% C.I). Our assessment of Largemouth Bass was consistent with other lakes in the Panhandle region. Conversely, Smallmouth Bass were less abundant and had a balanced size structure. Bass populations in these lakes support abundant angling opportunity and are important to anglers, especially Largemouth Bass. However, angler harvest was low and had minimal potential to influence population dynamics. This survey should periodically be replicated to evaluate the response of Black Bass to management actions, particularly Northern Pike suppression.

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INTRODUCTION

Understanding population dynamics is essential to fisheries management to determine sustainable yields of fish populations. The dynamic rate functions (e.g. recruitment, growth, and mortality) influence the current and future status of populations and describe the ways in which a population grows and declines over time (Ricker 1975). This can therefore determine the number of fish existing in the population. Surveying the status and trends in abundance, size, maturity, and fecundity of fish in a population is central to management decision-making (Pope et al. 2010). Estimates of all three dynamic rate functions are commonly used in combination to evaluate management activities (e.g., harvest regulations, habitat enhancement) and formulate management objectives.

Substantial research has been dedicated to understanding the population dynamics and biology of Largemouth Bass *Micropterus salmoides* and Smallmouth Bass *M. dolomieu* (collectively referred to as Black Bass, hereafter) to satisfy a diversity of values among the angling public. As such, Black Bass population dynamics must be assessed at the appropriate levels of organization (i.e., community, ecosystem, landscape; Garvey et al. 2002). Most importantly are harvest, lake productivity, and interaction among fish species (i.e., competition and predation). Continued monitoring of these variables is necessary to maintain or improve Black Bass fisheries in Idaho (Teuscher et al. 2006).

The Coeur d'Alene Tribe Fisheries Program, in collaboration with Idaho Department of Fish and Game, designed a project to reduce Northern Pike *Esox lucius* abundance in the southern end of Lake Coeur d'Alene, which includes Chatcolet and Benewah lakes. This project takes place during the spring (following ice-out and extending into May) and the fall (October extending into November). The primary objective is to improve survival of adfluvial Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* by alleviating predation from Northern Pike. Bull trout *Salvelinus confluentus* survival also may improve from a reduction in Northern Pike abundance. Although this project targets Northern Pike, Black Bass bycatch is likely in this portion of the system. As such, there are concerns about population-level impacts to Black Bass due to incidental take from netting. Conversely, there is also an interest in evaluating whether Northern Pike suppression benefits Black Bass over time. The main objective of this multi-year study is to evaluate the influence of Northern Pike removal on Black Bass population characteristics and abundance. The immediate objective for this portion of the study was to provide baseline information on Black Bass populations in Chatcolet Lake and Benewah Lake for future comparisons by:

1. Estimating dynamic rate functions (i.e., growth, recruitment, and mortality) and population characteristics (i.e., relative abundance, size structure) of Smallmouth Bass and Largemouth Bass.

2. Estimating angler exploitation and use of Largemouth Bass and Smallmouth Bass.

METHODS

Fish Sampling

Black Bass were sampled June 3-6, 2019 using nighttime boat-mounted electrofishing consisting of a Midwest Lakes Systems Infinity control box powered by a 5,000-W generator. Electrofishing output was standardized to 3,000 W based on ambient water conductivity and temperature (Miranda 2009). The shoreline of both Chatcolet and Benewah lakes were segmented into 400-m long sample sites (Figure 1). Electrofishing effort consisted of a single, 600-s pass with two netters in each 400-m segment proceeding in a clockwise direction around the lake. All Largemouth Bass and Smallmouth Bass were netted, and Northern Pike were netted when possible. All other species were not netted, although any Cutthroat Trout and Bull Trout were noted. Chatcolet and Benewah lakes have been connected since the completion of Post Falls Dam in 1906, especially during summer pool when both lakes are inundated and indistinguishable from Coeur d'Alene Lake. Therefore, data from Chatcolet and Benewah lakes were pooled for analysis.

Following each electrofishing run, each Largemouth Bass and Smallmouth Bass were enumerated, measured to the nearest millimeter (total length), weighed to the nearest g, and released. The first and second dorsal spines were removed from 10 individuals per 10-mm length group for each lake. Both Largemouth Bass and Smallmouth Bass were tagged using non-reward FD-94 T-bar anchor tags (76 mm; Floy Tag Inc., Seattle, Washington, USA) near the posterior end of the dorsal fin to evaluate angler exploitation. Only stock length (i.e., 305 mm) and larger individuals were tagged. All tags were uniquely-numbered and included the telephone number for the IDFG's "Tag! You're It!" reporting hotline. Any Northern Pike sampled were enumerated, measured to the nearest millimeter (total length), weighed to the nearest g, and culled.

Hard Structure Processing

Dorsal spines collected were placed in coin envelopes to air dry. Spines were mounted in epoxy using 2-mL microcentrifuge tubes following Koch and Quist (2007). Cross sections (0.9 mm thick) were cut near the base of each dorsal spine just distal to the articulating process using an Isomet low-speed saw (Buehler Inc., Lake Bluff, Illinois, USA). Digital images were taken for each dorsal spine cross-section using a dissecting microscope at 5X magnification with transmitted light and an image analysis system (LAS X; Leica Microsystems, Buffalo Grove, Illinois, USA). Annuli were enumerated and recorded along a single transect from the focus to the outer edge on all structures by a single reader using the RFishBC package (Ogle 2016) in the R environment (R Core Team 2021). To back-calculate lengths-at-age, incremental growth proportions for each annuli recorded along the ageing structure were calculated using the RFishBC package (Ogle 2020). Knowledge of biological information for each fish was unknown during the age estimation process to avoid bias.

Data analysis

Catch-per-unit-effort (CPUE) was estimated as the number of fish sampled per hour of electrofishing. Length frequency histograms were constructed to visually assess size structure. Proportional size distribution (PSD) was used to summarize length-frequency distributions (Gablehouse 1984; Neumann et al. 2012) and describe size structure. Proportional size distribution was calculated as

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

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 (Anderson and Neumann 1996). Age structure was estimated with an age-length key (Isermann and Knight 2005; Quist et al. 2012). Age-length keys were modeled using conditional probabilities of the observed ages per 10-mm length group to determine that a fish of a given length is of a certain age. These probabilities were applied to the unaged fish in the sample (Isermann and Knight 2005). Length-at-age data was used to fit a von Bertalanffy growth function. For aged fish, lengths at ages prior to capture were back-calculated using the Dahl-Lea method (Francis 1990). Growth was summarized by relative growth index (RGI) values from back-calculated mean lengths-at-age (Jackson et al. 2008). RGI was estimated as 100 times the mean back-calculated length divided by the standard length at age from populations throughout a species distribution (Jackson et al. 2008). RGI values greater than 100 suggest better than standard growth and values less than 100 suggest slower growth. Fish condition was summarized using relative weights (W_r; Anderson and Neumann 1996). Relative weights above 100 suggest good body condition and values lower than 100 suggest poor body condition.

Total annual mortality (A) was estimated using a weighted catch curve (Miranda and Bettoli 2007). Both, Smallmouth Bass and Largemouth Bass appeared to be fully recruited to the sampling gear at age-4, so A was only estimated for fish four years of age and older. Age structure information was used to describe patterns in recruitment using several techniques. Recruitment was first indexed using the residual technique described by Maceina (1997) where residual estimates derived from a catch curve regression represent relative year-class strength (i.e., positive residuals equal strong year-classes, negative residuals equal weak year-classes). Year class strength was determined by identifying Studentized residuals that were in the 80th (strong year class) and 20th percentile (week year class; Ogle 2016). Secondly, recruitment was indexed using the recruitment variability index (RVI; Guy and Willis 1995) and was calculated as

$$\mathrm{RVI} = [S_N / (N_M + N_P)] - N_M / N_P,$$

where S_N is the summation of the cumulative relative frequencies across year-classes included in the sample, N_M is the number of year-classes missing from the sample (year-classes beyond the oldest year-class in the sample are excluded), and N_P is the number of year-classes present in the sample (N_P must be greater than N_M). Recruitment variability index values vary from -1 to 1, with values close to 1 representing stable recruitment. Development of the RVI was partially based on catch curve analysis because fish populations with stable recruitment will exhibit a steady decline in abundance as age increases. Lastly, the recruitment coefficient of determination (RCD; Isermann et al. 2002) was also used to explain stability in recruitment. The RCD is simply the coefficient of determination (R^2) value that results from a catch curve regression. Indices of recruitment are often useful for providing a general idea of recruitment stability over multiple years.

Exploitation (μ) was estimated as the number of fish harvested by anglers (obtained from tag return information) divided by the number of fish tagged, after one year at-large. We assumed a 54% reporting rate, 10% tag-loss, and 1% tagging mortality for Smallmouth Bass and a 39% reporting rate, 15% tag-loss, and 1% tagging mortality for Largemouth Bass (Meyer et al. 2012).

RESULTS

A total of 134 Largemouth Bass were sampled from both lakes for a CPUE of 26.5 fish/h (SE = 4.0; Figure 1; Table 1). Largemouth Bass total length varied from 186 to 558 mm with a mean total length of 335 mm (SE = 6.2; Table 1; Figure 2) and a PSD estimate of 73 (Table 1). Ages varied from 2-17 years from 111 Largemouth Bass that were able to be aged (Figure 3). Largemouth Bass achieved preferred size (380 mm) at age-5.9 (Figure 3). RGI values estimated from mean back-calculated lengths at age varied from 69-100 (Figure 4). Largemouth Bass were in fair body condition for the stock, quality, and preferred length categories and normal for the trophy category (Figure 5).

Largemouth Bass appeared to fully recruit to the sampling gear at age-4 and 61% of the catch was age-4 and age-5 fish. Catch curve regressions were fitted to age-4 and older fish along the descending limb of log linearized age-frequency distribution. Total annual mortality was 38.0% (Table 1). Recruitment patterns showed variability among years with two strong year classes and one weak year class (Figure 6). However, there were two missing year classes resulting in a RVI of 0.46 that indicates moderately stable recruitment. Similarly, RCD was estimated at 0.90 and in indicative of stable recruitment.

A total of 88 Largemouth Bass were released with non-reward tags. Anglers reported catching 12 tagged Largemouth Bass as of July 1, 2020 (about one year at-large). Anglers harvested one tagged Largemouth Bass and released 11 other tagged fish. Two additional Largemouth Bass were incidentally killed in October 2019 by the Coeur d'Alene Tribe fall pike suppression netting (Jon Firehammer, Coeur d'Alene Tribe, and personal communication). These two fish were not included in the angler exploitation and use analysis. The estimated corrected annual exploitation rate for Largemouth Bass was 3.4% (±4.9% 90% C.I) and use was 41.4% (±19.5% 90% C.I; Table 1).

A total of 119 Smallmouth Bass were sampled from both lakes for a CPUE of 23.8 fish/h (SE = 6.3; Figure 1; Table 1). Smallmouth Bass total length varied from 108-552 mm with a mean total length of 262 mm (SE = 5.9; Table 1; Figure 2). The PSD estimate was 45, suggesting a balanced size structure (Table 1). Ages varied from 2-11 years from 87 Smallmouth Bass that were able to be aged (Figure 3). Smallmouth Bass generally did not achieve preferred size (350 mm) by age-7 (Figure 3). RGI values estimated from mean back-calculated lengths-at-age varied from 86-114 (Figure 4). Smallmouth Bass were in fair body condition for the stock, quality, and preferred length categories and normal for the trophy category (Figure 5).

Smallmouth Bass appear to fully recruit to the sampling gear at age-4 and catch curve regressions were fitted to age-4 and older fish along the descending limb of log linearized age-frequency distribution. Total annual mortality was 62.2% (Table 1). Recruitment patterns showed variability among years with only one strong year-class (Figure 6). However, there were no missing year classes, and higher catch of younger year classes resulted in an RVI of 0.85 that indicated stable recruitment. Similarly, RCD was estimated at 0.81 and was indicative of stable recruitment.

A total of 31 Smallmouth Bass were released with non-reward tags. Anglers reported catching one tagged Smallmouth Bass as of July 1, 2020 (about one year at-large), and it was harvested. The corrected annual exploitation rate was 6.7% (±9.8% 90% C.I), and angler use was 6.7% (±9.8% 90% C.I; Table 1).

DISCUSSION

Largemouth and Smallmouth Bass are two of the most popular resident sportfish species in Idaho (IDFG 2019). Both species can be found in all seven IDFG regions where they support popular fisheries, both consumptive and non-consumptive. In northern Idaho lakes, Largemouth Bass have been well-established for many years and produce some of the best angling in Idaho. Smallmouth Bass are recently established and were illegally introduced into Coeur d'Alene Lake in the early-1990s. Since then, Smallmouth Bass have slowly distributed throughout the lake and connected waterbodies providing a popular fishery (IDFG 2019).

For Largemouth Bass in Chatcolet and Benewah lakes, our assessment of population dynamics is fairly consistent with other studies in the Panhandle region (Fredericks et al. 1997: Hardy et al. 2010; Watkins and Dux 2021). Abundance was slightly lower, but size structure was greater than six other Panhandle Region lakes sampled in 2014-2015 (Watkins and Dux 2021). Largemouth Bass in this study had moderate growth and were long-lived, similar to other Largemouth Bass populations in the Pacific Northwest (Rieman 1987; Beamesderfer and North 1995; Dillon 1990). Fish sampled in 2019 grew faster than those described in Nelson et al. (1997) from Chatcolet and Benewah lakes. Largemouth Bass achieved preferred size (380 mm) at age-9 and age-10 in Nelson et al. (1997) compared to age-6 in this study. Even though growth was faster for fish sampled in this study, the youngest age class was smaller than the relative growth standard. Furthermore, fish were below the relative weight standard for each length category, except for trophy sized fish of which few fish were sampled. Total annual mortality was slightly higher than the average of 28.4% from six Panhandle region lakes in 2014-2015 (Ryan et al. 2018). Year class strength was more variable compared to other systems, but recruitment was relatively stable. Variable year class strength is more common in some Panhandle region waterbodies (Ryan et al. 2018) than others (Liter et al. 2009).

For Smallmouth Bass in Chatcolet and Benewah lakes, our assessment of population dynamics is inconsistent with other lakes in the Panhandle region where Smallmouth Bass are established. CPUE was considerably lower than Priest Lake (43.8, Ryan et al. 2018), Hayden Lake (90, IDFG unpublished data), and Lake Pend Oreille (146.4, see Lake Pend Oreille Smallmouth Bass Investigations chapter this report). PSD suggested a balanced size structure and was considerably greater than Smallmouth Bass sampled in the northern-most section of Coeur d’Alene Lake (Fredericks et al. 2000) and some other regional waters. Smallmouth Bass in this study were slow growing but grew slightly better than other lakes in the region, reaching a length of 305 mm a year earlier (Ryan et al. 2018). Even though growth was better for fish sampled in this study, these fish were still smaller than the relative growth standard, especially for the youngest age class. Furthermore, these fish were below the relative weight standard for each length category, except for trophy sized fish of which few fish were collected. Total annual mortality was slightly higher than in Lake Pend Oreille (58%, see Lake Pend Oreille Smallmouth Bass Investigations chapter this report) and considerably higher than Priest Lake (Ryan et al. 2018). However, recruitment was stable despite having strong and weak year classes.

One possible explanation for the differences seen between this study and other Smallmouth Bass studies in the Panhandle region is the contrast in available Smallmouth Bass habitat. Most waterbodies with Smallmouth Bass populations have deep, steep-sloping shorelines that make electrofishing difficult. In contrast, shoreline habitat in Chatcolet and Benewah lakes is relatively shallow and more conducive to electrofishing. Furthermore, the substrate in Chatcolet and Benewah lakes is less rocky and less favorable for Smallmouth Bass than other regional waters. The absence of abundant optimal habitat may explain the lower catch rates observed in this study. However, the shallowness may have increased the effectiveness to sample Smallmouth Bass for a better representation and therefore more accurate estimate of size structure.

Smallmouth Bass were found along the western and southern shoreline of the sampling area while Largemouth Bass were generally found in Benewah Lake and the transition area between the lakes. However, bass distributions likely differ among seasons. In general, bass move into shallow, warm water in the spring for spawning before setting up a summer range in water with optimal for temperature for growth (Whiteledge et al. 2002). In the fall as water cools, bass move to the warmest water possible which is typically in deeper water (Lewis and Flickinger 1967). Similar seasonal movement patterns likely occur between Chatcolet and Benewah lakes.

Chatcolet Lake has a maximum depth of approximately 12 m during the summer when Lake Coeur d'Alene is at full pool and is much deeper than Benewah Lake. Benewah Lake is ubiquitously shallow with a max depth of 4 m at full pool and only 2 m during the winter. Because Largemouth Bass prefer warmer water than Smallmouth Bass, they tend to stay in the shallower waters of Benewah Lake for longer in the summer than Smallmouth Bass. However, as water levels and temperature decline in the fall and winter, Largemouth Bass likely join Smallmouth Bass in the deeper and warmer water of Chatcolet Lake to over-winter. Movement of bass between the lakes was corroborated by angler tag returns. Several anglers gave detailed locations of their catch that showed fish tagged in one lake moved and were caught in the other.

Largemouth Bass and Smallmouth Bass populations support abundant angling opportunity and are important to anglers. Our evaluation demonstrates anglers are pursuing Black Bass, especially Largemouth Bass, in Chatcolet and Benewah lakes and are catch-and-release oriented. Smallmouth Bass are a more recent addition to the Panhandle region in the last 30 years. They are less widespread than Largemouth Bass but are becoming more prevalent throughout the region through illegal introductions. In systems where they have become established and abundance is sufficient for reasonable angler catch rates, they now support popular fisheries (e.g. Priest Lake; Ryan et al. 2018, Watkins et al. 2018). Since the illegal introduction of Smallmouth Bass into Coeur d'Alene Lake and subsequent dispersal into connected waterbodies, angler interest in Smallmouth Bass has increased (Hardy et al. 2010). However, our study shows angler use of Smallmouth Bass is much lower than for Largemouth Bass in Chatcolet and Benewah lakes. Regardless of species, harvest by anglers is very low and has little potential to influence population dynamics.

This survey establishes a baseline for comparison in future years that will be useful for evaluating management actions, particularly Northern Pike suppression that began in 2019. This suppression program is expected to exert some level of incidental bycatch mortality on Black Bass in the southern end of Coeur d'Alene Lake. However, only two of our tagged Largemouth Bass were captured during Northern Pike netting efforts. This suggests bycatch mortality is currently low. Continued monitoring will allow potential impacts of bycatch mortality to be further evaluated. In addition, Northern Pike suppression is expected to alter the fish assemblage structure and may benefit Black Bass in this portion of the lake. This should be evaluated by periodically replicating this survey.

MANAGEMENT RECOMMENDATIONS

1. Perform periodic standardized sampling to evaluate changes to Largemouth Bass and Smallmouth Bass populations in Chatcolet and Benewah lakes.

Table 1. Sample size (n), mean catch-per-unit-effort (CPUE = fish/h of electrofishing, ±1 SE), total length (mm; Minimum–Maximum [Min–Max]) statistics, proportional size distribution (PSD), total annual mortality (A), recruitment coefficient of determination (RCD), recruitment variability index (RVI), annual angler exploitation (µ ± 90% C.I.) and angler use (± 90% C.I.) for Largemouth Bass and Smallmouth Bass sampled during 2019 in Benewah and Chatcolet lakes (pooled).

			Total length							
Species	*n*	CPUE	Mean	Min–Max	PSD	*A*	RCD	RVI	*µ*	*use*
Largemouth Bass	134	26.5 (4.0)	335.1 (6.2)	186-558	73	38.0	0.90	0.46	3.4 (4.9)	41.4 (19.5)
Smallmouth Bass	119	23.8 (6.3)	261.9 (5.9)	108-522	45	62.2	0.81	0.85	6.7 (9.8)	6.7 (9.8)

Figure 1. Bass species composition within each sampling unit in both Chatcolet Lake (numbers) and Benewah Lake (letters). Pie chart size represents relative abundance of bass sampled and pie chart locations represent the start of each sampling unit.

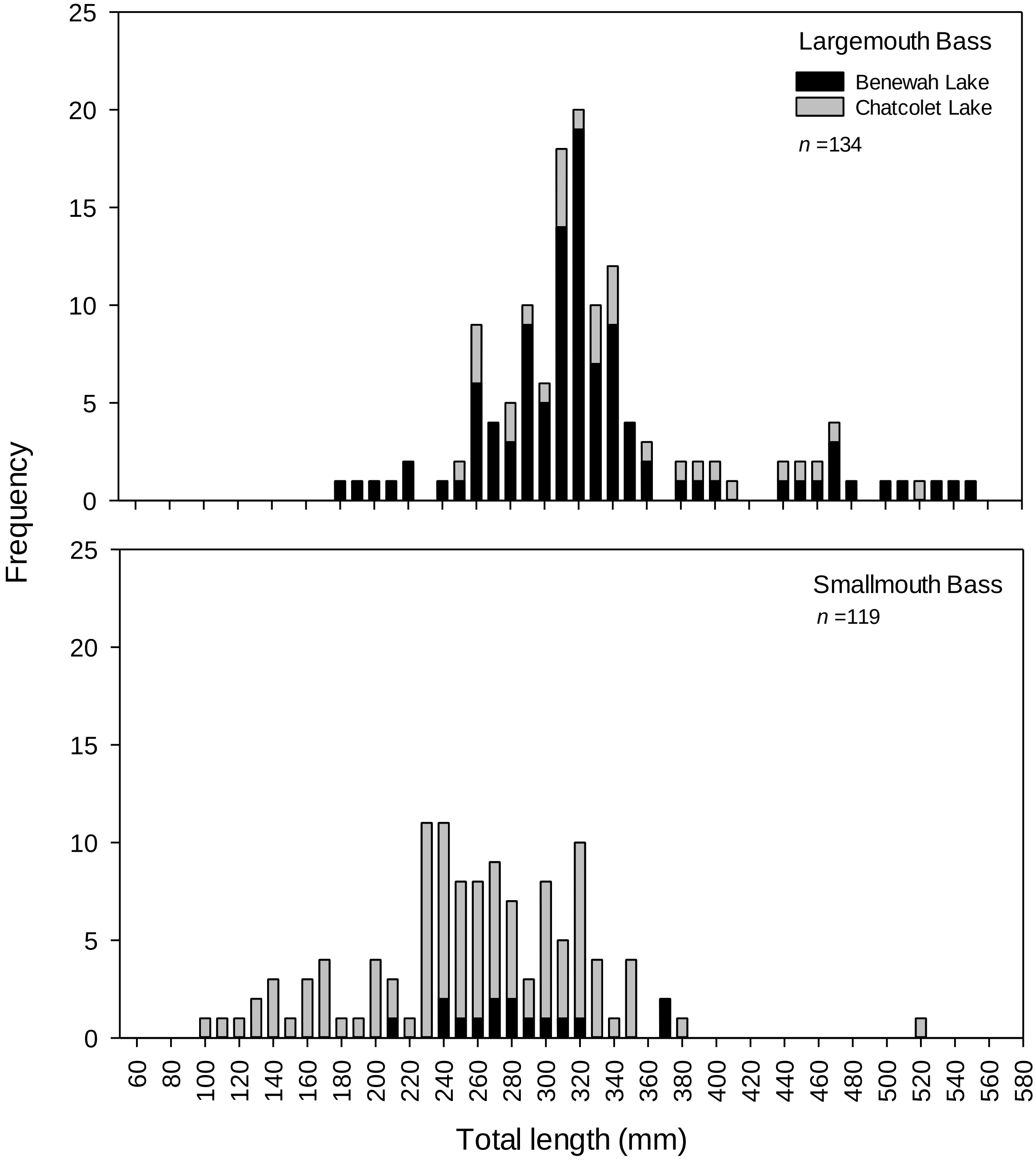

Figure 2. Length-frequency distributions for Smallmouth Bass (top panel) and Largemouth Bass (bottom panel) sampled from Benewah and Chatcolet lakes.

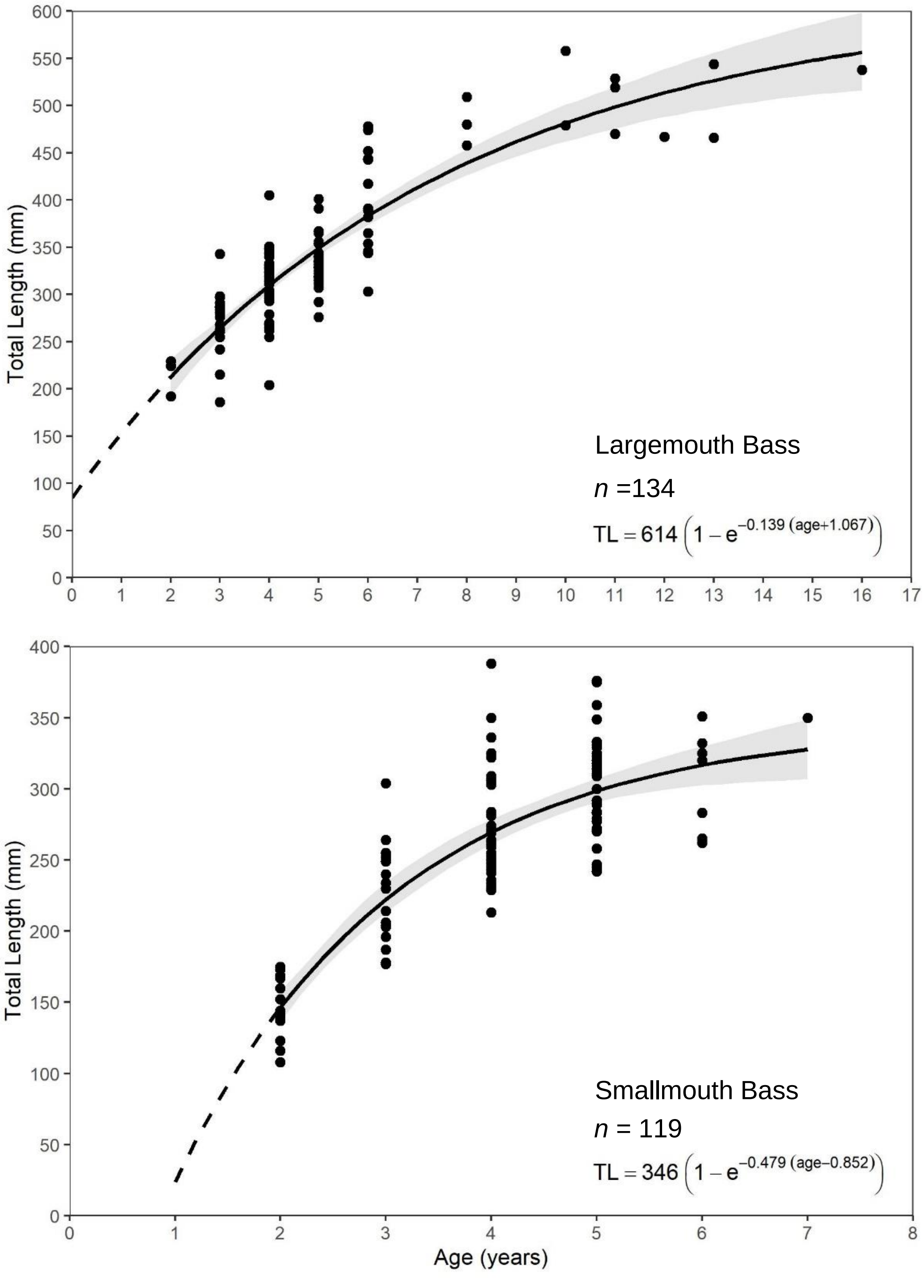

Figure 3. Length-at-age and von Bertalanffy growth functions for Smallmouth Bass (top panel) and Largemouth Bass (bottom panel) sampled from Benewah and Chatcolet lakes (pooled).

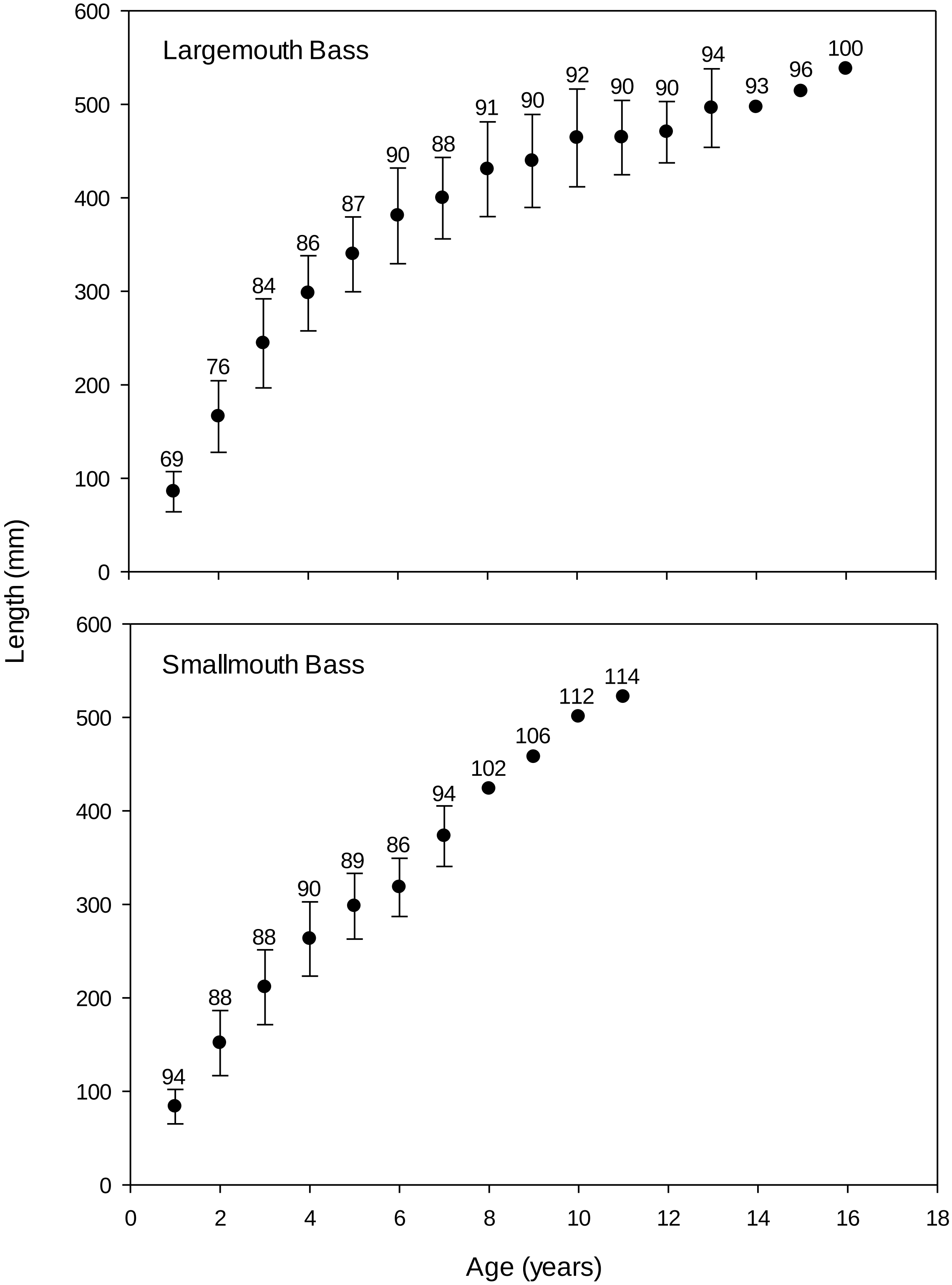

Figure 4. Mean (±1 SD) back-calculated length at age and relative growth index (RGI; numbers above symbols) for Largemouth Bass and Smallmouth Bass sampled in Benewah Lake and Chatcolet Lake (pooled).

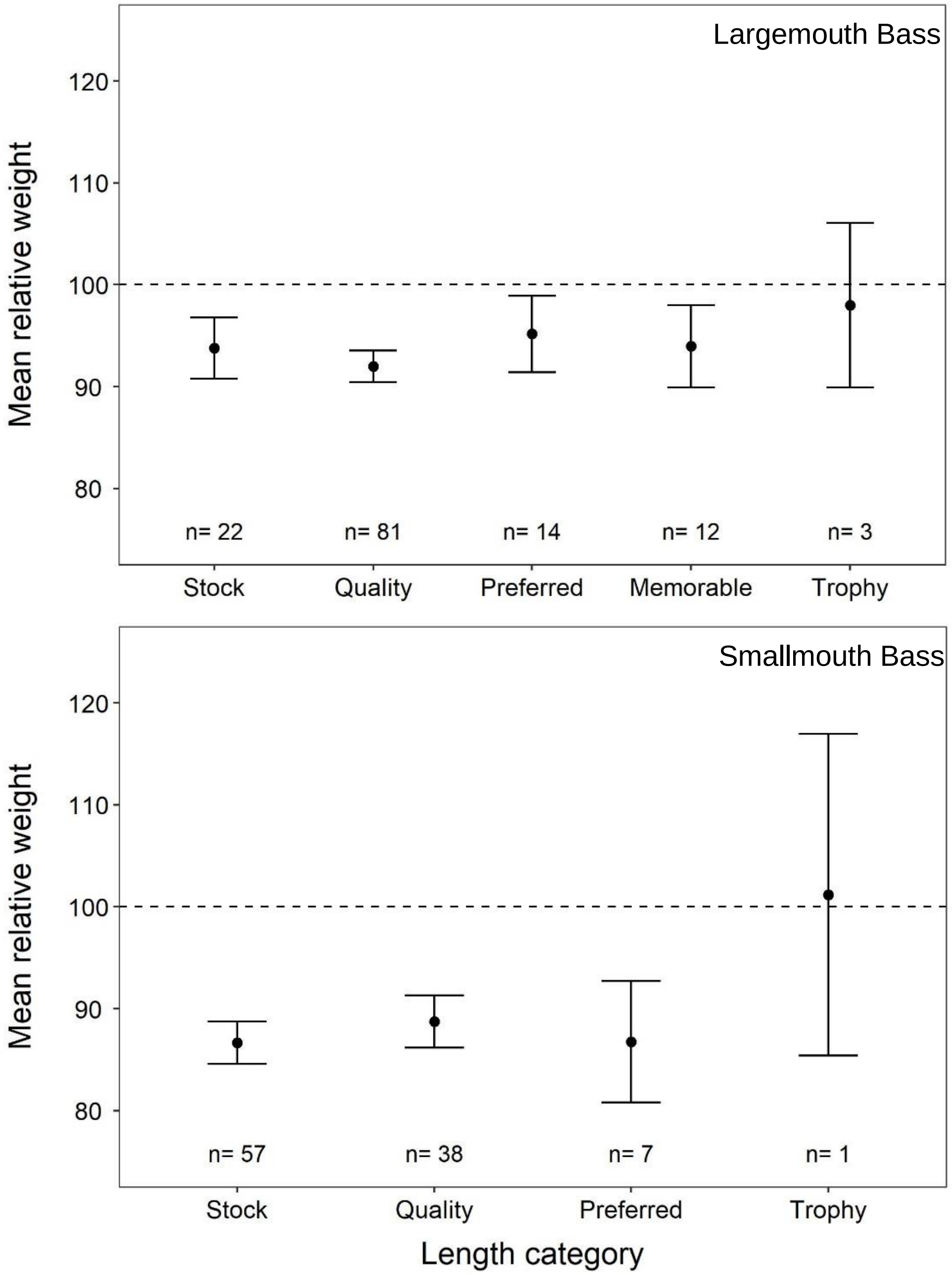

Figure 5. Mean relative weight (±95% C.I.) by length category for Largemouth Bass (top panel) and Smallmouth Bass (bottom panel) sampled from Benewah and Chatcolet lakes (pooled). Dashed line represents standard weights.

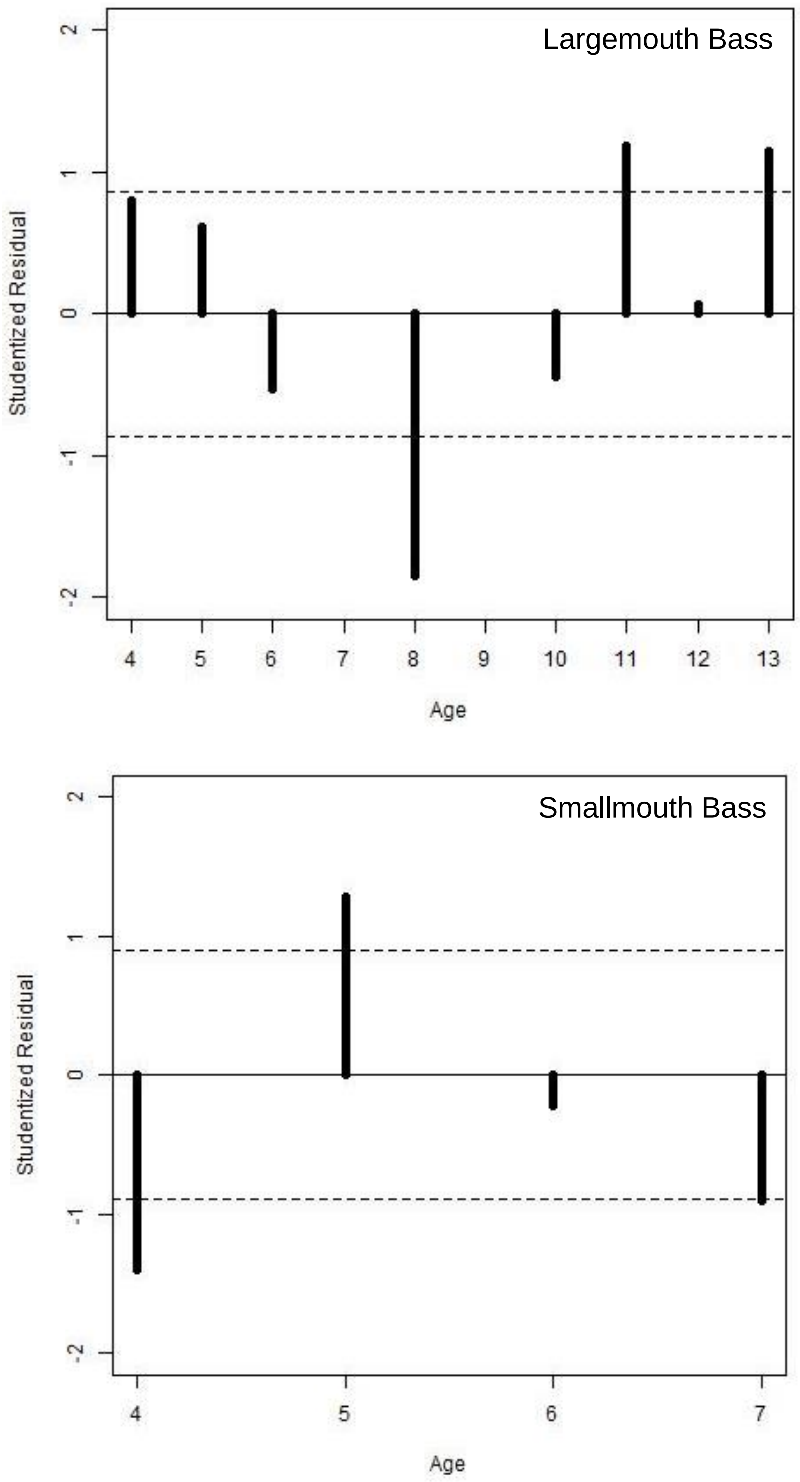

Figure 6. Estimates from Studentized residuals from catch curve regressions for Largemouth Bass and Smallmouth Bass from Chatcolet and Benewah lakes (pooled). Dashed lines represent the 80th and 20th percentiles. Positive residuals above the 80th percentile line represent strong year classes and negative residuals below the 20th percentile represent weak year classes.

LAKE COEUR D’ALENE CHINOOK SALMON EVALUATIONS

ABSTRACT

Chinook Salmon support an important recreational fishery in Lake Coeur d’Alene and also have the potential to alter the pelagic prey (i.e., kokanee *O. nerka*) community, necessitating continued monitoring to understand changes to the fishery at-large. 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 addition to adult abundance monitoring, we continued efforts to improve performance of hatchery Chinook Salmon supplementation. Starting in 2016, experimental juvenile outplants from the Fort Peck State Fish Hatchery adfluvial broodstock in Montana have been annually stocked in Wolf Lodge Creek. In 2019, we observed a total of 61 redds which was more than double the number of redds from 2018. All redds were observed in the Coeur d’Alene River, and none were observed in the St. Joe River. Hatchery outplants were adipose fin clipped for identification for evaluations when fish recruit to the fisheries. No hatchery fish were recovered during carcass recoveries on the spawning grounds. Future assessments should include annual monitoring of adult escapement and spawner age structure so that changes in abundance, age-at-maturity, and growth can be identified. Information related to population characteristics can be used to assess population-level changes and facilitate better management of the Lake Coeur d’Alene fishery.

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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 species are able to adopt adfluvial life history strategies, naturalize, and persisting well outside of their native distribution.

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

Chinook Salmon stocking was intended to supplement the wild population and contribute to the trophy fishery. Historically, IDFG's management objective for 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) were used to regulate Chinook Salmon abundance to either increase or decrease the impact of Chinook Salmon on kokanee abundance. However, the effectiveness of managing Chinook Salmon densities using supplemental stocking and redd excavation to regulate kokanee abundance has been unsubstantiated. Furthermore, the kokanee population appears to be influenced more by environmental conditions rather than predator abundance. As such, IDFG has not excavated Chinook Salmon redds since 2009, but has monitored trends in redd abundance and supplemental stocking has been maintained at ~20,000 individuals annually since 2010 to supplement the wild population.

One factor that has influenced the IDFG's ability to manage Chinook Salmon abundance in Lake Coeur d'Alene is related to performance and retention of hatchery fish. Although 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 et al. (2014) evaluated performance of hatchery Chinook Salmon among rearing hatcheries and between spring and fall stocking seasons. The authors reported that hatchery fish performance may be lower among cohorts that were raised at Nampa Fish Hatchery and released in spring stocking groups. These results have influenced current management, and the IDFG now rears supplemental Chinook Salmon for Lake Coeur d'Alene at Cabinet Gorge Hatchery in Clark Fork, Idaho. In addition, stocking has been moved to early fall (i.e., late-September or early-October) when fish are larger and 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 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 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 targeted 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 water body located in the Panhandle of northern Idaho (Figure 7). Lake Coeur d’Alene lies within Kootenai and Benewah counties and it is the second largest natural lake in Idaho with a surface area of 12,742 ha, mean depth of 24 m, and maximum depth of 61 m (Rich 1992). The Coeur d’Alene and St. Joe rivers are the major tributaries to Lake Coeur d’Alene; however, many smaller second and third order tributaries also exist. The outlet to Lake Coeur d’Alene is the Spokane River, a major tributary to the Columbia River. Water resource development in the watershed includes Post Falls Dam, which was constructed on the Spokane River in 1906, and raised the summer lake level approximately 2.5 m.

The fish assemblage in Lake Coeur d’Alene is composed of three native sport fish species, five native nongame species, 16 introduced sport fish species, and one introduced nongame species. The fishery in the lake, however, can be broadly summarized as belonging to one of three components—kokanee, Chinook Salmon, or littoral species; all 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 (e.g., Coeur d’Alene, Spokane), Lake Coeur d’Alene generates high angling effort, contributing considerably to both state and local economies.

METHODS

Spawner abundance

Chinook Salmon escapement has been monitored using annual redd counts in the Coeur d’Alene and St. Joe rivers since 1990. Standardized index reaches (Table 2) 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 (Ryan et al. 2014). Two individuals floated the Coeur d’Alene River index reaches during October 9–18, 2019 and the St. Joe index reach during October 23, 2019. Three additional non-index sections from the mouth Little North Fork Coeur d’Alene River upstream to the Coeur d’Alene River Road steel bridge (bridge crossing the Coeur d’Alene River approximately 13 miles east from the intersection with the Little North Fork Road near Linfor, Idaho along the Coeur d’Alene River Road). During sampling, all redds were enumerated and georeferenced with a global positioning system. Redd abundance was estimated as the total number of redds observed among all index reaches and were compared to previous annual surveys to provide insight on trends in abundance.

Performance of supplemental Chinook Salmon

Eggs from Fall Chinook Salmon were acquired from Fort Peck State Fish Hatchery located near Fort Peck, Montana following spawning in the fall of 2018. Eggs were hatched and reared at Cabinet Gorge Hatchery in Clark Fork, Idaho. The adipose fin was completely removed from all individuals (*n* = 23,050) prior to stocking. Hatchery individuals were stocked into Wolf Lodge Creek (Figure 7) on September 17, 2019. Hatchery Chinook Salmon were stocked post-smoltification and in an upstream location along Wolf Lodge Creek to improve homing behavior and survival.

RESULTS

We summarized redd abundance to provide insight on adult escapement and to monitor trends in natural production. We observed a total of 61 redds in index reaches and 1 redd in non-index reaches of the Coeur d'Alene River basin. In the index reaches, we observed 38 redds in the mainstem Coeur d'Alene River between Cataldo and the confluence of the South Fork Coeur d'Alene River, 9 redds in the North Fork Coeur d'Alene River between the confluence of the South Fork Coeur d'Alene River and the confluence of the Little North Fork Coeur d'Alene River, and 14 redds in the South Fork Coeur d'Alene River between the confluence with the North Fork Coeur d'Alene River and Theatre Road bridge (Table 2). In the non-index reaches, a single redd was found in the mainstem Coeur d'Alene River between the mouth of the Little North Fork Coeur d'Alene River and the mouth of Steamboat Creek. No redds were observed in the St. Joe River index reach between St. Joe City and the Calder Bridge (Table 2). Chinook Salmon redd abundance more than doubled between 2018 and 2019 (Figure 8).

DISCUSSION

The Chinook Salmon fishery has improved substantially over the past decade, although 2019 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. The most recent redd survey showed that adult escapement was slightly below the long-term average (mean = 83 redds).

Additional non-index reaches in the Coeur d'Alene River were surveyed in 2019. These reaches and other non-index reaches in the St. Joe River and Wolf Lodge Creek were annually surveyed in the past, but were discontinued in 2010-2011 when IDFG stopped using aircraft for aerial surveys. Upon termination of aerial flights, index reaches were chosen as a way to monitor trends in the spawning population while reducing the amount of river miles surveyed. Three reaches in the Coeur d'Alene River basin and one reach in the St. Joe River were deemed as index reaches because they typically accounted for more than 80% of the redds observed since surveys started in 1990. Periodic surveys of the non-index reaches should be conducted to validate the assumption that the vast majority of redds are being counted in the index reaches. If large shifts in the spawning distribution occurred undetected, index only data could result in erroneous trend analysis and unnecessary management actions. Results from this year suggest the current index reaches are sufficient for evaluating Chinook Salmon spawning abundance trends.

The Chinook Salmon fishery in Lake Coeur d'Alene has historically been supported almost entirely by naturally produced individuals regardless of supplemental hatchery stocking. Despite ongoing efforts to identify factors influencing return-to-creel of hatchery produced Chinook Salmon, the post-release fate of those individuals remains unknown. Previous research has addressed factors that limit survival (Maiolie et al. 2013; Ryan et al. 2014), but no work has sought to understand retention of hatchery-origin Chinook Salmon and whether entrainment or post-release emigration may be a limiting factor. 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 (Arthur Butts, personal communication). Additionally, hatchery Chinook Salmon stocked into Anderson Ranch Reservoir have been reported in Arrowrock Reservoir and Lucky Peak Reservoir (Arthur Butts, personal communication). This raises concern about post-release retention of hatchery stock and its effect on return-to-creel.

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

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 annually.

3. Periodically survey non-index reaches to assess if spawning distribution has changed enough to bias redd abundance estimates for trend analysis in the current index reaches.

Table 2. Chinook Salmon redd counts in the Coeur d'Alene (CDA) River drainage, St. Joe River, and Wolf Lodge Creek, Idaho, 1990-2019.

	Coeur d'Alene River								St. Joe River							
Date	Cataldo Mission to S.F. CDA River[a]	South Fork CDA to L.N.F. CDA River[a]	L.N.F. CDA to Steamboat Creek	Steamboat Creek to Steel Bridge	Steel Bridge to Beaver Creek	South Fork CDA River[a]	Little North Fork CDA River	Subtotal	St. Joe City to Calder[a]	Calder to Huckleberry Campground	Huckleberry Campground to Marble Creek	Marble Creek to Avery	Subtotal	Wolf Lodge Creek	Total	Index Only Total
1990	41	10	-	-	-	-	-	51	4	3	3	0	10	-	66	55
1991	11	0	2	-	-	-	-	13	0	1	0	0	1	-	14	11
1992	29	5	3	1	-	-	-	21	18	1	2	0	21	-	63	52
1993	80	11	6	0	-	-	-	97	20	4	0	0	24	-	121	111
1994	82	14	1	0	0	13	0	110	6	0	1	1	8	-	118	115
1995	45	14	1	2	0	-	2	64	1	0	0	0	1	-	65	60
1996	54	13	13	0	0	4	0	84	59	5	7	0	71	-	155	130
1997	18	5	6	3	1	0	0	33	20	2	2	0	24	-	57	43
1998	11	3	1	0	0	0	0	15	3	1	0	2	6	4	25	17
1999	7	5	0	0	0	0	0	12	0	0	0	0	0	5	17	12
2000	16	20	3	0	0	5	1	45	5	0	0	0	5	3	53	46
2001	18	13	2	1	0	4	0	38	21	15	-	-	36	4	78	56
2002	14	10	6	0	0	3	0	33	14	4	0	0	18	0	51	41
2003	27	17	2	0	0	5	0	51	15	9	3	0	27	0	78	64
2004	24	36	4	2	0	4	1	71	15	3	0	0	18	1	90	79
2005	30	7	3	0	0	8	1	49	7	3	0	0	10	1	60	52
2006	30	80	14	7	0	10	0	141	15	1	0	0	16	-	157	135
2007	63	20	4	1	0	13	0	101	23	4	0	0	26	-	127	119
2008	79	6	1	2	0	4	0	92	13	3	1	0	17	-	109	102

Table 2 (continued)

	Coeur d'Alene River								St. Joe River							
Date	Cataldo Mission to S.F. CDA River[a]	South Fork CDA to L.N.F. CDA River[a]	L.N.F. CDA to Steamboat Creek	Steamboat Creek to Steel Bridge	Steel Bridge to Beaver Creek	South Fork CDA River[a]	Little North Fork CDA River	Subtotal	St. Joe City to Calder[a]	Calder to Huckleberry Campground	Huckleberry Campground to Marble Creek	Marble Creek to Avery	Subtotal	Wolf Lodge Creek	Total	Index Only Total
2010	71	16	7	9	0	8	0	112	20	0	2	0	22	-	134	115
2011	79	12	5	0	0	17	2	115	-	-	-	-	-	-	134[b]	108
2012	65	7	-	-	-	13	-	85	9	-	-	-	9	-	94	94
2013	108	2	-	-	-	14	-	124	4	-	-	-	4	1	129	128
2014	104	62	-	-	-	4		170	9	-	-	-	9	-	179	179
2015	210	68	-	-	-	10		288	15	-	-	-	15	-	303	303
2016	76	29	-	-	-	-		105	0	-	-	-	0	-	105	105
2017	61	18	-	-	-	-		79	0	-	-	-	0	-	79	79
2018	27	1	-	-	-	-		28	0	-	-	-	0	-	28	28
2019	38	9	1	0	-	14		62	0	-	-	-	0	-	62	61

[a] Index reach.

[b] Total based on a proportion of the previous 5 years (see Fredericks et al. 2013 for details).

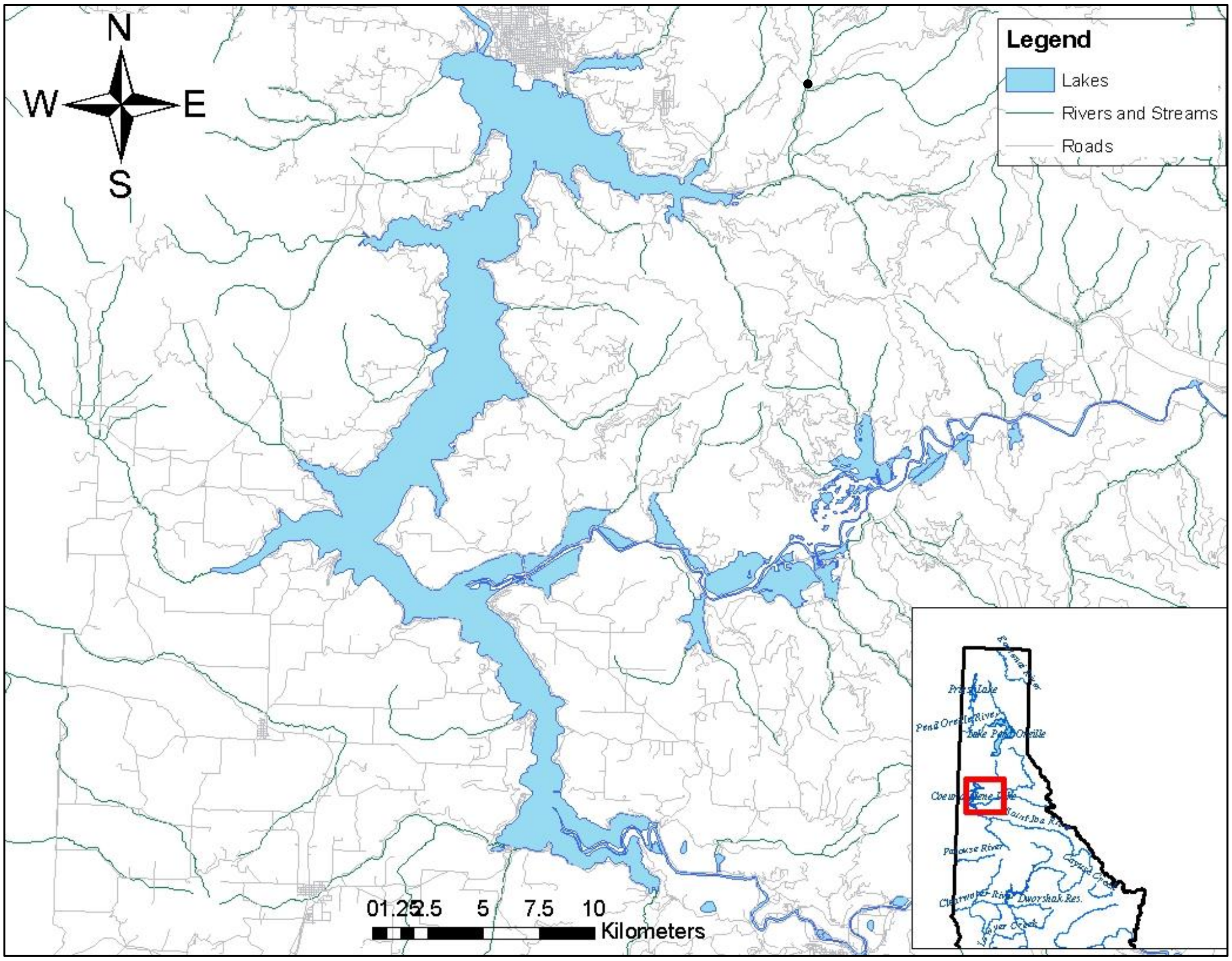

Figure 7. Location of Lake Coeur d’Alene, Idaho. The black dot represents the location where juvenile hatchery Chinook Salmon were released.

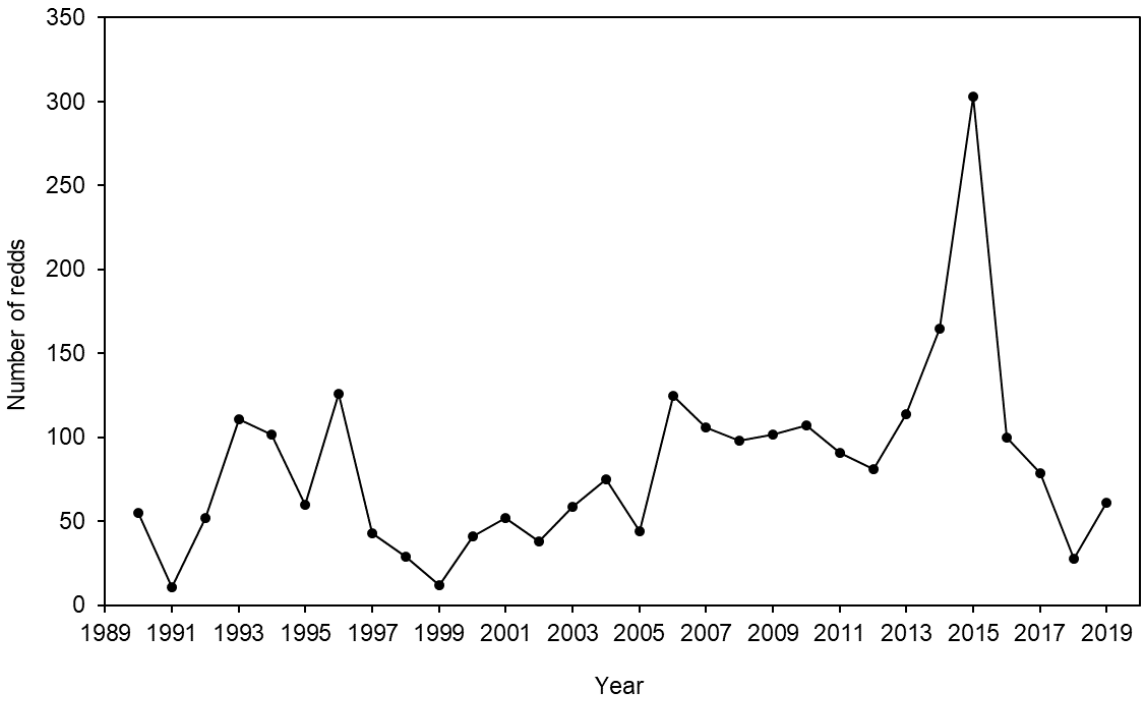

Figure 8. Number of Chinook Salmon redds counted during sampling of index reaches in the Coeur d'Alene River and St. Joe River from 1990–2019.

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 August 2–4, 2019. We estimated a total abundance of 11,389,620 and 452,862 kokanee in Lake Coeur d’Alene and Spirit Lake, respectively. The Lake Coeur d’Alene kokanee population had below average abundance of adult fish during 2019, but relatively high abundance of age-0 and age-1 fish. The low adult density resulted in fish size (mean TL = 375 mm) that exceeded the longstanding management objective for Lake Coeur d’Alene. Similar to Lake Coeur d’Alene, the Spirit Lake kokanee population also had a low abundance of adult fish and a relatively high abundance of age-0 fish. Mean total length of adult kokanee in Spirit Lake was 297 mm, which was larger than in previous years. Poor recruitment in 2016 and 2018, along with high annual mortality of the 2017 year-class, suggests that adult size may remain high. However, recruitment was strong again in 2019. We recommend continued monitoring of both kokanee populations to assess trends in age-specific abundance and growth. Monitoring should focus on assessing the fishery-level effects in both lakes from recent weak year-classes.

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INTRODUCTION

Kokanee *Oncorhynchus nerka* are a popular sport fish across much of the western U.S. because of their high catchability and table value. Kokanee angling is especially popular among local anglers because it is family-oriented, consistently entertaining, and may be done with simple gear. Kokanee comprise much of the fishing effort in northern Idaho lakes, making them an important focus for management. The Idaho Department of Fish and Game's (IDFG) current policy is to manage for adult kokanee abundances that support high annual harvest yields and provide prey for predators. Current and continued evaluations of kokanee populations in Lake Coeur d'Alene and Spirit Lake will provide information necessary to manage these fisheries.

Kokanee were introduced to Lake Coeur d'Alene in 1937 by the IDFG to establish a harvest-oriented fishery (Goodnight and Mauser 1979; Hassemer and Rieman 1981; Maiolie et al. 2013). Initial introductions were made from a late-spawning shoreline stock from Lake Pend Oreille (originally Lake Whatcom, WA stock). During the early-1970s, attempts were made to introduce kokanee 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 1977; Mauser and Horner 1982). Despite unsuccessful attempts to establish early-spawners, the kokanee fishery peaked in the mid-1970s and the wild, late-run stock was producing annual yields between 250,000–578,000 fish during that time (Goodnight and Mauser 1977; Goodnight and Mauser 1979; Rieman and LaBolle 1980). By the early 1980s, fishery managers had documented density-dependent effects on adult size structure of kokanee which prompted an increase in the daily bag limit from 25 to 50 fish per day and the introduction of Chinook Salmon *O. tshawytscha* as a biomanipulation tool to reduce kokanee abundance (Mauser and Horner 1982). Chinook Salmon naturalized in the system and are now an important component of the Lake Coeur d'Alene fishery. In recent history, the kokanee population has not been highly influenced by abundance of predators, but rather by environmental conditions, particularly high runoff events.

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 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 et al. 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 et al. 2013). However, it has been thought that beaver dams and limited spawning habitat precluded them from naturalizing and significantly contributing to the fishery. 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. Continue long-term monitoring to provide information related to kokanee management in Lake Coeur d'Alene and Spirit Lake.

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

STUDY AREA

Lake Coeur d'Alene

Lake Coeur d'Alene is a mesotrophic natural lake located in the Panhandle of northern Idaho (Figure 9). Lake Coeur d'Alene lies within Kootenai and Benewah counties and it is the second largest natural lake in Idaho with a surface area of 12,742 ha, mean depth of 24 m, and maximum depth of 61 m (Rich 1992). The Coeur d'Alene and St. Joe rivers are the major tributaries to Lake Coeur d'Alene; however, many smaller tributaries also exist. The outlet to Lake Coeur d'Alene is the Spokane River, a major tributary to the Columbia River. Water resource development in the lake includes Post Falls Dam, which was constructed on the Spokane River in 1906 and raised the summer lake level by approximately 2.5 m. In addition to creating more littoral habitat and shallow-water areas, the increased water level created more pelagic habitat for salmonids (e.g., kokanee, Chinook Salmon).

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

Spirit Lake

Spirit Lake is located in Kootenai County near the town of Spirit Lake, Idaho (Figure 10). 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).

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

METHODS

During 2019, kokanee were sampled from Spirit Lake and Lake Coeur d'Alene on August 2 and 3–4, 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 18 and 5 predetermined transects throughout Lake Coeur d'Alene and Spirit Lake, respectively (Figure 9; Figure 10). 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 (Ryan et al. 2014). During fish sampling, the bottom and top of the kokanee layer was identified using the onboard sonar unit, and the trawl was towed in a stepwise pattern (2.4-m increments; three minutes per step) to capture the entire 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). Whole otoliths were viewed by a single reader using a dissecting microscope with reflected light to estimate age.

Kokanee spawner length and age structure was estimated to evaluate growth objectives. Mature adults were sampled on December 6, 2019 using a sinking experimental gill net (46.0 m × 1.8 m with panels of 50-, 64-, 76-, 88-, and 100-mm stretch-measure mesh) in the vicinity of Higgens Point in Wolf Lodge Bay where kokanee index netting has historically occurred. Sampled fishes were sexed and measured for TL (mm). In addition, otoliths were removed from 10 individuals per 1-cm length group immediately after sampling. Whole otoliths were viewed by a single reader using a dissecting microscope with reflected light to estimate age.

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

RESULTS

Lake Coeur d'Alene

We sampled a total of 1,285 kokanee by trawling in Lake Coeur d'Alene. We estimated a total population abundance of 11,242,697 kokanee and density of 1,165 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 4.5 million age-0, 5.0 million age-1, 1.5 million age-2, and 98,000 age-3/4 kokanee based on trawling (Table 3). The highest kokanee fry (age-0) densities were observed in the northern portion of the lake (Section 1; Figure 9), particularly near Wolf Lodge Bay. Section 2 contained the highest densities of age-1 and age-2 kokanee and was the only section where adults were caught. Kokanee sampled by trawling varied in length from 13–337 mm TL (Figure 11) and varied in age from 0 to 4 years old (Figure 12).

Spawning kokanee varied in length from 276 to 412 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 13). Mean TL was 384 mm (SD = 11.9) for male and 341 mm (SD = 21.1) for female kokanee. Overall mean TL was 375 mm (SD = 22.7). Mean TL of kokanee spawners in 2019 was higher than in 2018, and all sampled fish met or exceeded the adult length objective (Figure 13).

Spirit Lake

We sampled a total of 51 kokanee by trawling in Spirit Lake. We estimated a total abundance of 452,862 kokanee. We estimated abundances of 385,960 age-0, 48,474 age-1, 7,321 age-2, and 11,107 age-3 kokanee based on trawling (Table 4). We estimated a total density of around 760 kokanee/ha and a density of 19 age-3 kokanee/ha (Table 4). An above average number of fry were sampled; however, the remaining year classes were weak with age-2 kokanee abundance was the lowest since 2000. Kokanee sampled during trawling varied in length from 38–306 mm TL (Figure 14) and varied in age from 0 to 3 years old (Figure 15). There did not appear to be any pattern in age-specific abundance around the lake; kokanee tended to be well-distributed across all transects.

DISCUSSION

Lake Coeur d'Alene

The kokanee population in Lake Coeur d'Alene has supported a productive harvest fishery during the past several years. Despite the low adult kokanee abundance, angling was reportedly good again during 2019 and produced above average sized fish to the delight of many anglers. In the past, the population has been negatively affected by adverse environmental conditions, namely high runoff events (Maiolie et al. 2013); however, apparent stable conditions during about the past decade have allowed the population to be sustained at a fairly high level. Abundance of young-of-year kokanee, as indexed by trawling, is the highest in the last 10 years and is 2-fold higher than the previous 10-year mean. However, adult (age-3 and age-4) abundance was low and resulted in large-sized kokanee. Lower than expected abundance of age-2 kokanee caught in 2019 suggests anglers should expect another year of large-sized adults with similarly low abundance in 2020.

We found that adult kokanee spawner size exceeded the management objective which seeks to balance abundance, angler catch rate, and size. During 2019, adult spawner size exceeded the most recent 10-year average. Anecdotal angler reports suggested catch rates were satisfactory for anglers given the large body size of the average adult kokanee with some anglers reporting a catch of daily limits. While potential management options for influencing the kokanee fishery are limited, continued population monitoring is important for understanding kokanee ecology and for providing public information.

Spirit Lake

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

Overall kokanee abundance was slightly higher than 2018 but was still substantially lower compared to surveys in the past 10 years. This pattern has likely been influenced by poor recruitment of the 2016- and 2018- hatch year classes and high annual mortality of the 2017 hatch year class. Relative year-class strength and survival of kokanee among years appears to be similar to Coeur d'Alene Lake. Additionally, adult kokanee size in Spirit Lake was larger than previous surveys. Similarities in year-class strength, annual mortality, and relative adult size between Spirit Lake and Coeur d'Alene Lake may be attributed to regional environmental conditions. Annual sampling should be continued to better understand long-term trends in kokanee population abundance and size structure in relation to environmental conditions.

Unlike other large northern Idaho lakes (i.e., Lake Pend Oreille, Lake Coeur d'Alene). Spirit Lake did not have any pelagic predators until 2016 when Fall Chinook Salmon were introduced. The kokanee population often exhibited strong density-dependent growth, thus depressing size structure and at times leading to decreased interest among anglers. The introduction of a predator could reduce kokanee abundance and subsequently increase kokanee size structure and angler interest. It is too early to determine if the initial Chinook stockings have successfully survived or if they have had a meaningful impact on the kokanee population. The first Chinook stocking should mature in 2020 and provide some insight to their growth and survival in Spirit Lake.

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

MANAGEMENT RECOMMENDATIONS

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

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

Table 3. Estimated abundance of kokanee made by midwater trawl in Lake Coeur d’Alene, Idaho, from 1979–2019.

Year	Age class				Total
	Age-0	Age-1	Age-2	Age-3/4	
2019	4,566,629	5,047,069	1,531,018	97,982	11,242,967
2018	1,003,259	503,060	58,008	428,884	1,993,211
2017	2,114,549	53,927	4,437,410	899,195	7,505,082
2016	690,170	729,709	2,461,281	1,306,550	2,967,710
2015	349,683	3,664,419	5,307,640	135,809	9,457,551
2014	2,877,209	2,153,877	2,790,295	319,080	8,140,461
2013	1,349,000	3,663,000	1,319,000	373,000	6,704,000
2012	--	--	--	--	--
2011	3,049,000	1,186,000	1,503,000	767,000	6,505,000
2010	660,400	2,164,100	1,613,300	506,200	4,943,900
2009	731,600	1,611,800	2,087,400	333,600	4,764,400
2008	3,035,000	3,610,000	1,755,000	28,000	8,428,000
2007	3,603,000	2,367,000	136,000	34,000	6,140,000
2006	7,343,000	1,532,000	91,000	33,900	8,999,000
2005	--	--	--	--	--
2004	7,379,000	1,064,000	141,500	202,400	8,787,000
2003	3,300,000	971,000	501,400	182,300	4,955,000
2002	3,507,000	934,000	695,200	70,800	5,207,000
2001	7,098,700	929,900	193,100	25,300	8,247,000
2000	4,184,800	783,700	168,700	75,300	5,212,600
1999	4,091,500	973,700	269,800	55,100	5,390,100
1998	3,625,000	355,000	87,000	78,000	4,145,000
1997	3,001,100	342,500	97,000	242,300	3,682,000
1996	4,019,600	30,300	342,400	1,414,100	5,806,400
1995	2,000,000	620,000	2,900,000	2,850,000	8,370,000
1994	5,950,000	5,400,000	4,900,000	500,000	12,600,000
1993	5,570,000	5,230,000	1,420,000	480,000	12,700,000
1992	3,020,000	810,000	510,000	980,000	5,320,000
1991	4,860,000	540,000	1,820,000	1,280,000	8,500,000
1990	3,000,000	590,000	2,480,000	1,320,000	7,390,000
1989	3,040,000	750,000	3,950,000	940,000	8,680,000
1988	3,420,000	3,060,000	2,810,000	610,000	10,900,000
1987	6,880,000	2,380,000	2,920,000	890,000	13,070,000
1986	2,170,000	2,590,000	1,830,000	720,000	7,310,000
1985	4,130,000	860,000	1,860,000	2,530,000	9,370,000
1984	700,000	1,170,000	1,890,000	800,000	4,560,000
1983	1,510,000	1,910,000	2,250,000	810,000	6,480,000
1982	4,530,000	2,360,000	1,380,000	930,000	9,200,000
1981	2,430,000	1,750,000	1,710,000	1,060,000	6,940,000
1980	1,860,000	1,680,000	1,950,000	1,060,000	6,500,000
1979	1,500,000	2,290,000	1,790,000	450,000	6,040,000

Table 4. Estimated abundance of kokanee made by midwater trawl in Spirit Lake, Idaho, from 1981–2019.

Year	Age class				Total	Age-3/ha
	Age-0	Age-1	Age-2	Age-3		
2019	385,960	48,474	7,321	11,107	452,862	19
2018	172,543	64,137	10,816	64,010	311,506	133
2017	287,804	1,755	62,891	42,317	396,209	73
2016	11,940	28,332	307,544	30,612	378,428	53
2015	7,598	60,828	2,104,886	368,167	2,541,479	629
2014	44,295	720,648	653,945	231,356	1,650,245	396
2013	--	--	--	--	--	--
2012	--	--	--	--	--	--
2011	1,092,000	185,700	382,300	65,500	1,725,400	112
2010	138,200	459,900	88,800	61,600	748,500	105
2009	260,700	182,600	75,900	30,000	549,200	51
2008	281,600	274,400	188,800	56,400	801,200	96
2007	439,919	210,122	41,460	20,409	711,910	35
2006	--	--	--	--	--	--
2005	508,000	202,000	185,000	94,000	989,100	161
2001–04	--	--	--	-	--	--
2000	800,000	73,000	6,800	7,800	901,900	13
1999	286,900	9,700	50,400	34,800	381,800	61
1998	28,100	62,400	86,900	27,800	205,200	49
1997	187,300	132,200	65,600	6,500	391,600	11
1996	--	--	--	--	--	--
1995	39,800	129,400	30,500	81,400	281,100	142
1994	11,800	76,300	81,700	19,600	189,400	34
1993	52,400	244,100	114,400	11,500	422,400	20
1992	--	--	--	--	--	--
1991	458,400	215,600	90,000	26,000	790,000	45
1990	110,000	285,800	84,100	62,000	541,800	108
1989	111,900	116,400	196,000	86,000	510,400	150
1988	63,800	207,700	78,500	148,800	498,800	260
1987	42,800	164,800	332,800	71,700	612,100	125
1986	15,400	138,000	116,800	35,400	305,600	62
1985	149,600	184,900	101,000	66,600	502,100	116
1984	3,300	16,400	148,800	96,500	264,900	168
1983	111,200	224,000	111,200	39,200	485,700	68
1982	526,000	209,000	57,700	48,000	840,700	84
1981	281,300	73,400	82,100	92,600	529,400	162

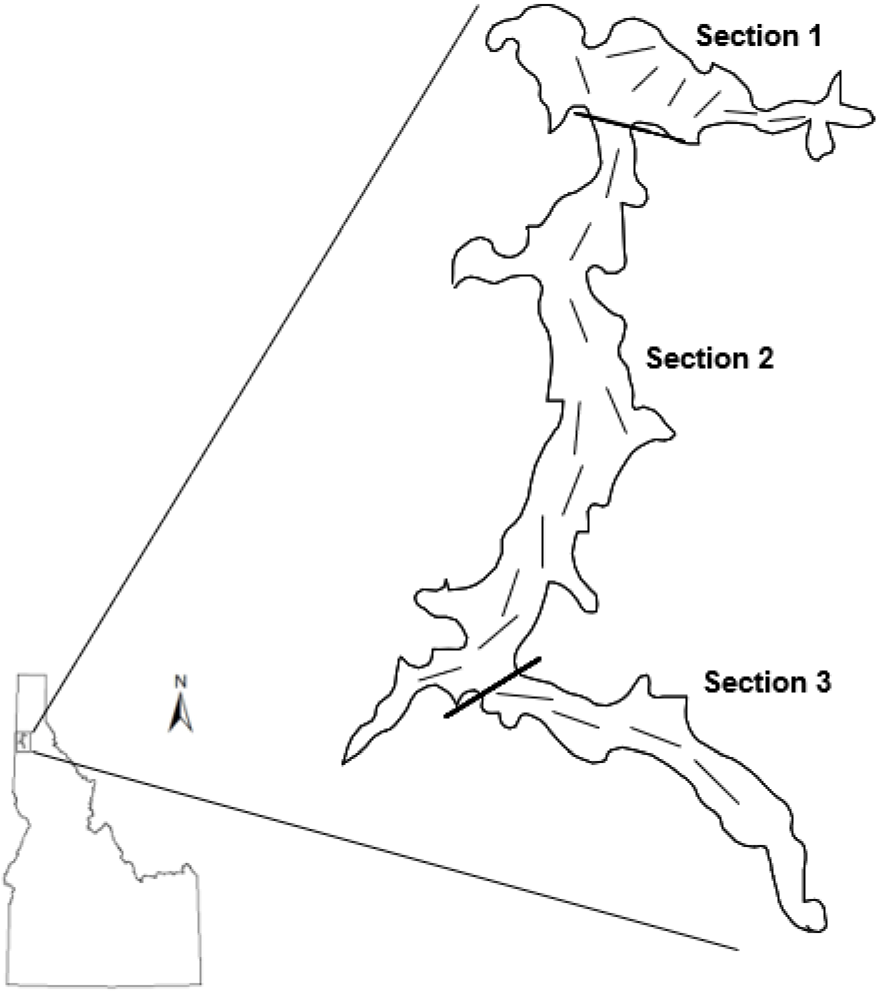

Figure 9. Approximate location of historical trawling transects used to estimate abundance of kokanee in Lake Coeur d'Alene, Idaho.

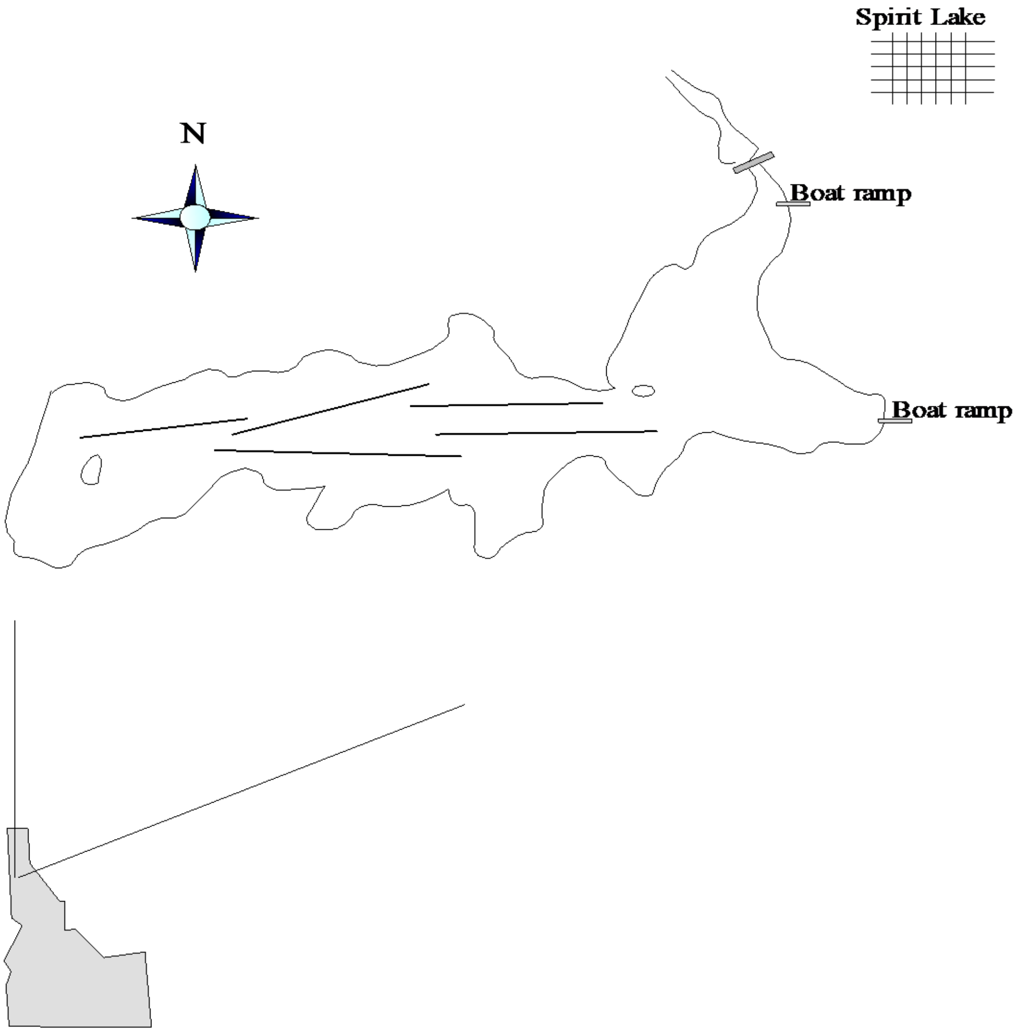

Figure 10. Approximate location of historical trawling transects used to estimate abundance of kokanee in Spirit Lake, Idaho.

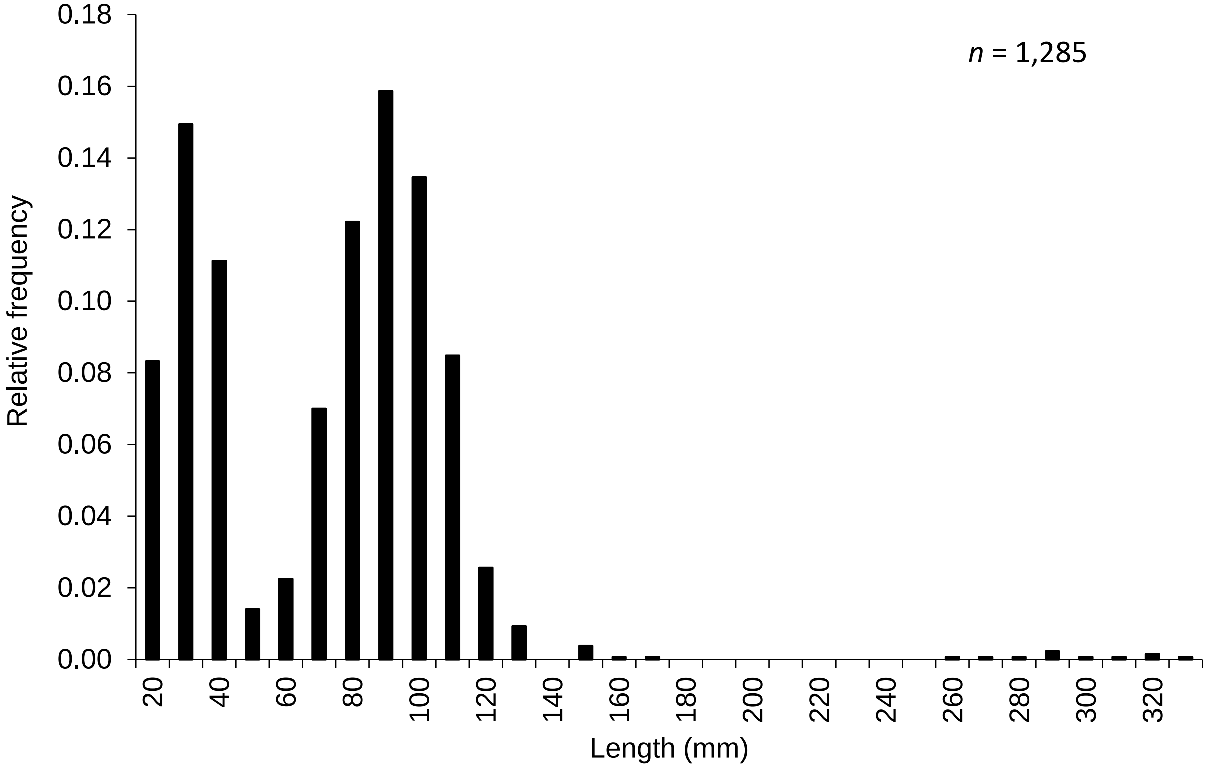

Figure 11. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (August 3–4, 2019).

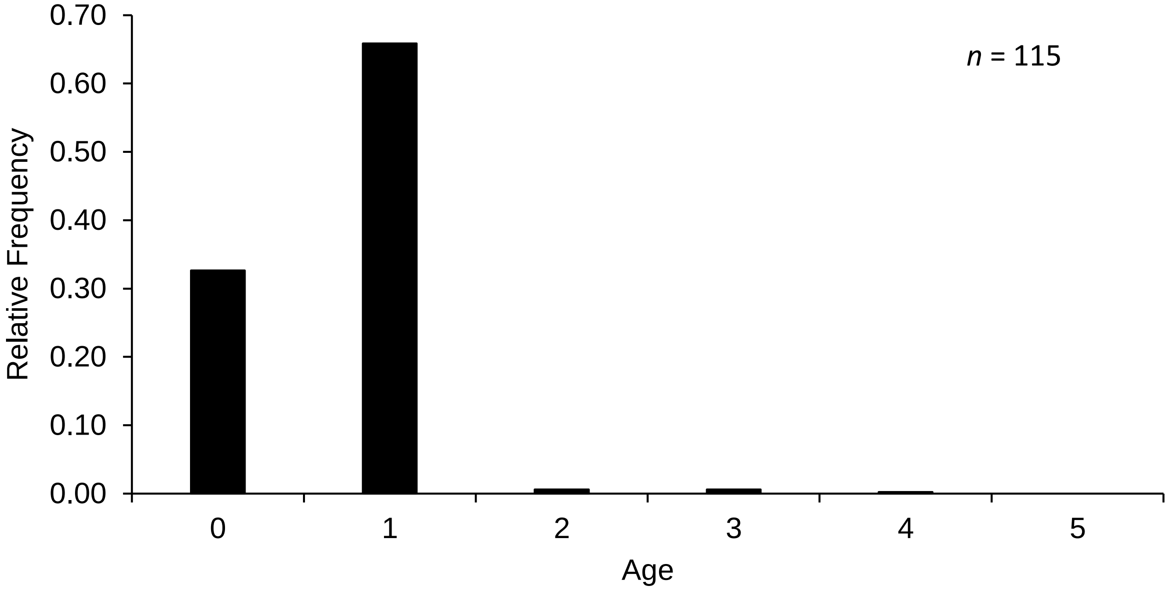

Figure 12. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Lake Coeur d'Alene, Idaho (August 3–4, 2019).

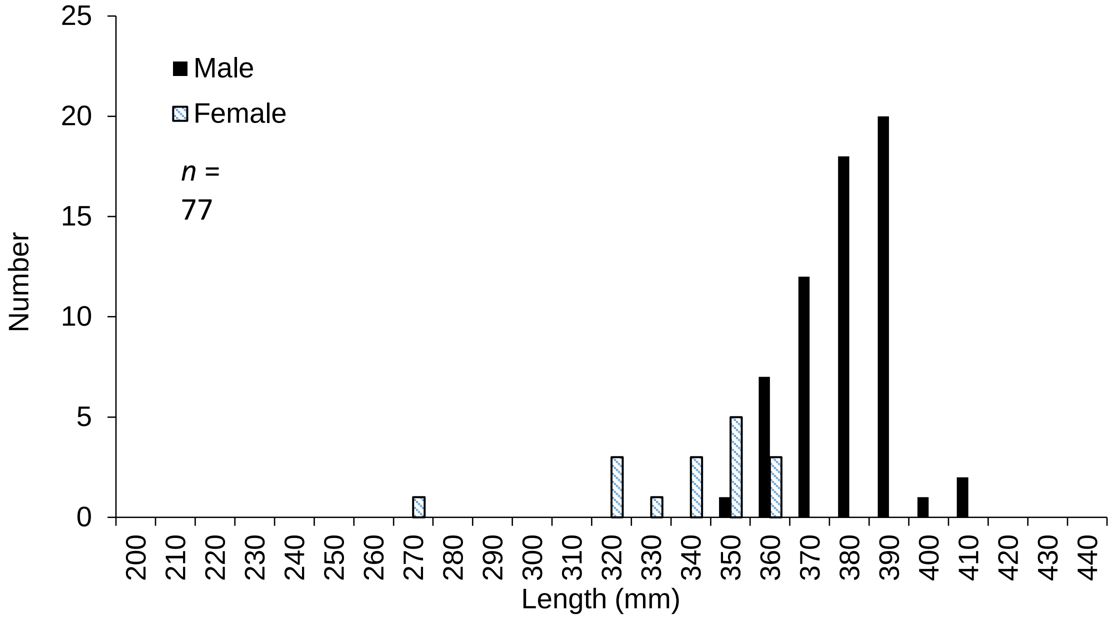

Figure 13. Length-frequency distribution for male and female spawning kokanee sampled from Lake Coeur d'Alene, Idaho (December 6, 2019).

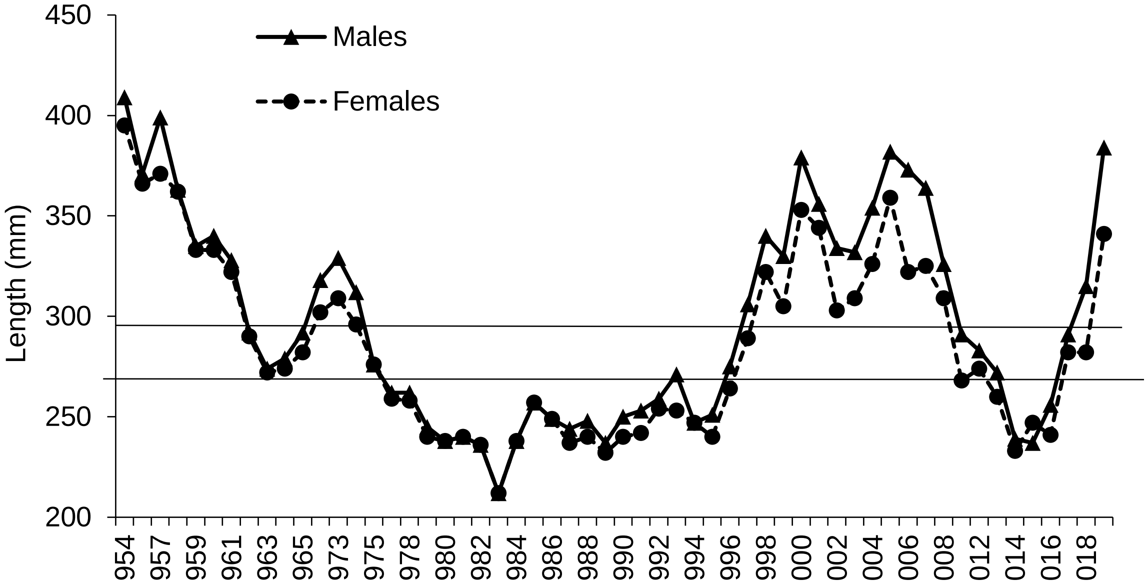

Figure 14. Mean total length of mature male and female kokanee sampled near Higgens Point in Lake Coeur d'Alene, Idaho (1954–2019). Horizontal lines indicate the upper and lower limit of the adult length management objective (250–280 mm).

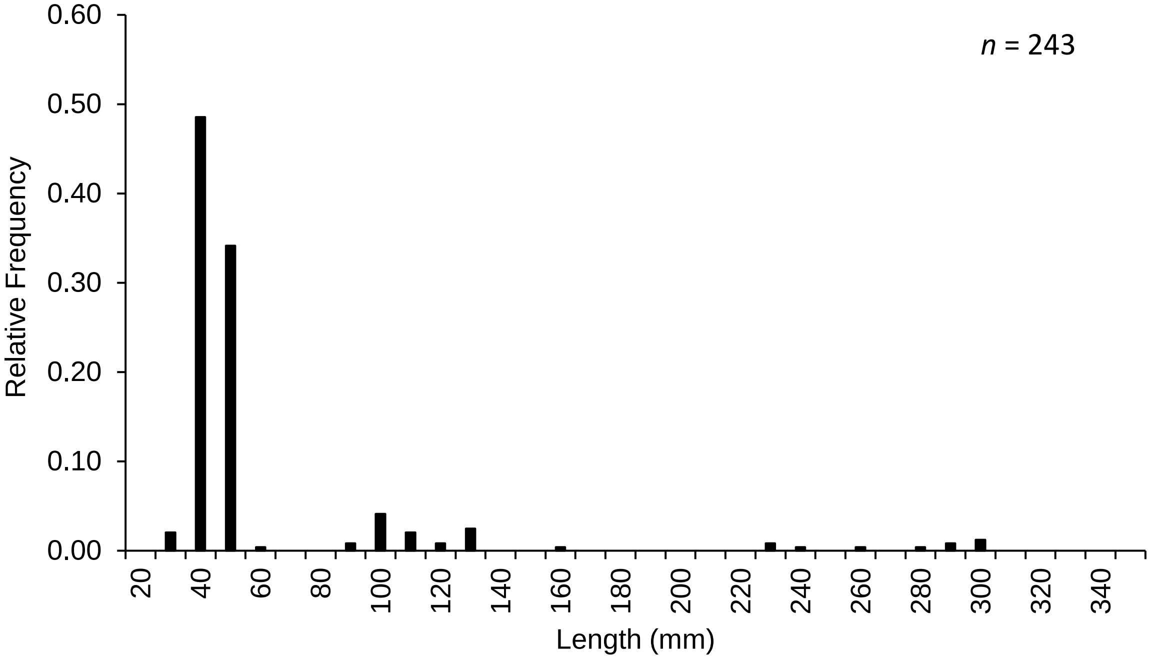

Figure 15. Length-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (August 2, 2019).

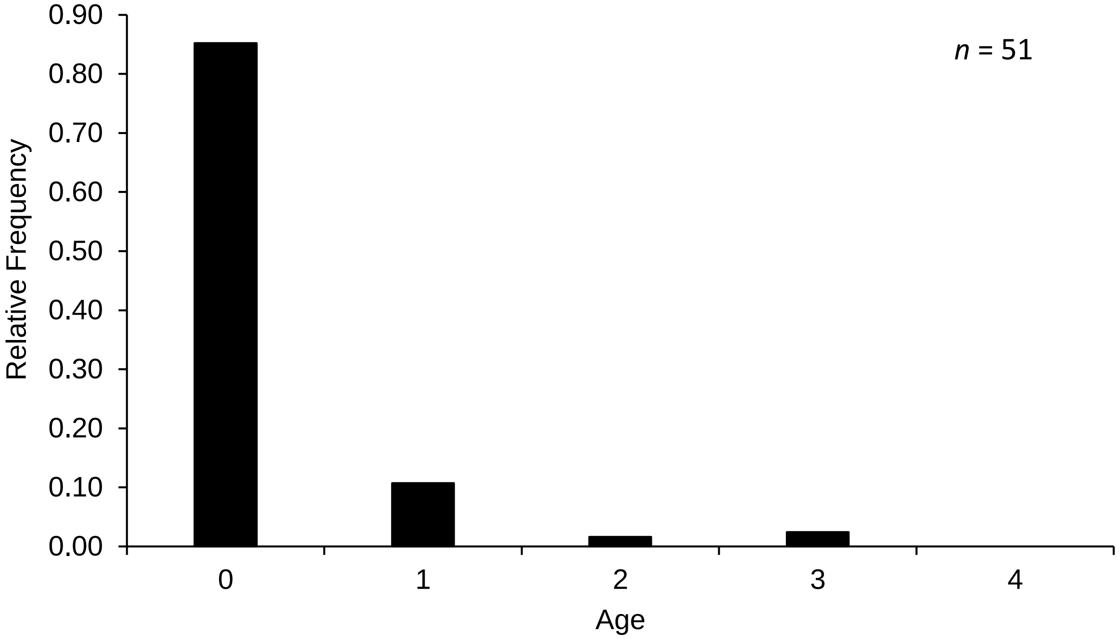

Figure 16. Age-frequency distribution for kokanee sampled using a modified-midwater trawl from Spirit Lake, Idaho (August 2, 2019).

SPOKANE BASIN WILD TROUT MONITORING

ABSTRACT

Long-term data obtained from historical snorkeling transects have been important for informing management of wild salmonids in the upper Spokane River Basin. 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 22–30, 2019, we used daytime snorkeling to observe fishes at historical sampling transects in the Coeur d'Alene River (n = 41) and St. Joe River (n = 34) basins. We estimated total Westslope Cutthroat Trout densities of 0.60 fish/100 m^2 in the North Fork Coeur d'Alene River (including Tepee Creek), 1.04 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 1.23 fish/100 m^2 in the St. Joe River. For Westslope Cutthroat Trout ≥ 300 mm in total length, we estimated densities of 0.05 fish/100 m^2 in the North Fork Coeur d'Alene River, 0.13 fish/100 m^2 in the Little North Fork Coeur d'Alene River, and 0.20 fish/100 m^2 in the St. Joe River. Densities of Rainbow Trout *O. mykiss* remained relatively low in both drainages, with estimates being similar to the past 15–20 years. Size structure of Westslope Cutthroat Trout in the St. Joe River was similar 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 during the past two decades and abundance continues to be variable, yet relatively high. Future monitoring should continue to better inform management of Westslope Cutthroat Trout and to evaluate 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 conservation measures for 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, many populations of Westslope Cutthroat Trout have been negatively influenced by a variety of factors. Extensive land and water development activities, which have reduced available instream habitat and altered flows and thermal regimes, have negatively affected Westslope Cutthroat Trout (Peterson et al. 2010). Another important factor related to range and abundance reductions has been interaction with non-native salmonids (i.e., Rainbow Trout *O. mykiss*, Brook Trout *Salvelinus fontinalis*), which often leads to competition and hybridization (Rainbow Trout only; Marnell 1988; Allendorf et al. 2004; Shepard et al. 2005; Muhlfeld et al. 2009).

Concerns about the rangewide status of Westslope Cutthroat Trout have resulted in two petitions for listing under the U.S. Endangered Species Act (ESA 1973, as amended) in 1997 and 2001. Subsequent evaluations of extant populations determined that the relatively broad distribution and persistence of isolated populations in Oregon, Washington, and Canada did not warrant protection under the ESA (U.S. Federal Register 1998, 2003). However, the U.S. Forest Service and Bureau of Land Management regard Westslope Cutthroat Trout as a sensitive species. 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 and St. Joe rivers to large communities (i.e., Coeur d’Alene, Spokane) makes these waters popular destination trout fisheries, and angling effort has increased in recent times (Fredericks et al. 1997; Dupont et al. 2009).

During 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, the entire Spokane River Basin within Idaho is now managed under a catch-and-release regulation for Westslope Cutthroat Trout, with the exception of the St. Maries River (seasonal two fish daily bag limit). The shift to catch-and-release rules led to improvements in these populations; however, increased education, enforcement of regulations, and habitat rehabilitation have also contributed. Westslope Cutthroat Trout populations responded positively to regulation changes and angler use followed suit. Improvements in the quality of the fishery, combined with the elimination of season restrictions, also increased angler use in the Coeur d’Alene and St. Joe rivers (IDFG 2013). 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.

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 publicly-owned and managed by the U.S. Forest Service (Strong and Webb 1970). Dominant land-use practices in both drainages include hard rock and placer mining and extensive timber harvest (Strong and Webb 1970; Quigley 1996; DEQ 2001). While the combination of these activities has negatively influenced instream habitat and water quality, increased oversight and regulation of land-use have improved environmental conditions for native fishes in both the Coeur d'Alene and St. Joe river drainages (DEQ 2001).

Historical sampling reaches were established on the Coeur d'Alene River in 1973 (n = 38; Figure 16; Bowler 1974) and St Joe River in 1969 (n = 28; Figure 17; Rankel 1971; Davis et al. 1996_b). Sampling was conducted periodically at the start of monitoring until 1990. Since 1990, sampling has been conducted annually. Sampling sites in the Coeur d'Alene River basin have evolved since the inception. However, the sampling scheme currently used was created in 2003 and incorporates all the reaches from previous sampling scheme iterations. Unlike the Coeur d'Alene River basin, sites in the St Joe River basin have been static except for the addition of seven reaches in the lower river between Avery and Calder in 1996 (Davis et al. 1996_b). Sampling reaches in the St. Joe River drainage occur only in the mainstem St. Joe River (Figure 17), 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, Prichard Creek, and Teepee Creek (Figure 16).

METHODS

Standard 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 22–24, 2019 using daytime snorkeling (Dupont et al. 2009; Thurow 1994). Some index reaches were unable to be sampled in 2019. In the North Fork of the Coeur d'Alene (including Teepee Creek), the two uppermost sites (NF22 and NF23) were not sampled due to access issues on the trail and NF01 slough was incorporated into site NF01 because the river channel moved and the slough is now part of the main channel. In the St. Joe River, SJ04 was note sampled due to hazardous water conditions that were not suitable for safe snorkeling. 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. For each species, the total number of fish observed from all sites was divided by the total surface area sampled from all sites sampled in a year to provide a standardized annual density measure. Due to minor calculation inconsistencies in previous years, annual densities were recalculated for all years with readily available fish observation and area snorkeled data. Annual densities were recalculated for 1997 through 2018 for the Coeur d'Alene River basin and 1998 through 2018 for the St. Joe River. In addition, a 10-year density average was calculated using the arithmetic mean from the 10 previous annual densities to 2019.

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

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

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

RESULTS

Coeur d'Alene River Basin

Totals of 769 Westslope Cutthroat Trout, 11 Rainbow Trout, and 1,723 Mountain Whitefish were observed among the 41 sampling sites in the Coeur d'Alene River basin. In addition, we observed 176 Northern Pikeminnow *Ptychocheilus oregonsis*, 4 Largescale Suckers *Catostomous macrocheilus*, and 3 Brook Trout. The density of Westslope Cutthroat Trout was 0.52 fish/100 m^2 in the Coeur d'Alene River basin (Figure 18). The density of Westslope Cutthroat Trout ≥ 300 mm was 0.05 fish/100 m^2 Coeur d'Alene River basin (Figure 19). For Westslope Cutthroat Trout, estimates of density for all fish and density of fish ≥ 300 mm were lower than the 10-year average (all Westslope Cutthroat Trout = 0.94 fish/100 m^2; Westslope Cutthroat Trout ≥ 300 mm = 0.22 fish/100 m^2). Rainbow Trout density was <0.01 fish/100 m^2 and was lower than the 10-year average of 0.13 fish/100 m^2 (Figure 20). Mountain Whitefish density was 1.16 fish/100

m^2 and was lower than the 10-year average of 2.78 fish/100 m^2 (Figure 21). We estimated an RSD-305 of 41 for the Coeur d'Alene River basin (Figure 25).

St. Joe River

Totals of 790 Westslope Cutthroat Trout, zero Rainbow Trout, and 820 Mountain Whitefish were observed among the 34 sampling sites in the St. Joe River. In addition, we observed 221 Largescale Sucker, 126 Northern Pikeminnow, and zero Bull Trout *S. confluentus* during 2019 sampling. Density of all Westslope Cutthroat Trout was 0.71 fish/100 m^2 and was lower than the 10-year average (1.10 fish/100 m^2; Figure 22). The density of Westslope Cutthroat Trout ≥300 mm was 0.12 fish/100 m^2 and was lower than the 10-year average (0.42 fish/100 m^2; Figure 23). Rainbow Trout density was zero fish/100 m^2 and was on par with the 10-year average (0.00 fish/100 m^2; Figure 24). Mountain Whitefish density was 0.67 fish/100 m^2 and was lower than the 10-year average (1.37 fish/100 m^2; Figure 24). Size structure of Westslope Cutthroat Trout in the St. Joe River (RSD-305 = 42) was slightly higher than in the Coeur d'Alene River Basin (Figure 25).

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 historical declines in abundance and size structure in both the Coeur d'Alene and St. Joe rivers were directly related to recruitment overfishing and habitat degradation (Rankel 1971; Lewynsky 1986; Mallet and Thurow 2022). However, in the Spokane River Basin and elsewhere in Idaho, Westslope Cutthroat Trout populations have positively responded to changes in angling regulations and habitat quality.

Westslope Cutthroat Trout densities increased from the beginning of this monitoring program and peaked during the 2010s. Current densities are below 10-year averages for both rivers. Densities from 2019 appear to be lower than recent years; however, we have documented a considerable amount of variability in annual density estimates since the regulation change to a catch-and-release fishery in 2008.

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

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

In recent history, a major concern among the angling public has been about the effect of summer conditions and its interaction with angling-induced fish mortality. In 2015, the Coeur d'Alene River and St Joe River basins experienced moderate to extreme drought conditions characterized by unusually warm and dry climate (NOAA 2016). While densities for Westslope

Cutthroat Trout did decline in the year after the drought, the decline was no greater in magnitude than observed declines that occurred before 2015. Furthermore, densities for all Westslope Cutthroat Trout and those >305 mm returned to or near 10-year averages between the initial decline in 2016 and 2019. This suggests any immediate drought-induced mortality that occurred was negligible and did not impact the fish population. Westslope Cutthroat Trout are known to utilize cold water refugia when water temperature exceeds 22ºC by moving to the mouths of or into cold water tributaries and to cold water upwellings in side channels (Dupont et al. 2008). Strategic movements to cold water refugia can negate impacts from sustained warm water periods. Several of these areas in the Coeur d'Alene River basin have been identified (Dupont et al. 2008, Watershed Sciences 2007) to protect from development and degradation. IDFG has already acquired some surrounding properties and worked with landowners to place conservation easements on others. As climate patterns shift and extreme temperatures occur more frequently, thermal refugia will become more important for Westslope Cutthroat Trout.

Alternatively, over wintering conditions likely have more effect on mortality than summer conditions. Westslope Cutthroat Trout utilize slow, deep pools in larger rivers (Bjornn and Reiser 1991; Hunt 1992; Schmetterling 2001) connected to a wide floodplain (Dupont et al 2008). Deep pools provide refuge from faster water velocities during normal flows resulting in lower energetic costs to maintain position. Similarly, floodplain connectivity adjected to deep pools provide refuge from faster velocities during winter/spring high flow events, such as rain-on-snow, ice dam breakup, and spring runoff. During winters with decreased river levels, pool abundance and depth can be greatly reduced. The result is a reduction of an already limited habitat and an increase in competition stressors by congregated fish, especially larger fish (Cunjak and Power 1986). In the St. Joe and Coeur d'Alene rivers, mean winter base flows in 2018 were nearly as low or lower than the winter of 2015. In the years following these lower baseflows, Westslope Cutthroat Trout densities were also lower.

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

3. Continue to seek opportunities for property acquisitions or conservation easements to protect areas of thermal refugia from development and degradation.

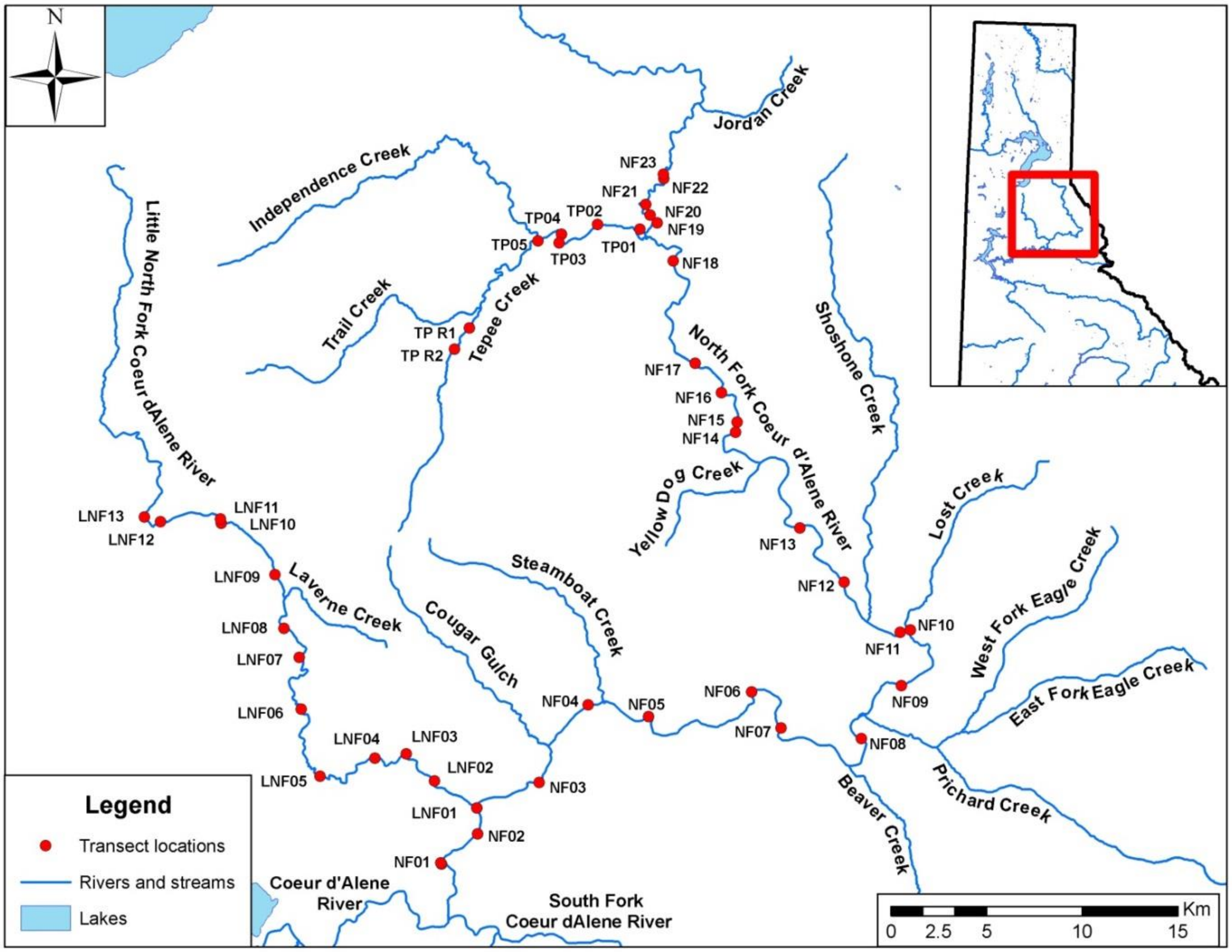

Figure 17. Location of 44 index reaches sampled using snorkeling in the Coeur d’Alene River, Idaho during July 22–24, 2019.

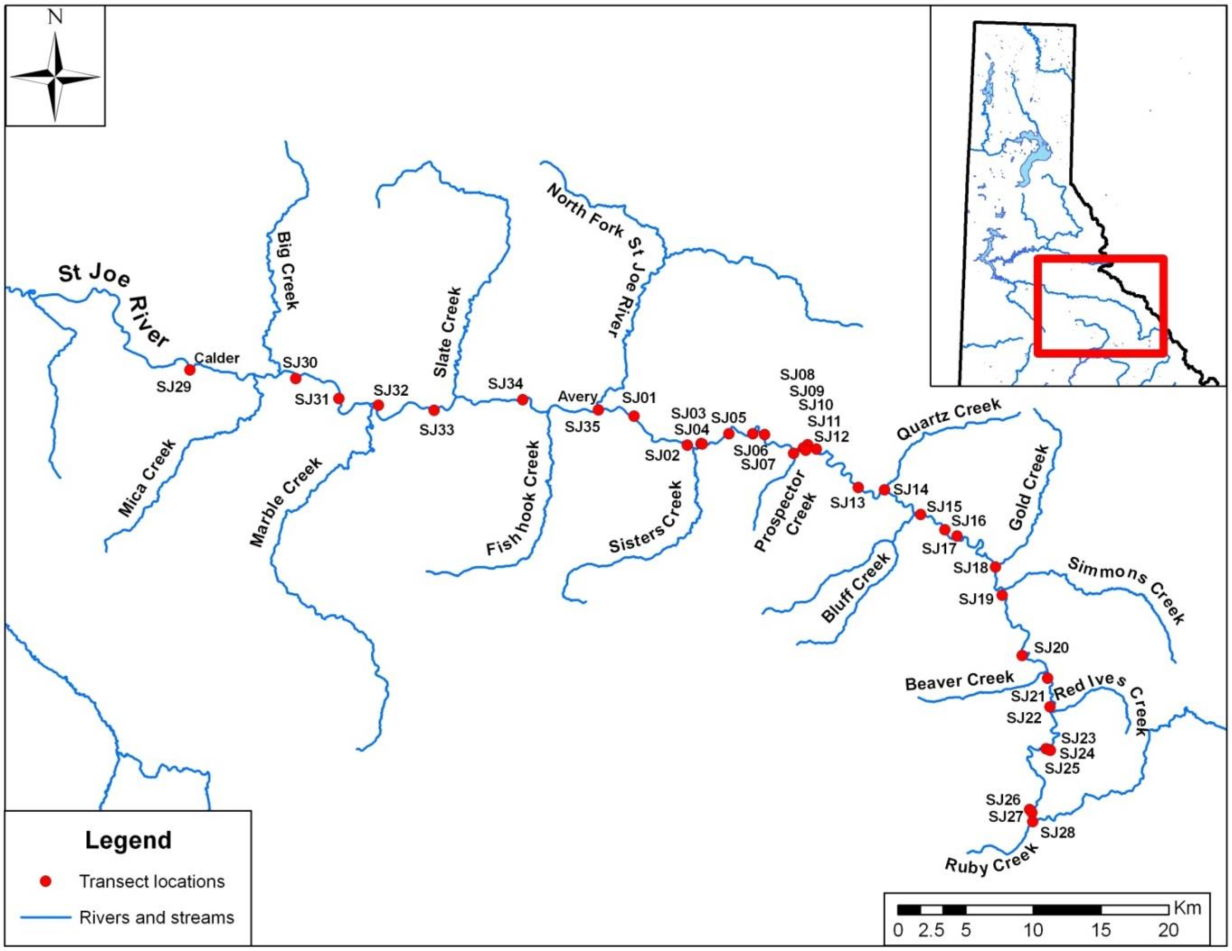

Figure 18. Location of 35 index reaches sampled using snorkeling in the St. Joe River, Idaho during July 29–30, 2019.

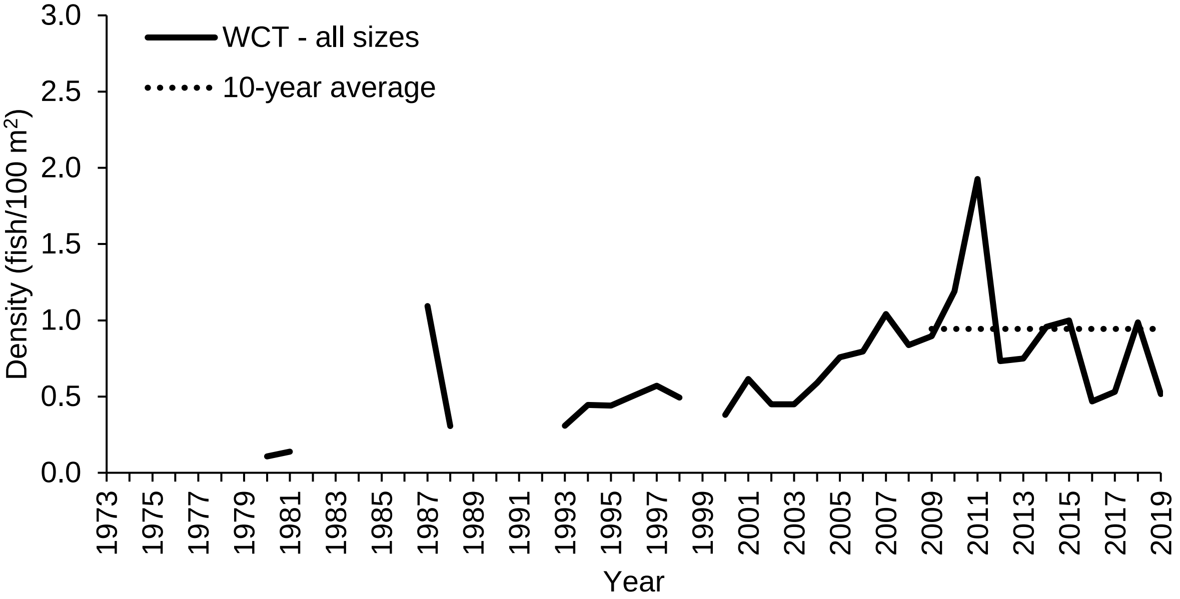

Figure 19. Density and 10-year average of Westslope Cutthroat Trout observed during snorkeling in the Coeur d'Alene River basin (1973–2019).

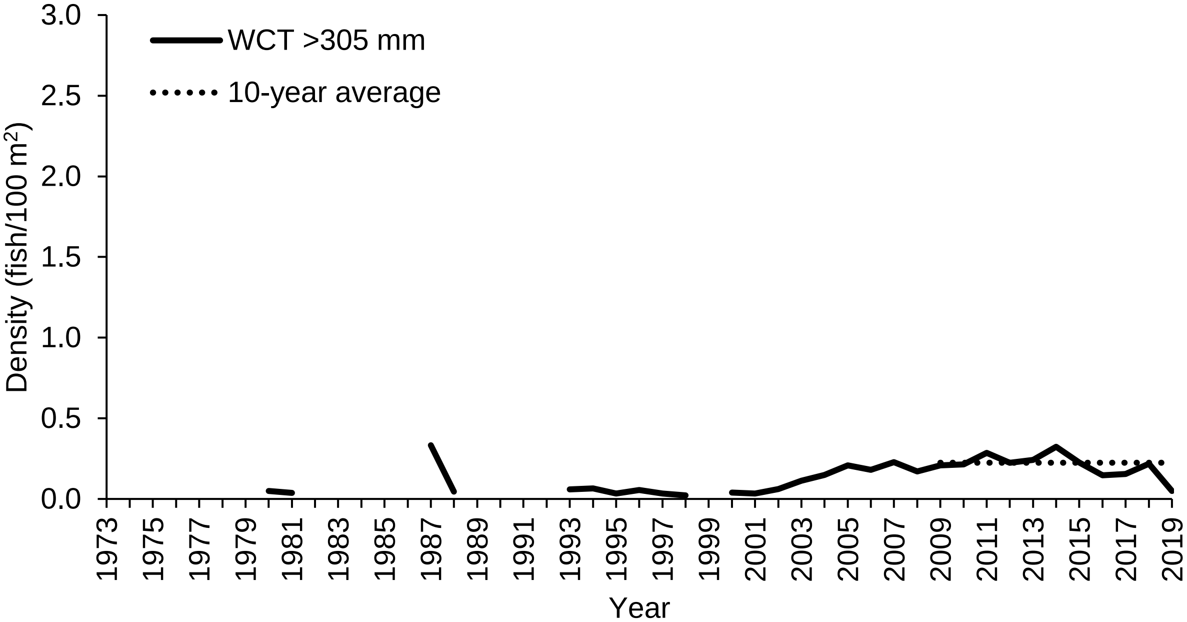

Figure 20. Density and 10-year average of Westslope Cutthroat Trout larger than 305 mm TL observed during snorkeling in the Coeur d'Alene River basin (1973–2019).

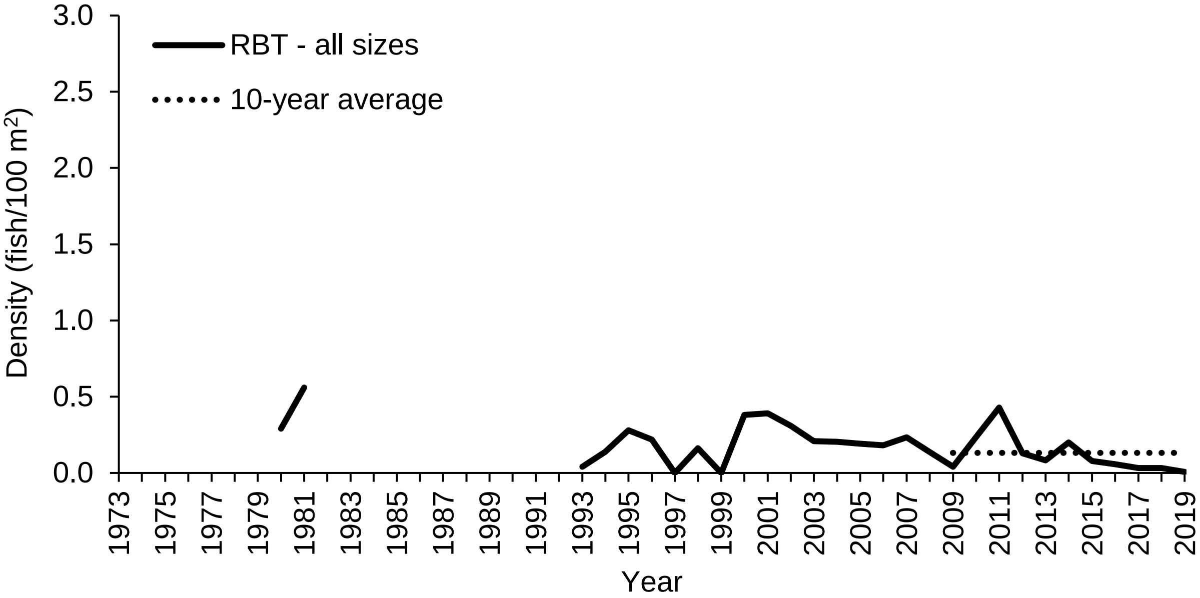

Figure 21. Density and 10-year average of Rainbow Trout observed during snorkeling in the Coeur d’Alene River basin (1973–2019).

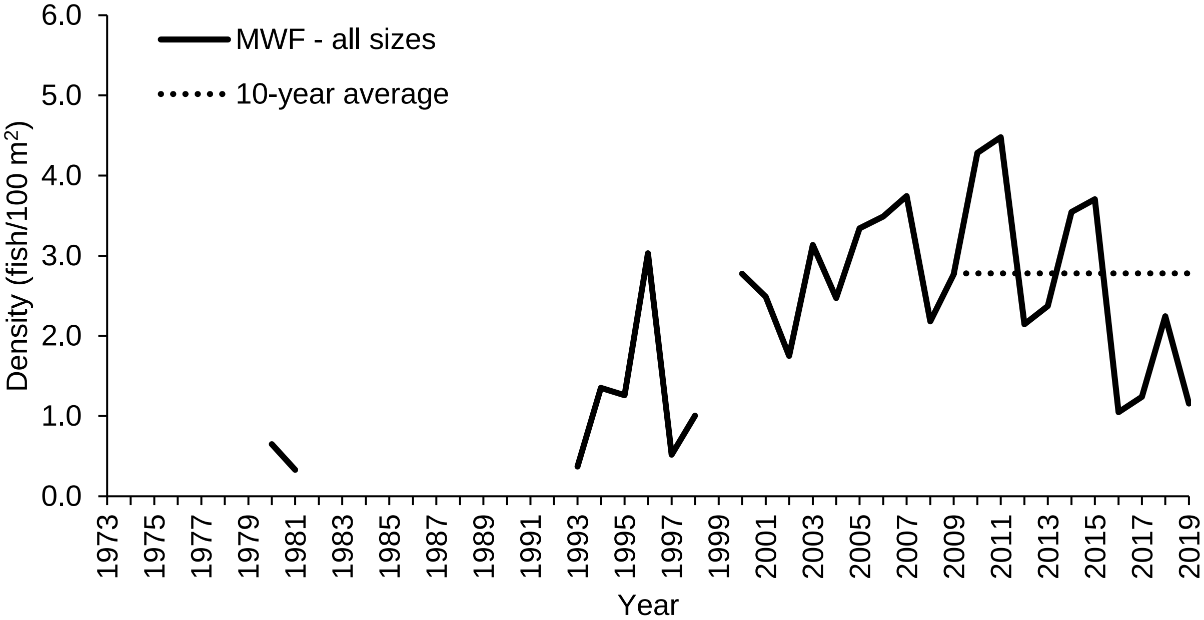

Figure 22. Density and 10-year average of Mountain Whitefish observed during snorkeling in the Coeur d’Alene River basin (1973–2019).

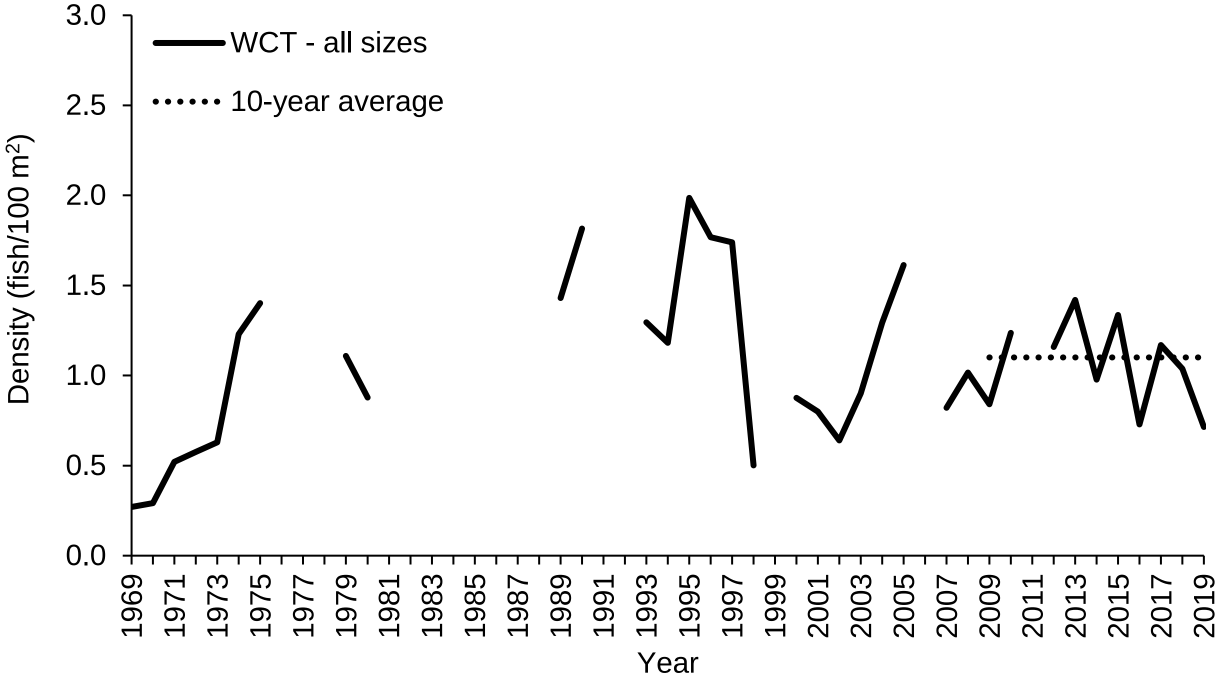

Figure 23. Density and 10-year average from the current year of Westslope Cutthroat Trout observed during snorkeling in the St. Joe River (1969–2019).

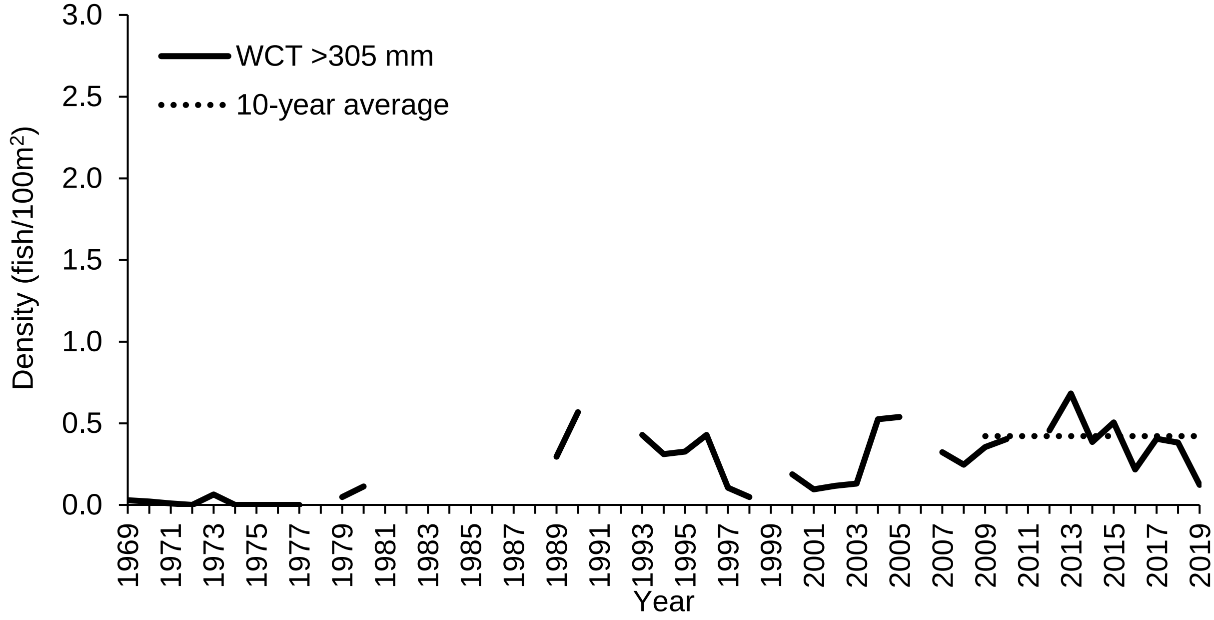

Figure 24. Density and 10-year average from current year of Westslope Cutthroat Trout larger than 305 mm TL observed during snorkeling in the St. Joe River (1969–2019).

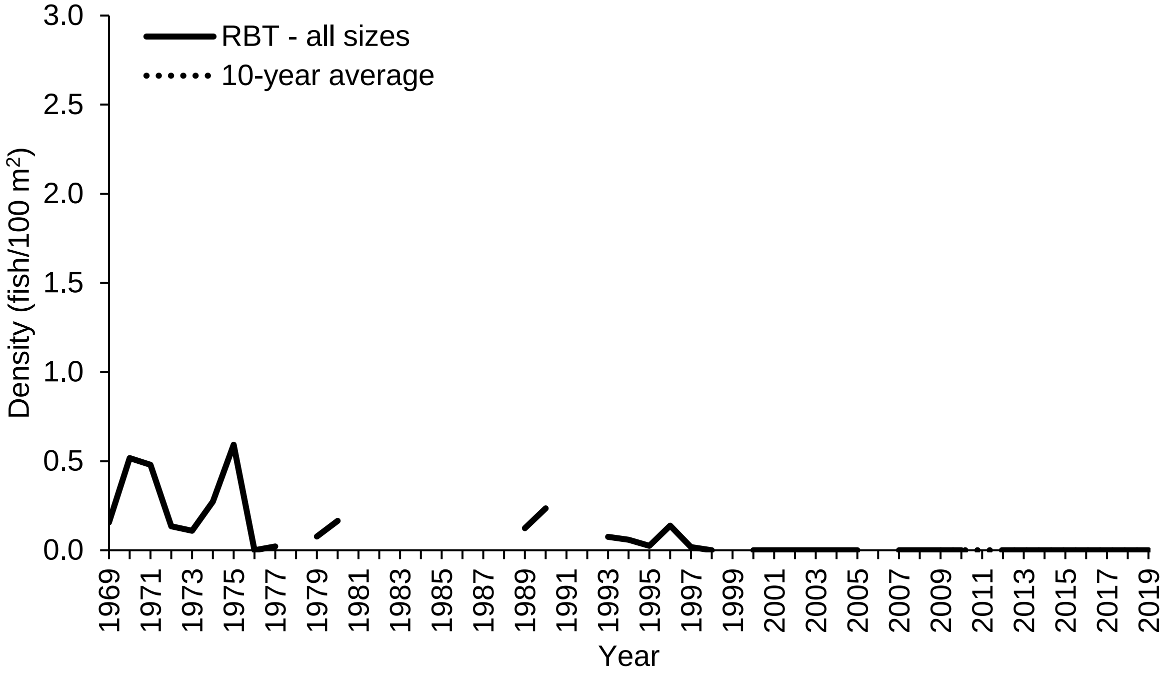

Figure 25. Density and 10-year average from current year of Rainbow Trout observed during snorkeling in the St. Joe River (1969–2019).

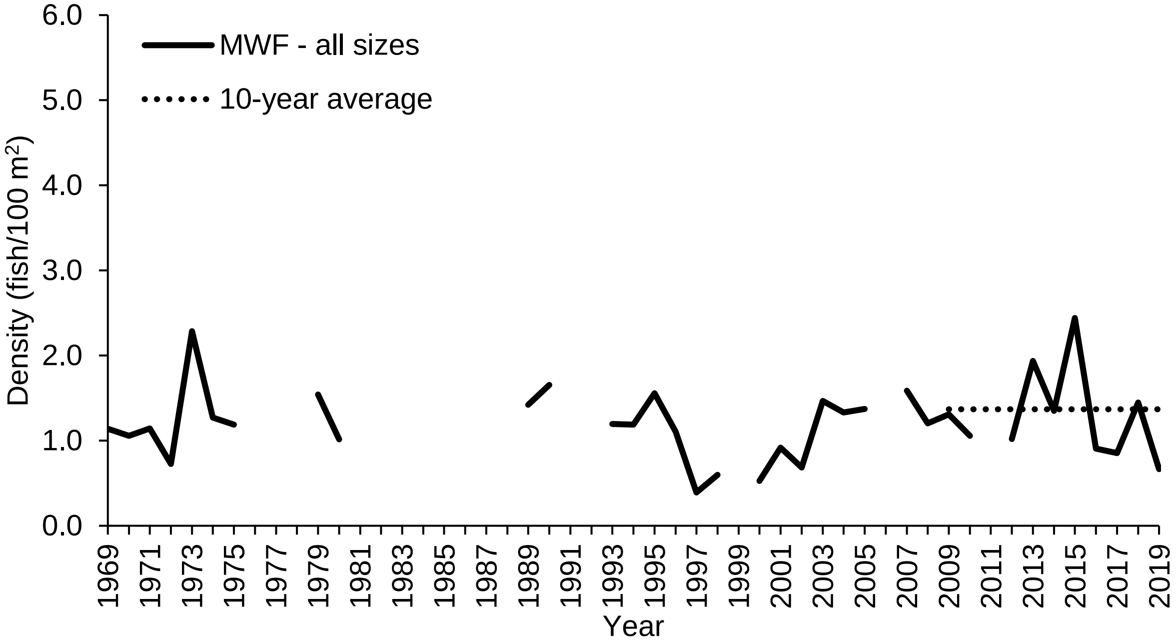

Figure 26. Density and 10-year average from current year of Mountain Whitefish observed during snorkeling in the St. Joe River (1969–2019).

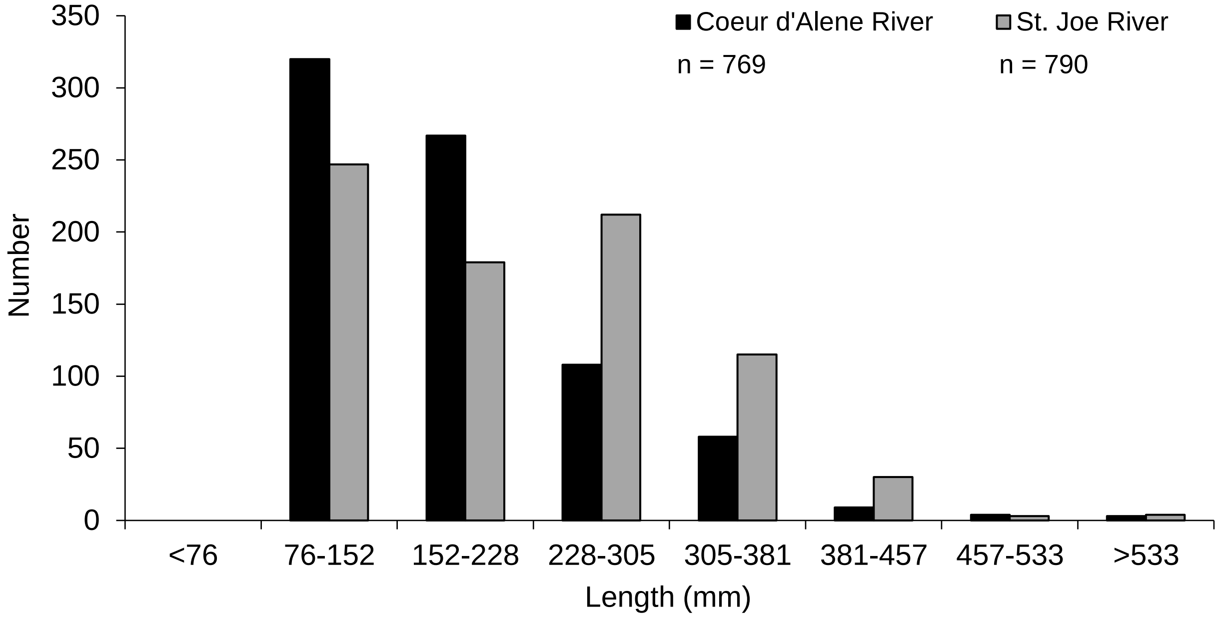

Figure 27. Length-frequency distributions of Westslope Cutthroat Trout observed during snorkeling in the Coeur d’Alene River basin and St. Joe River (2019).

BULL TROUT REDD COUNTS

ABSTRACT

In 2019, we counted Bull Trout *Salvenlinus confluentus* redds as an index of adult abundance in three of the major drainages in northern Idaho's Panhandle Region. A total of 93 redds were detected, including 67 redds in the Upper Priest Lake drainage and 26 redds in the St. Joe River drainage. No redds were observed in Kootenai River tributaries. Redd count totals from 2019 were generally low compared to average counts from the previous ten-year period.

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INTRODUCTION

Bull Trout *Salvelinus confluentus* were listed by the U.S. Fish and Wildlife Service (USFWS) as a threatened species under the Endangered Species Act in 1998. Thus, monitoring population trends for this species 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 USFWS core recovery areas (USFWS 2015) located in the Panhandle Region. Redd counts allow for evaluation of the status of populations in these areas and help in directing future management and recovery activities. Results for redd count surveys conducted in tributaries to Lake Pend Oreille are reported separately (Ransom et al. 2020).

METHODS

We counted Bull Trout redds in select tributaries of the Upper Priest River, St. Joe River, and Kootenai River drainages where migratory Bull Trout were known or believed to spawn. In the Upper Priest River and tributaries we surveyed nine index reaches. Upper Priest River index reaches were established in 2013 (Ryan et al. 2014). Prior to 2013, nine additional transects were surveyed inconsistently. However, current index reaches accounted for an average of 85% of all redds observed across survey years since 1993. We located redds visually by walking along standardized sections within each tributary (Ryan et al. 2020_a). Surveys were conducted by experienced redd counters or an experienced counter paired with an unexperienced counter in most cases. Unexperienced redd counters were provided basic training in identifying redds prior to a survey. Bull Trout redds were defined as areas of clean gravels at least 0.3 x 0.6 m in size with gravels of at least 76 mm in diameter having been moved by fish and with a mound of loose gravel downstream from a depression (Pratt 1984). In areas where one redd was superimposed over another redd, each distinct depression was counted as one redd. Redd surveys were conducted during a standardized time period (late–September to mid-October). In some surveys, redd locations were recorded on maps and/or recorded by global positioning system (GPS). For reporting purposes, 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

We completed Priest Lake core area redd counts on October 1, 2019. We counted 67 Bull Trout redds across seven standard (Ryan et al. 2020_a) stream reaches surveyed in the core area (Table 5). The total redd count represented an increase from the previous year and was above the previous 10-year average (55 redds) for combined counts. The current 10-year average was greater than the average of counts from 1993 to 2009 of 29 redds.

St Joe River

St. Joe River (Coeur d’Alene core area) redd counts were completed on September 23–24, 2019. We surveyed three index streams (Wisdom Creek, Medicine Creek, and mainstem St. Joe River between Heller Creek and St. Joe Lake) that have consistent monitoring data. We counted a total of 13 Bull Trout redds among three index reaches in the core area (Table 6). We counted five redds in Medicine Creek, two redds in Wisdom Creek, and six redds in the St. Joe River between Heller Creek and St. Joe Lake. Total redds observed in 2019 represented a 3-fold increase in redds from the previous year, but the total redd abundance remained below the 10-year average (25 redds) for index streams.

In addition to redd counts in the three index reaches, a comprehensive redd survey was completed in areas where Bull Trout spawning has been observed or where environmental DNA (eDNA) indicated Bull Trout were present. Reaches were surveyed during September 23-October 4 by IDFG, USFWS, USFS, and the Coeur d’Alene Tribe. Of the 26 total reaches (excluding index reaches) surveyed, 13 redds were counted in six reaches (Table 6). Redds were not observed in 20 of the reaches. This more intensive survey effort confirmed that Bull Trout population size in this core area has declined to an exceptionally low level and has not been misrepresented by the trend in index reaches. Results from the comprehensive survey indicate that index reaches annually surveyed by IDFG encompass >50% of spawning activity in the basin. Adding Heller Creek and Red Ives Creek to the annually surveyed index reaches would encompass >75% of the redd abundance.

Streams in the St. Joe River core area have been surveyed opportunistically as personnel and logistical constraints allow. Thus, interpretation of total counts from this time series should be done cautiously. We recommend future efforts focus on counting redds annually in index streams unless specific questions arise that require a more comprehensive survey. We also recommend adding Heller and Red Ives creeks as index reaches. This will allow population trends in this core area to be monitored more effectively with a fairly minimal increase in survey effort. We believe this is warranted given the small population size of Bull Trout in this core area and associated conservation concerns.

Kootenai River Core Area

Redd counts in the Idaho portion of the Kootenai River core area were completed in mid-October (Table 7). No redds were observed in the three streams that were surveyed. The 10-year average of redd counts was 6 and the historical average of counts from 2002 to 2009 was 21. This is the first time that a survey has been conducted without detecting any redds in this group of streams. Redd counts in these streams have been exceptionally low in recent years, but the 2019 count suggests that these local populations are on the brink of extirpation. Most remaining Bull Trout occur in streams within the Montana portion of the Kootenai River core area (USFWS 2015). Thus, the risk of Bull Trout extirpation at a core area-scale is lower. Although redds were not observed in Idaho streams during 2019, we recommend continuing annual surveys to monitor whether extirpation has occurred.

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. In the St. Joe drainage, add Heller Creek and Red Ives Creek as index reaches to be counted annually.

Table 5. Bull Trout redd counts by stream and count transect from the Upper Priest River, Idaho. Redd counts were reported for 2019. Average redd counts were reported for the previous 10-year period (2009-2018) and the period from 1993 through 2018. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row.

Stream	Transect Description	Length (km)	1993-2018	2009-2018	2019
Upper Priest River	Falls to Rock Cr.	12.5	17 (23)	22 (10)	49
	Rock Cr. to Lime Cr.	1.6	6 (26)	14 (10)	1
	Lime Cr. to Snow Cr.	4.2	7 (26)	9 (10)	12
	Snow Cr. to Hughes Cr.	11	3 (25)	2 (10)	5
	Hughes Cr. to Priest Lake	2.3	0 (8)	0 (3)	--
Rock Cr.	Mouth to F.S. trail 308	0.8	0 (16)	0 (4)	--
Lime Cr.	Mouth upstream 1.2 km	1.2	0 (18)	0 (4)	--
Cedar Cr.	Mouth upstream 3.4 km	3.4	0 (20)	0 (4)	--
Ruby Cr.	Mouth to waterfall	3.4	0 (9)	0 (2)	--
Hughes Cr.	Trail 311 to trail 312	2.5	1 (20)	0 (4)	--
	F.S. road 622 to Trail 311	4	1 (26)	2 (10)	0
	F.S. road 622 to mouth	7.1	2 (24)	4 (10)	0
Bench Cr.	Mouth upstream 1.1 km	1.1	0 (20)	0 (4)	--
Jackson Cr.	Mouth to F.S. trail 311	1.8	0 (17)	0 (4)	--
Gold Cr.	Mouth to Culvert	3.7	3 (26)	3 (10)	0
Boulder Cr.	Mouth to waterfall	2.3	0 (12)	0 (3)	--
Trapper Cr.	Mouth upstream 5.0 km	5	2 (18)	0 (3)	--
Caribou Cr.	Mouth to old road crossing	2.6	0 (7)	0 (1)	--
All stream reaches combined		44.1	42	56	67

Table 6. Bull Trout redd counts by stream and count transect from the St. Joe River, Idaho. Redd counts were reported for 2020. Average redd counts were reported for the previous 10-year period (2010-2019) and the period from 1992 through 2019. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row.

Stream	Transect	Length (km)	1992-2018	2009-2018	2019
Bad Bear Cr.	Mouth upstream 2.1 km	2.1	0 (3)	-- (0)	0
Bean Cr.	Mouth upstream 4.4 km	4.4	3 (5)	1 (3)	1
N.F. Bean Cr.	Mouth upstream 0.4 km	0.4	9 (3)	9 (3)	0
Beaver Cr.	Mouth upstream 7.2 km	7.2	0 (19)	1 (3)	0
Broadaxe Cr.	Mouth upstream 1.7 km	1.7	0 (4)	-- (0)	0
California Cr.	Mouth upstream 2.4 km	2.4	1 (18)	1 (3)	0
Cascade Cr.	Mouth upstream to barrier	0.4	2 (1)	2 (1)	0
Copper Cr.	Mouth upstream 5.1 km	5.1	0 (7)	-- (0)	0
Entente Cr.	Mouth upstream to barrier	2.6	0 (3)	-- (0)	0
Fly Cr.	Mouth upstream 4.3 km	4.3	1 (16)	1 (4)	0
Gold Cr.	Rkm 3.2 to Broadaxe Cr.	5.0	0 (2)	-- (0)	0
Heller Cr.	Mouth upstream 4.3 km	4.3	2 (23)	5 (8)	3
Medicine Cr.	Mouth upstream 3.9 km	3.9	31 (27)	20 (10)	5
Mill Cr.	Mouth upstream 1.6 km	1.6	8 (2)	8 (2)	2
Mosquito Cr.	Mouth upstream to falls	0.7	1 (8)	-- (0)	0
My Cr.	Mouth upstream 1.6 km	1.6	0 (1)	0 (1)	0
Quartz Cr.	Rkm 2.4 to Entente Cr.	1.6	0 (1)	-- (0)	1
Red Ives Cr.	Mouth upstream 3.1 km	3.1	1 (22)	1 (6)	4
Ruby Cr.	Mouth upstream 2.8 km	2.8	2 (4)	0 (1)	0
Sherlock Cr.	Mouth upstream 4.2 km	4.2	1 (19)	1 (4)	2
Simmons Cr.	Mouth to N.F. Simmons Cr.	5.0	0 (6)	0 (1)	0
	N.F. Simmons Cr. To Three Lakes Cr.	3.4	1 (4)	0 (1)	0
	Three Lakes Cr. To NF-1278	6.3	1 (9)	0 (1)	0
	NF-1278 Rd. to Washout Cr.	0.3	0 (8)	0 (1)	0

Table 6. (continued)

Stream	Transect	Length (km)	1992-2018		2009-2018		2019
St. Joe River	Heller Cr. to St. Joe River falls	11.7	6	(27)	3	(10)	6
Tenear Cr.	Mouth upstream 1.6 km	1.6	4	(2)	4	(2)	0
Timber Cr.	Mouth upstream 3.2 km	3.2	0	(3)	--	(0)	0
Wisdom Cr.	Mouth upstream 2.0 km	2.0	7	(27)	2	(10)	2
Yankee Bar Cr.	Mouth upstream 1.1 km	1.1	1	(13)	1	(1)	0
All stream reaches combined		94.0	53		36		24

Table 7. Bull Trout redd counts by stream and count transect from tributaries to the Kootenai River, Idaho. Redd counts were reported for 2019. Average redd counts were reported for the previous 10-year period (2009-2018) and the period from 2001 through 2018. Redd counts were not completed for all transects in all years. Values in parentheses indicate the number of years with completed counts represented by average values. The sum of all stream reaches surveyed in the count year, mean counts by year ranges, and the sum of counts for the count year are listed in the all stream reaches row.

Stream	Transect	Length (km)	2001-2018		2009-2018		2019
North Callahan Creek	Jill Cr to waterfall barrier	3.3	11	(15)	6	(8)	0
South Callahan Creek	F.S. Rd 4554 to F.S. Rd 414	4.3	2	(15)	1	(8)	0
Boulder Creek	Mouth to waterfall barrier	2.0	0	(14)	0	(6)	0
All stream reaches combined		10.0	14		7		0

HATCHERY RAINBOW TROUT EVALUATIONS

ABSTRACT

Cocolalla Lake and Fernan Lake are managed as mixed species fisheries under general regional bag and size limits. Catchable (>152 mm) Rainbow Trout *Oncorhynchus mykiss* were stocked in Cocolalla Lake and Fernan Lake in 2018 and 2019 to improve Rainbow Trout fishing. In 2019, we evaluated angler exploitation of stocked catchable Rainbow Trout to understand how these fish were utilized by anglers. Angler exploitation was estimated by using tag returns from Rainbow Trout tagged and released in each lake. Angler exploitation was 8.8% and 4.9% from April and May stocking groups in Cocolalla Lake, respectively. Angler exploitation was 8.2%, 6.7%, 17.8% for the April, June, and September stocking groups for Fernan Lake, respectively. Our evaluation suggests exploitation of catchable Rainbow Trout stocked in both lakes was low. We recommend periodic evaluation of angler exploitation be completed to better understand how angler use of this new fishing opportunity changes in the future.

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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 sport fish species used to enhance coldwater fishing opportunity. Catchable Rainbow Trout *Oncorhynchus mykiss* (typically released at 203–350 mm; hereafter referred to as "catchables") are the single most significant coldwater hatchery product used statewide, and the production of catchables accounts for 50% of the total annual resident fish hatchery program budget (Koenig et al. 2011).

Statewide evaluations of return-to-creel of catchables have been a focal point for IDFG research in recent history. Specifically, the 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 waters < 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), and the "Tag! You're It!" reporting system. Previous studies have produced important information that has been used to more effectively distribute hatchery catchables in Panhandle Region waters so as to maximize angler use and exploitation. With this study, we sought to estimate return-to-creel of catchables in two lowland lakes that received stockings during April-September.

STUDY AREA

Cocolalla Lake

Cocolalla Lake is located in Bonner County, Idaho, near the community of Westmond. The lake's surface area is approximately 325 hectares. Maximum depth is approximately 12 m. The lands surrounding the lake are primarily private ownership and many residences are located near the lakeshore. An Idaho Department of Fish and Game (IDFG) access site on the north side of the lake provides the only public boating access to the lake. Water depth at the IDFG boat ramp can limit access for larger boats from mid-summer through fall. An IDFG wildlife management area property abuts the lake on its southern end, but access to the lake through the property is undeveloped walk-in access only. The lack of public shoreline access results in minimal shoreline angling opportunity. Most shoreline angling occurs from privately-owned docks.

Cocolalla Lake is managed as a mixed species fishery under general regional bag and size limits. A variety of warmwater and salmonid species provide diverse fishing opportunity (Camacho et al. 2021). Warmwater species found in Cocolalla Lake include Black Crappie *Pomoxis nigromaculatus,* Brown Bullhead *Ameiurus nebulosus,* Largemouth Bass *Micropterus* *salmoides*, Smallmouth Bass *Micropterus dolomieu*, Pumpkinseed *Lepomis gibbosus,* and Yellow Perch *Perca flavescens*. Salmonid species present include hatchery Rainbow Trout *Oncorhynchus mykiss* and Westslope Cutthroat Trout *Oncorhynchus clarkia* stocked annually, as well as Brook Trout *Salvelinus fontinalis* and Brown Trout *Salmo trutta* historically stocked in the drainage and now persisting through natural recruitment. Non-game fishes including Peamouth *Mylocheilus caurinus*, Largescale Sucker *Catostomus macrocheilus*, Longnose Sucker *Catostomus*, and Bridgelip Sucker *Catostomus columbianus* have also been observed in previous surveys of the lake (Davis et al. 1996$_a$, Fredericks et al. 2009, Camacho et al. 2021).

Rainbow Trout have been stocked in Cocolalla Lake for many years with an interest in providing trout fishing opportunity (Idaho Department of Fish and Game, unpublished data). Catchable length (>152 mm) Rainbow Trout (catchables) were commonly stocked in Cocolalla Lake prior to 1993 and provided a popular fishery (Davis et al. 1996$_a$). Primarily fingerling length (<152 mm) Rainbow Trout were stocked in Cocolalla Lake from the late-1990s through 2017. No specific information was found describing the rationale for transitioning from catchable to fingerling length Rainbow Trout. Stocking of fingerling length Rainbow Trout in Cocolalla Lake was discontinued in 2017 due to poor survival post-outplant (Ryan et al. 2020$_b$). Catchable Rainbow Trout were again stocked in Cocolalla Lake in 2018 and 2019 with an interest in improving Rainbow Trout fishing. These stocking events represent the first use of “magnum” Rainbow Trout in Cocolalla Lake.

Fernan Lake

Fernan Lake is located in Kootenai County immediately east of the city of Coeur d’Alene. The lake has a surface area of 171 ha, an elevation of 647 m, and a maximum depth of approximately 8 m. It has historically been classified as an oligotrophic water body, but eutrophication has led to recent increases in its productivity and algal blooms during late-summer. There are two Kootenai County public boating access points on the lake. Most use is located on the western end of the lake by the outlet and has abundant shoreline and dock access for fishing. The other access point is on the northeast end near the mouth of Fernan Creek. Good shoreline angling is accessible from roadside pullouts adjacent to Fernan Lake Road along the entire north shoreline of the lake. The close proximity of the lake to densely populated areas of Coeur d’Alene and its mixed fishery of warmwater and coldwater species make Fernan Lake one of the most popular lowland lakes in the region.

Fernan Lake is managed as a mixed species fishery under general regional bag and size limits. A variety of warmwater and salmonid species provide diverse fishing opportunity (Ryan et al. 2020$_b$). Warmwater species found in Fernan Lake include Black Crappie *Pomoxis nigromaculatus,* Bluegill *Lepomis macrochirus,* Brown Bullhead *Ameiurus nebulosus,* Channel Catfish *Ictalurus punctatus*, Green Sunfish *Lepomis cyanellus*, Largemouth Bass *Micropterus salmoides*, Northern Pike *Esox Lucius,* Pumpkinseed *Lepomis gibbosus,* Smallmouth Bass *Micropterus dolomieu*, and Yellow Perch *Perca flavescens*. Salmonid species present include Rainbow Trout *Oncorhynchus mykiss* and Westslope Cutthroat Trout *Oncorhynchus clarkia.* Non-game fish including Tench *Tinca tinca* have also been observed in previous surveys of the lake (Ryan et al. 2020$_b$).

Catchable length (>152 mm) Rainbow Trout have been stocked annually into Fernan Lake since 1968 with an interest in providing a harvestable trout fishing opportunity (Idaho Department of Fish and Game, unpublished data). Starting in 2015, “magnum” length (mean TL = 305 mm) Rainbow Trout were stocked to maximize return-to-creel efficiency.

METHODS

Angler exploitation of hatchery Rainbow Trout was evaluated in Cocolalla Lake and Fernan Lake. Exploitation rates were estimated by tagging and releasing catchable length (mean length = ~305 mm) Rainbow Trout with individually numbered T-bar style tags (Floy®). Prior to release, individual fish were tagged at the Idaho Department of Fish and Game Sandpoint Fish Hatchery. Tags were inserted at an angle into the dorsal musculature just below the dorsal fin of each fish. Tag numbers and total fish length (TL; mm) were recorded for each individual. Tagged groups were held in a raceway after tagging for one to several days prior to stocking. Tags lost in the loading process or from fish that died post-tagging were removed from our sample. We tagged a proportion of fish from each standard stocking request for the lake in 2019.

Exploitation of catchable Rainbow Trout was estimated using tag returns as described by Meyer et al. (2012). Tags were printed with the Idaho Department of Fish and Game "Tag You're It" phone number for reporting. Angler tag returns were collected by phone, online (IDFG website), and in person at the IDFG Panhandle regional office. Tag returns were adjusted for tag loss (8.2%), tagged fish mortality (1.0%), and reporting rate (49.4%) based on reported mean values for hatchery Rainbow Trout in Meyer and Schill (2014). Fish harvested only because they were tagged were not used to calculate exploitation (Meyer and Schill 2014). Adjusted exploitation (μ) was estimated for one year at-large. We also estimated adjusted total use of stocked Rainbow Trout for one year at-large by including both harvested and released fish in our calculations.

RESULTS

Cocolalla Lake

Two groups of Rainbow Trout were tagged and released in Cocolalla Lake in 2019 (Table 8). The first group included 193 fish released on April 11. Mean length of fish released in April was 296 mm. The second stocking group included 198 fish released on May 23. Mean length of fish released in May was 302 mm.

Anglers reported harvesting seven tagged Rainbow Trout from our April stocking group. One additional tagged fish was caught and released. Four fish were harvested and reported by anglers from the May stocking group. One additional fish from that group was harvested because it was a tagged fish and one fish was caught and released. We estimated μ (± 80% C.I.) at 8.8% (8.5%) and 4.9% (6.0%) from the April and May stocking groups, respectively (Table 8). Angler use was 10.0% (9.3%) and 7.3% (12.7%) from April and May stocking groups, respectively. Five additional fish from the April group were caught and harvested beyond one year at-large. No fish were caught and reported by anglers from the May group beyond one year at-large.

Fernan Lake

Three groups of Rainbow Trout were tagged and released in Fernan Lake in 2019 (Table 8). The first stocked group included 191 fish with a mean length of 291 mm released on April 11. The second stocked group included 200 fish with a mean length of 292 mm released on June 21. The third stocked group included 200 fish with a mean length of 285 mm released on September 24.

Anglers reported harvesting a total of 41 fish from the three tagged groups within the first year at-large. Seven tagged Rainbow Trout from our April stocking group were harvested and none were released. Six tagged Rainbow Trout from our June stocking group were harvested and none were released. Sixteen tagged Rainbow Trout from our June stocking group were harvested, 10 were caught and released, and 2 were harvested because they were tagged that would otherwise have not been harvested according to the anglers. Reported fish were caught in every month during the one year at-large timeframe (April 2019 – September 2020), except for April 2019, February 2020, and August 2020. The mean days at-large for the April, June and September stocking groups were 104, 113, and 115 days, respectively. The maximum days at-large was 347 days. We estimated μ (± 80% C.I.) at 8.2% (4.2%) for the April stocked group, 6.7% (3.7%) for the June stocked group, and 17.8% (6.7%) for the September stocked group. (Table 8). Angler use was estimated at 8.2% (4.2%) for the April stocked group, 6.7% (3.7%) for the June stocked group, and 31.2% (9.7%) for the September stocked group (Table 8). No fish were reported beyond one year at-large.

DISCUSSION

Our evaluation suggested exploitation of catchable Rainbow Trout stocked in Cocolalla Lake was low. A range of exploitation rates on Rainbow Trout has been observed in the Panhandle Region. For example, Ryan et al. (2020a) and Ryan et al. (2020b) estimated angler exploitation on catchable Rainbow Trout stocked in a collection of lowland lakes in the region and found it varied from 2% to 64%. Although our estimates of exploitation were low, we expect stocked Rainbow Trout provided an improved angling opportunity. Anecdotal angler reports suggested trout angling was popular in 2019 relative to angler effort in the recent past. In addition, Camacho et al. (2021) found trout were commonly the target of anglers in an angler survey conducted from March 2018 through March 2019, incorporating the period during which stocking of catchable Rainbow Trout was reinitiated.

Exploitation rates in Fernan Lake were similar to Cocolalla Lake and lower than previous Fernan Lake estimates observed in 2016 from stocking events in the spring and early summer months (Ryan et al. 2020$_b$). In both 2016 and 2019, Fernan Lake exploitation estimates decreased from April to June suggesting summer stocking may not be the most efficient use of catchables. Furthermore, Fernan Lake experiences warm water conditions and annual blue green algae blooms during the warmest summer months (i.e., July and August). Such conditions prevent trout stocking and likely negatively impact angler use and exploitation indicated by the lack of tag returns observed between mid-June through mid-September. However, exploitation for the September stocking event was nearly double and use was more than triple than any other month, suggesting anglers were eager to resume fishing once conditions improved. Unfortunately, estimates from the 2016 fall stockings were not available for comparison. Future evaluations should include any fall stocking events to determine if the high exploitation and use was an anomalous event or potentially a more effective use of catchables for Fernan Lake.

Relative to most other waters, a large proportion of the Panhandle Region's annual hatchery catchable Rainbow Trout request was assigned to Cocolalla Lake and Fernan Lake in an effort to not only improve fishing opportunity but provide a high catch rate fishing experience. Stocking of catchable Rainbow Trout in Cocolalla Lake was reinitiated in 2018 and the stocking request for Fernan Lake was doubled from the previous year. We anticipate angling effort directed at catchable Rainbow Trout and subsequent angler exploitation of these fish will increase as anglers learn about the new opportunity provided at Cocolalla Lake and increased opportunity at Fernan Lake. We recommend periodic evaluation of angler exploitation be completed to better understand if this occurs. We also recommend that both Rainbow Trout fisheries be promoted in periodic outreach efforts to make anglers aware of improved fishing opportunities at that location.

If future monitoring indicates similarly low exploitation on these waters, a reduction in stocking density or timing may be warranted.

MANAGEMENT RECOMMENDATIONS

1. Periodically evaluate angler exploitation of catchable Rainbow Trout stocked in Cocolalla Lake and Fernan Lake.

2. Promote the Rainbow Trout fisheries through outreach efforts to make anglers aware of improved fishing opportunities.

Table 8. Rainbow Trout stocked, proportion tagged, adjusted exploitation (*μ*; ± 80% C.I.), and adjusted total use (± 80% C.I.) by stocking month from Cocolalla Lake and Fernan Lake, Idaho.

Water	Stocking month	# Stocked	Fish/ha	# Tagged	*μ*	Adjusted use
Cocolalla Lake	April	6,678	21	193	8.8% ± 8.5%	10.0% ± 9.3%
Cocolalla Lake	May	2,598	8	198	4.9% ± 6.0%	7.3% ± 12.7%
Fernan Lake	April	11,944	69	191	8.2% ± 4.2%	8.2% ± 4.2%
Fernan Lake	June	6,830	40	200	6.7% ± 3.7%	6.7% ± 3.7%
Fernan Lake	September	8,101	47	200	17.8% ± 6.7%	31.2% ± 9.7%

HAYDEN LAKE INVESTIGATIONS

ABSTRACT

Hayden Lake, located northeast of Hayden Idaho in the Panhandle Region, provides fishing opportunity for multiple fish species and is a popular fishing destination. Rainbow Trout *Oncorhynchus mykiss* have been stocked in Hayden Lake since the early 1900s and have historically provided a quality fishery, but have represented only a small portion of the effort and catch in recent years. Identifying the cause and remedy for declining quality trout fishing opportunities in Hayden Lake has been an ongoing focus of fisheries managers, but with little improvement resulting in the fishery. Kokanee *Oncorhynchus nerka* are also stocked in Hayden Lake and provide a popular pelagic fishery. Low-density stocking of early-spawning kokanee has resulted in large (>350 mm) kokanee at age-2. However, production from wild spawning observed in lake tributaries may influence population density and subsequent fishery quality if growth rate declines. In 2019, we attempted to evaluate survival of recently stocked Rainbow Trout in Hayden Lake using a gill net survey to describe relative abundance after stocking. Wild kokanee production was also evaluated by identifying the wild proportion of gill net-caught fish. Thermal marks were used to identify hatchery and wild kokanee. We also monitored mysid shrimp *Mysis diluviana* density in Hayden Lake to better understand trends in abundance. Mysids were sampled using vertical tows of a 0.5 m plankton net. We collected two Rainbow Trout in our gill net survey, suggesting survival of stocked fish was low and limiting our ability to compare stocking methods. Thermal marks were not detected for 26% of examined kokanee, indicating that wild production occurred at a relatively low level. The current wild kokanee contribution to the population does not appear to heavily influence growth. Mean mysid density in Hayden Lake was 53 ± 8 mysids/m^2 and represented a stable population trend. We recommend evaluations of fingerling Rainbow Trout stocking efforts be continued. We also recommend periodic monitoring of wild kokanee production in Hayden Lake. Because wild-origin kokanee were not abundant, we do not recommend efforts be made to limit kokanee spawning in Hayden Lake tributaries.

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INTRODUCTION

Hayden Lake, located northeast of Hayden Idaho in the Panhandle Region, provides fishing opportunity for multiple fish species and is a popular destination for anglers. A mix of warm water species including Largemouth Bass *Micropterus salmoides*, Black Crappie *Pomoxis nigromaculatus*, and Yellow Perch *Perca flavescens* were introduced in the early 1900s and are the primary focus of anglers (Maiolie et al 2011). More recent sportfish introductions in Hayden Lake also provide popular fishing opportunities. Smallmouth Bass *Micropterus dolomieu*, legally introduced, and Northern Pike *Esox lucius*, illegally introduced, added to popular littoral fisheries (Maiolie et al. 2011). Kokanee *Oncorhynchus nerka* stocked since 2011 have noticeably increased angling effort in the pelagic areas of the lake. Historically, Hayden Lake provided a popular fishery for native Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, but their abundance declined and they are now rare in the catch (Mauser 1978, Maiolie et al. 2011). Rainbow Trout *Oncorynchus mykiss* were stocked in Hayden Lake since the early 1900s and historically provided a quality fishery, but represented only a small portion of the effort and catch in recent years. Presumably, this is due to a decline in the quality of the fishery.

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

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

The introduction of mysids in Hayden Lake has been positively characterized. Mysids are thought to provide beneficial forage in Hayden Lake for multiple fish species (Horner et al. 1986, Lamansky 2011). Although mysids are generally considered to be a benefit in this waterbody, their influence on fish growth has not been definitively assessed. Mysids have not been routinely monitored in northern Idaho lakes. An exception has been Lake Pend Oreille, where a long monitoring history exists. Annual sampling of Lake Pend Oreille showed a sharp decline in shrimp beginning in 2010 (Wahl et al. 2016). The collapse of mysids in Lake Pend Oreille prompted an investigation of mysid densities in other northern Idaho lakes. Declines in abundance could have major effects on food webs and resulting fish communities.

In 2019, we continued Rainbow Trout stocking evaluations, kokanee monitoring, and mysid monitoring to understand and improve the Hayden Lake fishery. Recent investigations included evaluations of stocked Rainbow Trout origin (i.e., rearing hatchery), strain, and stocking density. We monitored kokanee origin to describe the level of wild production. In addition, we monitored mysid density to understand abundance trends and their potential impact on the fish community.

OBJECTIVES

1. Estimate relative contribution of Rainbow Trout stocked as fall fingerlings.
2. Describe wild kokanee production.
3. Estimate mysid density and describe abundance trends.

METHODS

Rainbow Trout Stocking Evaluation

We described relative abundance of hatchery Rainbow Trout in Hayden Lake using catch rates in standard floating experimental gill nets (IDFG 2012). Twenty-four nets were fished overnight in Hayden Lake from April 29 through April 30. Net locations were randomly selected. We reported mean catch-per-unit-effort (CPUE, fish/net) as a measure of relative abundance. We identified all fish, measured total length (mm), and checked individuals for marks.

We intended to use proportional differences in relative abundance to explore the success of different Rainbow Trout stocking groups in Hayden Lake (Table 9). Unique thermal marks were applied to Rainbow Trout during early rearing at Cabinet Gorge Hatchery prior to being stocked in 2017 and 2018. Thermal mark patterns of growth on otolith structures appear as banding patterns with the thickness and separation of bands influenced by the timing and duration of water temperature manipulation. Thermal mark patterns were unique to each year class. Identification of marks was completed by mounting otoliths, sulcus side up, to glass slides with Crystalbond 509 (Electron Microscopy Products, Hatfield, PA). Otoliths were then sanded until patterns were clearly viewable near the origin under 100x to 200x magnification and marks were identified if present. Marks were not available to distinguish every prior stocking group. As such, we anticipated also using fish lengths and fin condition to allow coarse identification of fish from earlier stocking groups.

Kokanee Monitoring

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

Kokanee otoliths were inspected for thermal marks to identify hatchery- and wild-origin fish. Thermal marks were applied at the IDFG Cabinet Gorge Fish Hatchery during early hatchery rearing by manipulating water temperature in a designated pattern. We processed otoliths for mark detection as previously described. We assigned age to individual kokanee using thermal mark patterns. Age was assigned by length for those fish without a detectable thermal mark.

Mysid Monitoring

Mysids were sampled in Hayden Lake on May 29, 2019 to estimate population density. Sampling occurred at night during the dark phase of the moon. Twelve random sites were sampled. We attempted to select sites *a priori* from a depth zone equal or greater than 46 m. Vertical net tows were made from a depth of 46 m to the surface. If in the field a selected site was not actually 46 m deep, we looked for the desired depth range in close proximity to the site or made a tow from the maximum depth available if no deeper zone was present. A 1-m hoop net with 1,000-micron mesh net and a 500-micron bucket was used for all tows. Area of the net mouth was 0.8 m^2. Each mysid collected was counted and classified as either young-of-the-year (YOY), immature, or adult based on relative size. We calculated density as mysids per square meter based on the area of the net mouth. We reported arithmetic mean density and 80% confidence intervals around each estimate.

RESULTS

Rainbow Trout Stocking Evaluation

Two Rainbow Trout (0.1 ± 0.1 fish/net; CPUE ± 80% C.I.) were captured among all gill net sets (Table 10). Based on appearance (fin condition), both fish were believed to be of hatchery origin. Total length of the Rainbow Trout caught suggested the fish were from the 2017 outplant. However, we were not able to identify thermal marks on either fish. Bycatch in our sample included Black Crappie, Bluegill *Lepomis macrochirus*, Brown Bullhead *Ictalurus nebulosus*, kokanee, Largemouth Bass, Northern Pike, Westslope Cutthroat Trout, and Yellow Perch (Table 9).

Kokanee Monitoring

We caught 56 kokanee among all gill net sets. Catch rate was 6.2 ± 3.1 fish/net (± 80% C.I.). Kokanee from age-0 to age-3 were represented in our sample (Table 11). Mean total length of age-2 kokanee was 363 mm. A single age-3 kokanee was collected. Otoliths from 50 fish were examined for marks. Thermal marks were not detected on 26% of examined otoliths.

Mysid Monitoring

Density of combined immature and adult mysids in Hayden Lake varied among sampled locations from 21 to 87 mysids/m^2 with a mean density of 53 ± 8 mysids/m^2 (± 80% C.I.; Figure 26). Young-of-the-year densities varied from 60 to 360 mysids/m^2. Estimated mysid density in 2019 was lower than the previous estimate in 2017 (86 ± 12 mysids/m^2), but represented a stable to increasing trend over the time period since 2013 when regular monitoring began (Figure 26).

DISCUSSION

Few Rainbow Trout were caught in April gill net samples, suggesting post-stocking survival remained low in Hayden Lake. Our results were consistent with prior evaluations of Rainbow Trout stocking in Hayden Lake conducted since 2013. Catch rate of Rainbow Trout in spring gill-net surveys varied from zero to 0.3 fish/net over this history of evaluations (Ryan et al. 2014, Ryan et al. 2018, Watkins et al. 2018, Ryan et al. 2020a, Ryan et al. 2020b, Camacho et al. 2021). As such, we were unable to determine differences in the relative contribution of stocking events and concluded that survival was likely poor for all recent stocking events.

Several variables have been recently modified that may influence survival of stocked Rainbow Trout. Fingerling stocking density was increased from 23 to 31 fish/hectare in Hayden Lake in 2017 with an interest in increasing detectability if low to moderate survival was occurring. In addition, Troutlodge all-female Kamloops, a strain of Rainbow Trout most similar to strains historically stocked in Hayden Lake, were stocked in 2018 and 2019. We recommend continued fingerling stocking and evaluation with an understanding that both stocking and evaluation costs are low and potential return to anglers may be high if a suitable stocking strategy is identified.

Our observed marking rate on kokanee collected from Hayden Lake suggests wild production remained low. Thus, efforts to restrict kokanee from accessing tributary spawning habitat is not necessary at this time. Prior estimates of wild proportion in the Hayden Lake kokanee population were 3% and 12% in 2017 and 2018, respectively (Ryan et al. 2020a, Camacho et al. 2021). Although we did not detect marks on otoliths from 26% of fish, we had a low level of confidence that these were fish were unmarked. Multiple fish required two structures be processed to clearly identify a thermal mark, suggesting our no-mark detection rate may be less than 100%. As such, the true amount of wild production may be even lower than estimated.

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

MANAGEMENT RECOMMENDATIONS

1. Continue to stock and evaluate survival of large (≥ 152 mm) fall fingerling Rainbow Trout stocking efforts by describing relative abundance during the spring.

2. Continue periodic monitoring of wild kokanee production to understand how wild production may impact density-dependent growth.

3. Do not limit kokanee migrations into spawning tributaries at this time C/f.

4. Periodically monitor mysid density in Hayden Lake.

Table 9. History of Rainbow Trout stocking in Hayden Lake, Idaho from 2011 through 2019. Information provided includes year and season of stocking, hatchery of origin, strain, size, number of fish stocked, and marks present on stocked fish to identify stocking group.

Year	Period	Hatchery	Strain/Type	Size	Number	Mark
2011	Fall	Grace	Triploid Troutlodge Kamloop	3-6 in. fingerlings	39,600	Ad Clipped
2011	Spring	Nampa	Triploid Troutlodge Kamloop	catchable	472	
2011	Spring	Hagerman	Triploid Troutlodge Kamloop	3-6 in. fingerlings	268,800	
2012	Spring	Grace	Hayspur Rainbow Triploid	3-6 in. fingerlings	18,000	
2012	Spring	Nampa	Triploid Troutlodge Kamloop	catchable	4,832	
2013	Fall	Grace	Hayspur Rainbow Triploid	3-6 in. fingerlings	39,312	
2014	Fall	Cabinet Gorge	Hayspur Rainbow Triploid	3-6 in. fingerlings	38,400	50% Ad Clipped
2015	Fall	Cabinet Gorge	Hayspur Rainbow Triploid	> 6 in. fingerlings	36,520	50% Ad Clipped
2015	Spring	Nampa	Hayspur Rainbow Triploid	catchable	8,867	
2016	Fall	Cabinet Gorge	Unspecified Rainbow Trout	> 6 in. fingerling	25,344	Thermal Marked
2016	Spring	Nampa	Unspecified Rainbow Trout	12 in. catchable	1,535	
2017	Fall	Cabinet Gorge	Unspecified Rainbow Trout	> 6 in. fingerling	50,700	Thermal Marked
2018	Fall	Cabinet Gorge	Troutlodge All Female Kamloop	> 6 in. fingerling	98,601	Thermal Marked
2019	Fall	Cabinet Gorge	Troutlodge All Female Kamloop	> 6 in. fingerling	33,690	Thermal Marked

Table 10. Catch (*n*), catch rate, mean total length (TL), and length spread by species from a gill net survey used to evaluate Rainbow Trout stocking in Hayden Lake, Idaho during April 2019.

Species	*n*	CPUE ± 80% C.I.	Mean TL (mm)	Min-Max TL(mm)
Black Crappie	3	0.1 ± 0.2	268	255-293
Bluegill	1	<0.1	165	--
Brown Bullhead	9	0.4 ± 0.5	325	306-355
Kokanee	33	1.4 ± 0.5	325	258-384
Largemouth Bass	4	0.2 ± 0.2	390	303-445
Northern Pike	9	0.4 ± 0.3	698	573-934
Rainbow Trout	2	0.1 ± 0.1	464	440-487
Westslope Cutthroat Trout	1	<0.1	250	--
Yellow Perch	1	<0.1	275	--

Table 11. Kokanee catch (*n*) by age from suspended gill nets fished in Hayden Lake, Idaho in July 2019. Associated metrics include length range observed and proportion identified as hatchery-origin.

Age	*n*	Mean TL (mm)	Min-Max TL (mm)	% Hatchery
0	3	97	92-104	--
1	26	180	128-198	70%
2	26	364	325-396	77%
3	1	388	--	100%

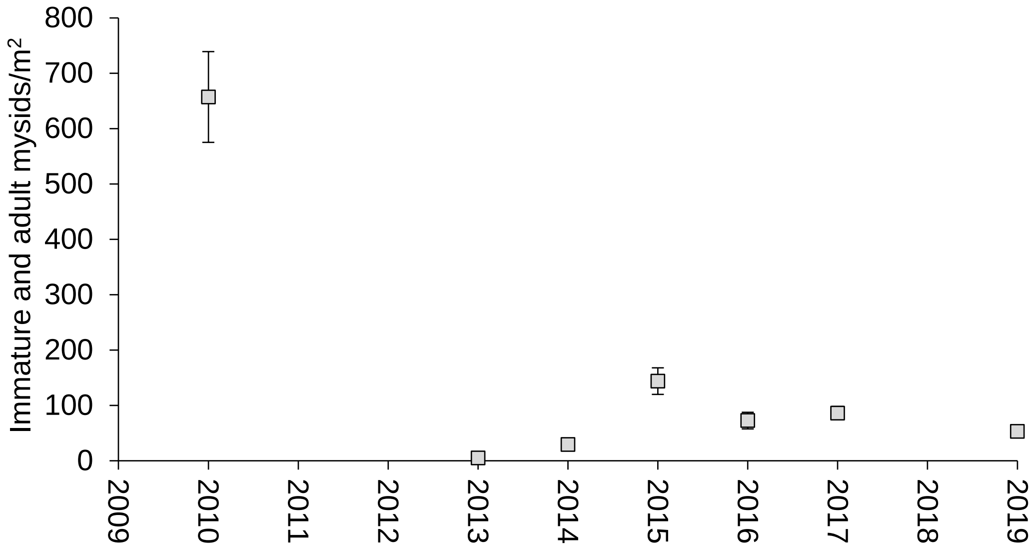

Figure 28. Mean density of immature and adult mysids in Hayden Lake, Idaho by year from 2010 through 2019. Error bars represent 80% confidence intervals.

LAKE PEND OREILLE SMALLMOUTH BASS INVESTIGATIONS

ABSTRACT

Lake Pend Oreille (LPO) has unique physical characteristics relative to most lentic water bodies in Idaho. The fish community of LPO is also unique with a diverse blend of native and non-native fishes and resulting fisheries. Smallmouth Bass are an unintentionally introduced species in LPO. It is generally known that Smallmouth Bass *Micropterus dolomieu* have expanded in LPO during the last 30 years, but little information has been collected to describe distributional changes of the population over time. In June 2019, we surveyed LPO to investigate the effectiveness of electrofishing as a tool for describing relative abundance, distribution, and size structure of Smallmouth Bass. In addition, we tagged Smallmouth Bass and estimated exploitation by recreational anglers. Smallmouth Bass were encountered at 38 of 40 sites sampled. Mean CPUE among all sites was 146.4 ± 31.6 (fish/h; 80% C.I.). Size structure was poor (PSD = 16; RSD-P = 5), and growth was slow with age at 305 mm estimated at 5.2 years. Annual mortality was 58%. Estimated exploitation and use rates were 17% and 35%, respectively. Our survey suggests Smallmouth Bass are well-distributed and abundant. Smallmouth Bass CPUE was greater than observed in other regional waters. Size structure and mortality of the LPO Smallmouth Bass population were similar to the Pend Oreille River population. Angler exploitation of LPO Smallmouth Bass describe in our survey was not considered to meet levels at which size structure of the population would be impacted. Electrofishing was a useful tool for sampling Smallmouth Bass in LPO, but exhibited limitations (e.g., size bias) that need to be considered when interpreting survey results.

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INTRODUCTION

Lake Pend Oreille (LPO) has unique physical characteristics relative to most lentic water bodies in Idaho. Specifically, the lake is large (32,900 ha) and deep (mean depth = 164 m) with steep, rocky slopes occur along most of the largely undeveloped shoreline. Shallow littoral habitat is limited, except in the northern third of the lake.

The fish community of LPO is also unique, supporting a diversity of native and non-native fishes and corresponding fisheries. Native game fish of LPO include Bull Trout *Salvelinus confluentus*, Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* and Mountain Whitefish *Prosopium williamsoni.* A host of non-native game fish have been introduced, including Kokanee *Oncorhynchus nerka*, Gerrard-strain Rainbow Trout *Oncorhynchus mykiss*, Lake Trout *Salvelinus namycush*, Lake Whitefish *Coregonus clupeaformis*, Brown Trout *Salmo trutta*, Black Crappie *Pomoxis nigromaculatus*, Pumpkinseed *Lepomis gibbosus*, Brown Bullhead *Ameiurus nebulosus*, Largemouth Bass *Micropterus salmoides*, Yellow Perch *Perca flavescens*, Walleye *Sander vitreus*, Northern Pike *Esox Lucius*, and Smallmouth Bass *M. dolomieu*.

Smallmouth Bass represent one of the most recent unintentional introductions to LPO. Montana Fish, Wildlife, and Parks introduced Smallmouth Bass in lower Clark Fork River reservoirs in the early 1980s (Huston 1985). Subsequent downstream drift was believed be the source of introduction of Smallmouth Bass in LPO. Their expansion was best documented in the Pend Oreille River, the outflow of LPO. Few Smallmouth Bass were present in the Pend Oreille River in the early 1990s (Bennett and Dupont 1993). However, by 2010 they were common (Maiolie et al. 2011). The expansion of Smallmouth Bass likely has had mixed effects. Smallmouth Bass support a growing littoral fishing opportunity in the system that has been embraced by many anglers. Bouwens et al. (2016), noted angler effort devoted to warmwater fisheries in LPO, noticeably increased from the early 2000s to 2014. Much of the increase in targeted angler effort was attributed to the growing Smallmouth Bass fishery. Harvest of Smallmouth Bass at the time of this survey was limited to six fish with no size restriction. In contrast, the expansion of Smallmouth Bass may negatively influence abundance of other native and non-native fishes (Camacho et al. 2021). While Smallmouth Bass have produced changes in the system, they appear to be generally compatible with fishery management goals for LPO.

Collectively, the unique physical characteristics of LPO make sampling littoral fish communities difficult. Because of this challenge, some knowledge gaps exist relative to the abundance and distribution of fishes, especially recently introduced non-native fishes. Smallmouth Bass represent one of those species for which knowledge gaps exist. It is generally known that Smallmouth Bass have expanded in LPO during the last 30 years, but little information has been collected to describe to what level expansion has occurred or how widely they are distributed in the lake.

In 2019, we surveyed LPO to investigate the effectiveness of electrofishing as a tool for describing relative abundance, distribution, and size structure of Smallmouth Bass. In addition, we estimated angler exploitation to better understand harvest behavior and its potential influence on the LPO Smallmouth Bass population.

OBJECTIVES

1. Investigate the effectiveness of electrofishing for sampling Smallmouth Bass in LPO.
2. Describe relative abundance, distribution, and population characteristics of Smallmouth Bass in LPO.
3. Estimate angler exploitation of Smallmouth Bass in LPO.

METHODS

We sampled Smallmouth Bass in LPO from June 10 to June 12, 2019. Forty random sample sites were chosen *a priori*. A stratified random survey design was used to divide sampling effort among three zones representing the southern, middle, and northern portions of the lake (Figure 27). The lake shoreline was divided into unique numbered segments from which sample sites were selected. Segments were created by overlaying a 500-m grid on a map of the lake using Terrain Navigator Pro (My Topo; Billings, Montana). A random number generator was used to select sites from numbered segments. Effort was divided amongst zones proportionally by area.

Two boat-mounted electrofishers were used to sample fish. Boats were equipped with Midwest Lake Electrofishing Systems Infinity control units. We used DC current of 60 pulses per second in a high voltage setting (i.e., > 500 volts). We adjusted duty cycle periodically during each sampling event to maximize fish attraction while limiting mortality. Two people per boat attempted to net all Smallmouth Bass encountered during each sample unit. Sample units were ten minutes in duration.

All Smallmouth Bass collected were enumerated, measured for total length (mm), and released. A subsample of fish was also tagged or dorsal spines were removed prior to release. Relative abundance was reported as average catch per unit effort (CPUE), which was standardized to catch per hour. Size structure of sampled fish was described using a length-frequency histogram and a proportional stock density (PSD) index (Anderson and Neumann 1996). Relative stock density of preferred size Smallmouth Bass (RSD-P) was also calculated. We used Fisheries Analysis and Modeling Simulator (FAMS, Slipke and Maceina 2014) software to calculate stock density indices.

Dorsal spines were removed from a subsample of Smallmouth Bass for age estimation. We attempted to collect three to five ageing structures per centimeter length group sampled. Dorsal spines 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. An age-length key was used to expand ages by length group observed in the subsample to all fish collected. Length-at-age at time of capture was reported as an index of growth.

Smallmouth Bass length and age data were used to estimate rates of growth and mortality. Growth rates were described as von Bertalanffy growth coefficients, estimated in FAMS from mean total length-at-age values described in our sample. Electrofishing capture of Smallmouth Bass is known to be biased negatively against length (Beamesderfer and Rieman 1988). As such, we anticipated maximum length in our survey would not likely represent maximum fish length in the population. To better describe growth in the population, we held length at infinity (L_∞) constant at 510 mm. Our constant L_∞ referenced maximum fish size observed in gill-net samples of the

Pend Oreille system and was consistent with prior Smallmouth Bass growth modeling in the system (Camacho et al. 2021). Catch-at-age of sampled Smallmouth Bass was used to describe general patterns of recruitment and to estimate mortality rates. An age-length key was used to predict ages of Smallmouth Bass based on length from a subsample of age estimates. Age frequencies were applied to a weighted catch curve in FAMS to estimate instantaneous total mortality (*Z*), from which annual mortality (*A*) and annual survival (*S*) were derived. Confidence intervals (80%) around *Z* were estimated from the mean square error of the regression model used to estimate *Z* as described in Miranda and Bettoli (2007).

Angler exploitation of Smallmouth Bass was estimated using a subsample of fish collected in our survey. We tagged and released Smallmouth Bass 254 mm and greater 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. Tagged fish were distributed throughout the lake during our electrofishing survey. We also tagged Smallmouth Bass during gill-net collections in Zone 3 from April 15-26, 2019. We tagged fish during this period to increase the proportion of large Smallmouth Bass in our tagging sample. Each tag was printed with the Idaho Department of Fish and Game “Tag You’re It” phone number for reporting. Rewards were not offered for tag returns. Angler tag returns were collected by phone, online (IDFG website), and in person at the IDFG Panhandle Regional Office through May 2020. Exploitation rates were estimated using tag returns as described by Meyer et al. (2012). We did not include reported harvest from anglers indicating they harvested a fish solely because it was tagged. We corrected tag returns for tag loss (10.5%), tagged fish mortality (2.0%), and reporting rate (54.1%; Meyer et al. 2012, Meyer and Schill 2014). Exploitation was also estimated by size class (i.e., stock (180-279 mm; TL), quality (280-349 mm), preferred (350-429 mm), and memorable/trophy (≥ 430 mm) to describe patterns in harvest relative to fish size.

We coarsely evaluated the effectiveness of electrofishing as a tool for sampling Smallmouth Bass in LPO by describing variability in catch and biases in capture by size. We used the coefficient of variation (CV) of CPUE as a comparable description of variability in catch. We expected CPUE would vary widely among survey units as a result of shoreline complexity and bathymetry. The CV in our survey was compared to surveys of the Pend Oreille River and Priest Lake to understand how habitat complexities in LPO may be different than other systems (Camacho et al. 2021, Watkins et al. 2018). To describe the potential for size bias in electrofishing collections of Smallmouth Bass from LPO, we compared length frequencies from our survey with fall gill-net collections from LPO and the Pend Oreille River (Ryan et al. 2020_a). Gill nets were 1.8 m tall, 61.0 m long, and had eight monofilament panels (each 7.6 m long) with 25-, 38-, 51-, 64-, 76-, 102-, 127-, and 152-mm stretched mesh. Both timing and location of sampling conducted with gill nets differed from our electrofishing survey. Gill nets were broadly distributed rather than being solely shoreline oriented.

RESULTS

Smallmouth Bass were encountered at 38 of 40 sites sampled. Mean CPUE among all sites was 146.4 ± 31.6 (fish/h; 80% C.I.; Table 12). Catch rate varied by zone. Zone 1 had the lowest catch rate at 98.6 ± 22.8 fish/h. Catch rates from Zone 2 and 3 were 150.9 ± 31.6 and 178.8 ± 74.0 fish/h, respectively. Water temperature also varied by zone from 12.8°C in zone 1 to 22°C in zone 3.

Mean length of Smallmouth Bass was 182 mm and varied from 47 to 487 mm (Table 12; Figure 28). Length distribution of the catch was similar in all zones. PSD and RSD-P were 16 and 5, respectively. Age at 305 and 406 mm were 5.1 and 9.1 years, respectively (Figure 29).

Age-1 through age-11 Smallmouth Bass were represented in the catch (Figure 30). However, no age-8 or age-10 fish were detected. Estimated *Z* from three to eleven years of age was -0.87 (± 0.28; 80% C.I.) and the corresponding *A* was 58%.

A total of 99 Smallmouth Bass were tagged and released during our June electrofishing survey (Table 13). An additional 48 fish were tagged in April 2019. Mean length of fish tagged in June was 309 mm and varied from 252 to 487 mm (Figure 31). Mean length of fish tagged in April was 394 mm and varied from 345 to 485 mm (Figure 31). The majority of tags were placed on fish in Zone 3 (Table 13). Twenty-five tagged fish were caught by anglers and reported through the "Tag You're It" program. Angler catches by zone were roughly proportional to tags released by zone. Of the 25 fish caught, 12 were harvested. A single fish was caught and released, but later caught and harvested. Another individual was caught and released twice. Estimated exploitation and use across all zones were 17.2% (±6.6%; 80% C.I.) and 35.4% (±10.8%), respectively. Exploitation was greatest on quality and preferred size Smallmouth Bass (Figure 32). No catch of fish in the memorable/trophy size class was reported by anglers.

Coefficient of variation of Smallmouth Bass CPUE in our survey was 107%. Comparable CV values from the Pend Oreille River and Priest Lake were 127% and 121%, respectively. A bimodal distribution was apparent in a comparison of length frequencies from electrofishing and gill net samples (Figure 33). Mean total length of Smallmouth Bass from our electrofishing survey (182 mm) was smaller than that estimated from fall gill net collections (337 mm).

DISCUSSION

Smallmouth Bass were well-distributed and abundant in LPO, suggesting usable habitat is ubiquitous within the littoral zone of the lake. We found Smallmouth Bass were present at 95% of the sampled locations. Catch rates suggested Smallmouth Bass were not only present at most locations, but were also abundant. In comparison, catch rates in all zones was greater than observed in other regional waters. For example, Camacho et al. (2021) found electrofishing catch rate of Smallmouth Bass in the Pend Oreille River was 36.6 fish/h. Catch rate in an electrofishing survey of Priest Lake was also lower at 43.6 fish/h (Watkins et al. 2018). Although fish were abundant, we detected variation in catch rates. Catch rates suggested abundance was greatest in the northern portion of LPO (Zone 3). In support of this observation, Zone 3 had more habitat diversity and is generally considered to be the most suitable for Smallmouth Bass.

Size structure and mortality of the LPO Smallmouth Bass population described in our survey were comparable to the Pend Oreille River population. Camacho et al. (2021) described characteristics of Pend Oreille River Smallmouth Bass, including size structure (PSD = 21) and mortality (*A* = 51%). We expected estimated metrics of these populations would be similar because the two water bodies are connected. Exchange of individuals between populations likely occurs, although this has not been formally documented. In contrast, Smallmouth Bass in Priest Lake had better size structure (PSD = 37) and lower mortality (*A* = 36%; Ryan et al. 2018).

Electrofishing capture of LPO Smallmouth Bass likely underestimated the size structure of the population. Others have demonstrated electrofishing capture of Smallmouth Bass is biased negatively against length (Beamesderfer and Rieman 1988). The mechanism of bias is assumed to be catchability based. Specifically, large mature Smallmouth Bass may occupy deeper portions of a waterbody, making them less susceptible to electrofishing capture during much of the year. The pattern of catch-by-length in our survey suggested a similar bias occurred. We found the majority of our catch was less than 300 mm. Our inclusion of gill-net caught Smallmouth Bass from the same system highlighted that larger and older individuals were much more abundant than described by electrofishing. Length bias in our survey likely impacted the accuracy of length-based metrics as well. For example, annual mortality estimated from a catch curve was likely biased high as a result of few older individuals represented in the age distribution.

Electrofishing was a useful tool for sampling Smallmouth Bass in LPO. Collectively, the information gained from an electrofishing survey on LPO provided valuable insight on relative abundance and distribution in the system. Further, we found catch rate variability in the LPO survey was comparable to that observed in other regional surveys, suggesting the habitat complexities of LPO were no more influential than in other nearby waters. Population characteristics we described were similar to Smallmouth Bass in the Pend Oreille River which provided additional confidence that variation attributed to our sampling technique was likely minimal. We highlighted limitations of electrofishing related to length bias and believe this impacts the accuracy of length-based metrics (i.e., size structure, age structure, age-based estimates of mortality). However, we argue that the data we did collect has value and sampling limitations just need to be considered when interpreting survey results. We recommend looking for future opportunity to collect data using alternate methods (e.g., gill nets) to supplement electrofishing. Sampling using multiple methods is likely necessary to address length bias and effectively monitor this population.

We sampled Smallmouth Bass in LPO during early June. The sampling window aligned with the anticipated period during which Smallmouth Bass spawning occurs in northern Idaho, based on prior sampling experience in the region. Water temperatures measured during our survey were variable, but were generally within the standard temperature range associated with Smallmouth Bass spawning (i.e., 12.8-18°C; Sigler and Zaroban 2018). We theorized, a representative distribution of fish sizes and ages would be present in shallow littoral areas during this period, making them vulnerable to capture. We observed large mature fish at some sample sites in shallow spawning type habitat. Their presence suggested spawning activity was occurring. Regardless, length bias in our survey suggested we did not effectively sample the entire population. In addition, a wide range of water temperatures were observed in sampling zones providing some evidence spawning activity may vary across lake zones. Our observations indicated it is difficult to predict an unbiased timeframe to effectively sample the population. However, we recommend future sampling efforts be completed within a standard time frame (e.g., early June) to limit sampling variability to what extent is possible.

A comparison of annual exploitation rates on Smallmouth Bass in Idaho waters suggests values observed in our survey were consistent with other populations. For example, Meyer and Schill (2014) estimated exploitation on multiple populations throughout Idaho. They found exploitation varied among waters from 12 to 34% and between years within a population by up to 16%. Similarly, exploitation of Smallmouth Bass in Dworshak Reservoir (2013-2016) was 15.9% (Hand et al. 2020). Although estimated exploitation of Smallmouth Bass was similar to other populations in Idaho, our estimate was greater than that estimated for Smallmouth Bass in the Pend Oreille River (8%; Camacho et al. 2021). Our estimate was also greater than exploitation of Largemouth Bass in multiple waters across the Panhandle Region, where exploitation on seven of nine waters surveyed varied from 0% to 15% (Ryan et al. 2018).

Angler exploitation estimated in our study was potentially biased by factors including angler reporting rate and the length distribution of tagged fish in our sample. Angler reporting rate used in our estimate of exploitation on Smallmouth Bass in LPO may not have accurately represented the true reporting rate. The value used in our study was an average statewide reporting rate described by Meyer et al. (2012) and reflects multiple waters with general statewide regulations. LPO differs from many waters in Idaho in that harvest is encouraged and incentivized for species including Lake Trout and Walleye. As such, LPO anglers may have reported harvest events at a higher rate because they were accustomed to this process. Estimated angler exploitation would therefore have been biased high in our study. In addition, we tagged and released Smallmouth Bass from our electrofishing sample and gill-net caught fish in an effort to include a wide-range of fish lengths in our sample. Although we may have tagged a size range of fish representative of the population, we were not able to confirm the true length distribution of fish in the population because of length bias associated with our survey. As such, the length distribution in our tagged sample may not have represented all length groups in the population (e.g., TL>487 mm). We found harvest of Smallmouth Bass varied by length group, suggesting a meaningful estimate of exploitation on the population required a representative sample of all fish lengths in the population. Notably, no harvest of large (≥ 430 mm) Smallmouth Bass was detected. However, a relatively small proportion of our total sample of Smallmouth Bass were large, limiting the odds of encounter by anglers fishing for Smallmouth Bass. To address potential bias associated with angler reporting rate in future exploitation studies, we recommend a lake specific angler reporting rate for Smallmouth Bass be estimated. We also recommend future exploitation studies on Smallmouth Bass address potential length bias by continuing to tag fish from a wide distribution of lengths or limit conclusions from estimates of exploitation to length specific groups from which tagging samples are possible.

Angler exploitation of Smallmouth bass in LPO was unlikely to impact the size structure of the population. Beamesderfer and North (1995) found that low productivity Smallmouth Bass populations exhibiting high to moderate natural mortality rates and slow growth were generally influenced little by harvest regulations intended to influence exploitation. Lake Pend Oreille was comparable to low productivity systems described in their review of Smallmouth Bass population characteristics across North America and typical of northern and northwestern populations. Similarly, Camacho et al. (2021) found exploitation of 0 to 27% had little impact on the abundance of large Smallmouth Bass (i.e., ≥406 mm) in the Pend Oreille River under high to moderate natural mortality rates and slow growth. Estimated exploitation in LPO was within rates incorporated in their evaluation. Although we did not estimate natural mortality in our survey, we previously described how estimates of *A* were consistent between these populations. Thus, we assume natural mortality may also have been similar. The Pend Oreille River and LPO also shared similar patterns of growth, although the age at 305 mm was estimated to be one year less in the Pend Oreille River (4.1 years; Camacho et al. 2021).

MANAGEMENT RECOMMENDATIONS

1. Periodically monitor Smallmouth Bass abundance and distribution in LPO using electrofishing as a sampling technique.

2. Acknowledge size biases associated with electrofishing samples of Smallmouth Bass when interpreting survey data.

3. Look for future opportunity to sample Smallmouth Bass using other techniques (e.g., gill nets) as a supplement to electrofishing surveys.

4. Completed future Smallmouth Bass electrofishing effort within a standardized work window (e.g., early June) to limit sampling variability.

5. Estimate an LPO specific angler reporting rate for tagged Smallmouth Bass in future exploitation studies.

6. Address potential length bias in future Smallmouth Bass exploitation studies by continuing to tag fish from a wide distribution of lengths or focus estimates of exploitation on length specific groups from which tagging samples are possible.

Table 12. Catch (*n*) and catch rate (CPUE ± 80% C.I.) of Smallmouth Bass by zone and associated length of caught fish (TL = total length) from an electrofishing survey of Lake Pend Oreille, Idaho in June 2019.

Zone	*n*	CPUE (fish/h)	Mean TL (mm)	Min-Max TL
1	198	98.6 ± 22.8	194	47-486
2	307	150.9 ± 28.3	179	61-459
3	484	178.8 ± 74.0	178	60-487
All	989	146.4 ± 31.6	182	47-487

Table 13. Tag allocation and tag returns associated with estimation of exploitation on Smallmouth Bass in Lake Pend Oreille, Idaho from June 2019 through May 2020. Tag encounters listed include those from fish harvested, caught and released, and harvested only because they were tagged (BT Harvested).

Zone	Tags Out	Tags Encountered	Harvested	Released	BT Harvested
1	17 (11.6%)	4 (16.0%)	2	1	1
2	15 (10.2%)	3 (12.0%)	3	0	0
3	115 (78.2%)	18 (72.0%)	7	11	0
Total	147	25	12	12	1

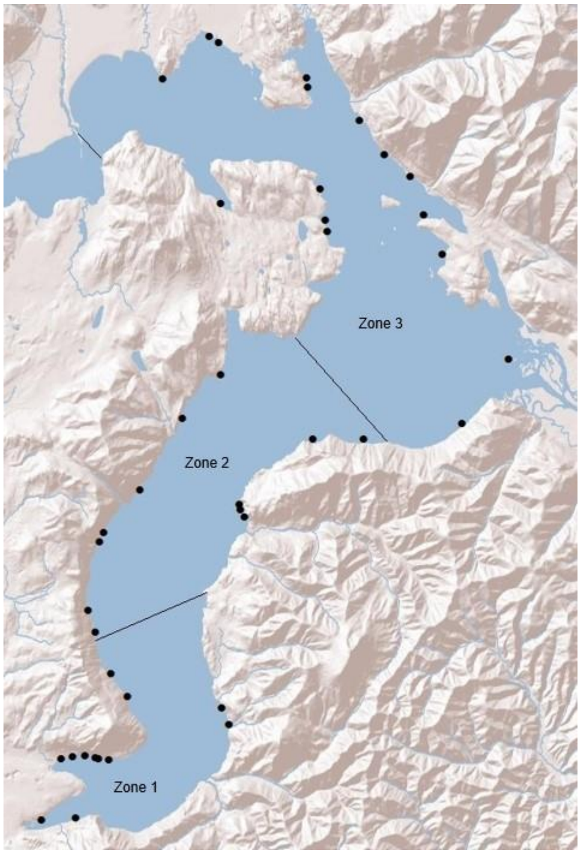

Figure 29. Sampling zones and electrofishing sites for a Smallmouth Bass survey conducted on Lake Pend Oreille, Idaho in June 2019.

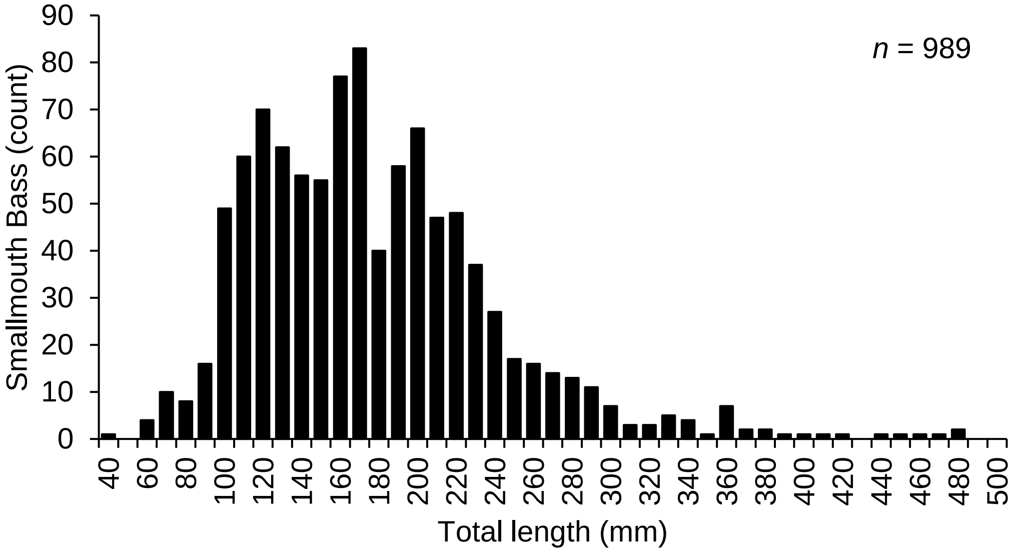

Figure 30. Length-frequency of Smallmouth Bass caught by electrofishing from Lake Pend Oreille, Idaho in June 2019.

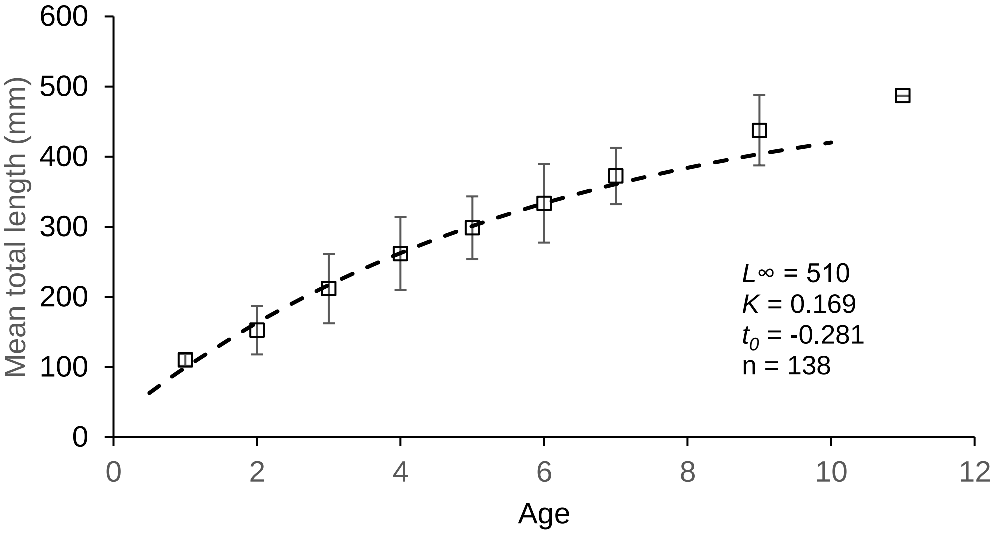

Figure 31. Mean length-at-age of Smallmouth Bass caught by electrofishing from Lake Pend Oreille, Idaho in June 2019.

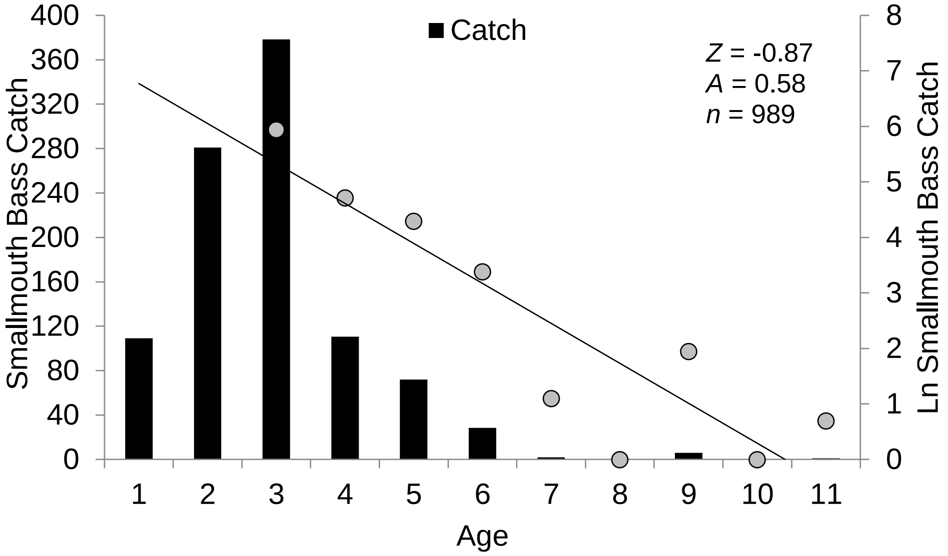

Figure 32. Catch frequency by age of Smallmouth Bass caught in electrofishing samples of Lake Pend Oreille, Idaho in June 2019. Figure includes an associated catch curve used to estimate annual mortality in the population.

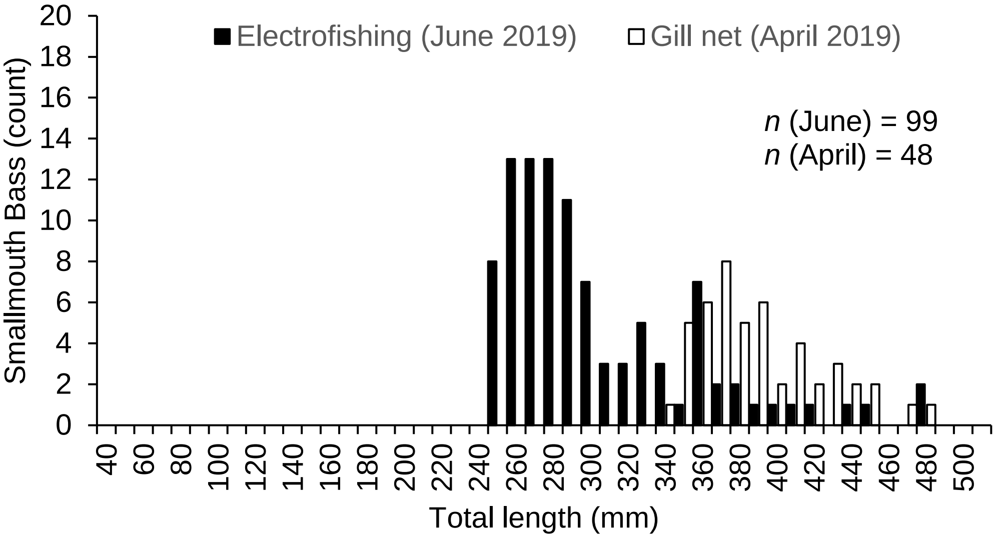

Figure 33. Length-frequency of tagged Smallmouth Bass collected from electrofishing samples in June 2019 and gill-net samples in April 2019 from Lake Pend Oreille, Idaho.

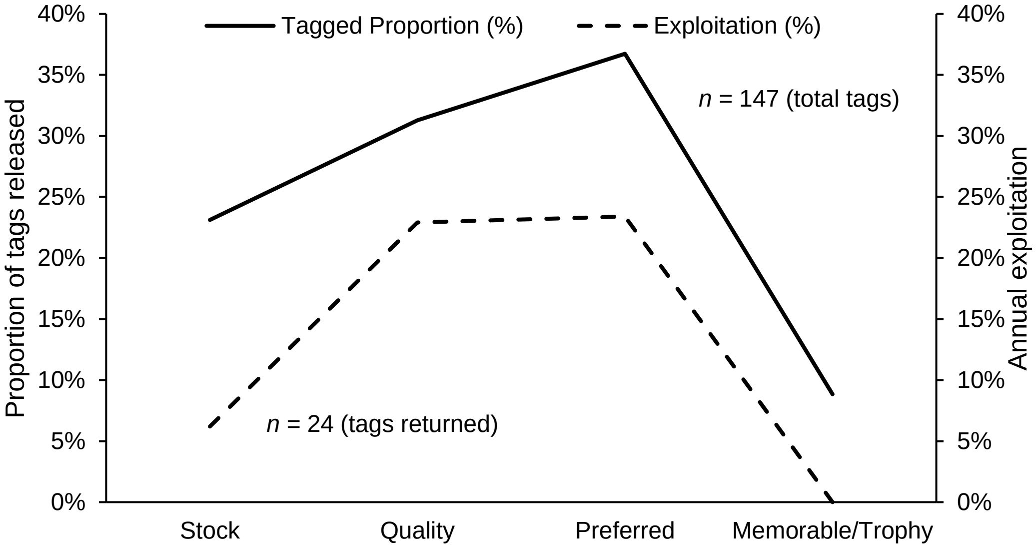

Figure 34. Proportion of Smallmouth Bass tagged by size class in Lake Pend Oreille, Idaho in 2019 and associated estimates of adjusted exploitation. Size classes include stock (180-279 mm; TL), quality (280-349 mm), preferred (350-429 mm), and memorable/trophy (≥ 430 mm).

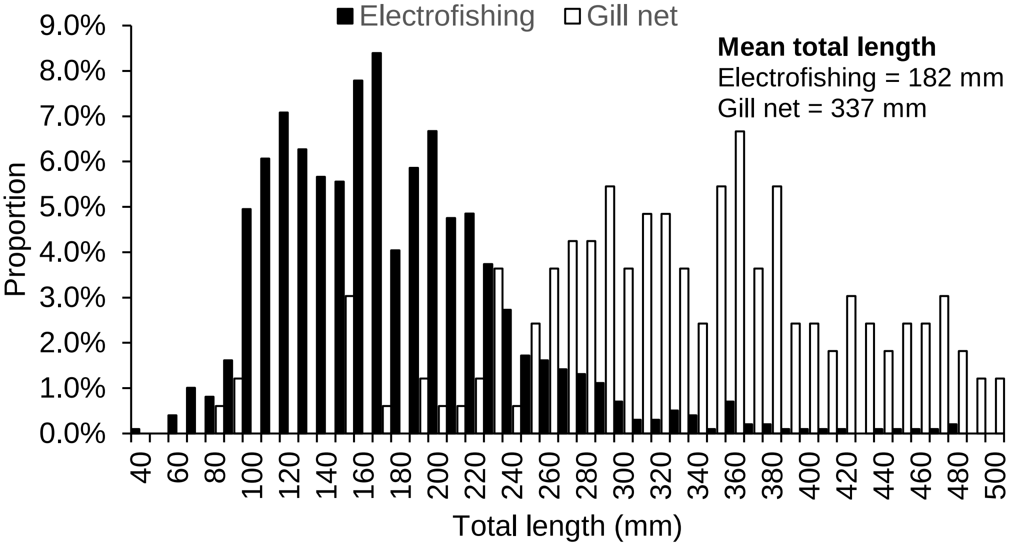

Figure 35. Proportional catch by length of Smallmouth Bass from Lake Pend Oreille, Idaho in electrofishing samples in June 2019 and gill net samples in October 2017.

PRIEST RIVER POPULATION MONITORING

ABSTRACT

The Priest River drainage is located in the northwest corner of the Idaho Panhandle. The Priest River is the lowermost segment of the drainage originating at the outflow of Priest Lake and flowing south approximately 72 km to its confluence with the Pend Oreille River. An underperforming wild salmonid fishery provides the primary angling opportunity in the river. In 2019, we completed two snorkel surveys of the Priest River. Surveys were designed to inform trends in fish abundance, explore seasonal variation in habitat use, and provide a baseline condition from which to evaluate future habitat enhancement efforts should they occur. We estimated fish densities in the Priest River by completing snorkel surveys at standard transects in June and August. We also completed snorkel surveys of previously identified coldwater transects in August. Six primary fish species were observed during our snorkel surveys, including Largescale Sucker *Catastomous macrochelius*, Mountain Whitefish *Prosopium williamsoni*, Northern Pikeminnow *Ptycocheilus orgenensis*, Rainbow Trout *Oncorhynchus mykiss*, Smallmouth Bass *Micropterus dolomieu*, and Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*. Densities of all fish species in standard transects were low (≤ 0.10 fish/100m^2) in both June and August sampling periods. Largescale Sucker were the most observed species at a density of 0.10 fish/100m^2 in both survey periods. Mountain Whitefish were also commonly observed relative to other species with estimated densities of 0.08 and 0.06 fish/100m^2 in June and August, respectively. Northern Pikeminnow and Smallmouth Bass were more abundant in standard transects surveyed in August than June. Densities of Largescale Sucker were significantly lower in coldwater transects than in standard transects in the August period. We observed higher densities of Northern Pikeminnow, but lower densities of Brown Trout *Salmo trutta*, Mountain Whitefish, and Rainbow Trout as compared to a similar survey of the Priest River completed in 2011. During August, coldwater transects appeared to be used by Mountain Whitefish as thermal refuge; however, this coldwater habitat was limited and only influenced fish distribution in localized areas of the river.

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INTRODUCTION

The Priest River drainage is located in the northwest corner of the Idaho Panhandle. The Priest River is the lowermost segment of the drainage originating at the outflow of Priest Lake and flowing south approximately 72 km to its confluence with the Pend Oreille River. Streamflow in Lower Priest River is regulated by the Priest Lake Outlet Dam, installed in 1950 and operated by the Idaho Department of Water Resources. This low-head dam is operated to maintain Priest Lake levels at 0.91 m during the summer recreation season (USGS gage no. 12393000) in accordance with Idaho Code §70-507. Dam operations target a discharge of at least 1.7 m^3s to the Priest River during the recreation season.

Native gamefish of the Priest River drainage include Bull Trout *Salvelinus confluentus*, Mountain Whitefish *Prosopium williamsoni*, and Westslope Cutthroat Trout *Oncorhynchus clarki lewisi* (IDFG 2019). Non-game fish known to occur in the system include Largescale Sucker *Catastomous macrochelius*, Northern Pikeminnow *Ptycocheilus orgenensis*, Redside Shiner *Richardsonius balteatus*, Longnose Dace *Rhinichthys cataractae*, and Peamouth *Mylocheilus caurinus* (Fredericks et al. 2013). Non-native fishes including Brook Trout *Salvelinus fontinalis*, Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, and Smallmouth Bass *Micropterus dolomieu* are also known to be present (Fredericks et al. 2013).

The Priest River provides little year-round habitat for salmonids. High mid- to late-summer water temperatures are the primary limiting factor for salmonids (Rothrock 2003). As such, an underperforming wild salmonid fishery provides the primary angling opportunity (IDFG 2019). Current harvest restrictions include a six trout limit with no harvest of Westslope Cutthroat Trout or Bull Trout allowed. In an effort to improve the recreational fishery in the Priest River, a coldwater enhancement project was evaluated (Brandt et al. 2021). If implemented, this project would cool Priest River water temperatures during summer by replacing a portion of the Priest Lake surface outflow with cold hypolimnetic water from the lake.

In 2019, we completed two snorkel surveys of the Priest River. Surveys were designed to inform trends in fish abundance, explore seasonal variation in habitat use relative to water temperature, and provide a baseline condition from which to evaluate future coldwater enhancement efforts should they occur.

METHODS

We estimated fish densities in the Priest River, Idaho in 2019 by completing snorkel surveys at standard transects. Transect locations were based on surveys completed in 2011 (Figure 34; Fredericks et al. 2013). Twenty-five standard transects were surveyed. Transects were distributed from river kilometer 10.5 to 68.5, where river kilometer 0.0 was located at the confluence of the Priest River with the Pend Oreille River. Surveys were completed during two independent periods (June 17-19 and August 12-19). Water clarity was poor at several transects during the August period and affected visibility. Surveys at four transects where visibly was poor were repeated on September 6. Warm summer water temperature has been identified as a limiting factor for fish in the Priest River (Rothrock 2003). Survey replication in June and August allowed us to describe seasonal habitat use patterns of fish, which was potentially influenced by water temperature.

During the August survey period 14 additional transects, identified as coldwater reaches, were also surveyed (Figure 34). Coldwater reaches were previously identified in Priest River temperature studies (personal communication, Todd Anderson, Kalispel Tribe). These coldwater transects were surveyed to further investigate factors influencing fish distribution in the river.

Snorkel surveys were completed following methods described by Dupont et al. (2009). Transects were generally wide (i.e., > 20 m). As such, two individuals snorkeled each transect to divide the total width surveyed. Surveys during the June period were completed by an IDFG crew. Surveys in the August/September period were split between an IDFG crew and a Kalispel Tribe crew. All fish observed ≥ 75 mm were identified to species, counted, and categorized by length. Although fish were categorized by length in our surveys, we observed so few fish that we chose to group all sizes in our analysis.

The area of each transect was measured for length and width using a handheld laser rangefinder. A single transect length was measured. Five to eight width measures were taken per transect and averaged to describe mean transect width. Sampled area was then estimated as the product of transect length and mean width. Temperature measurements were taken at the upstream end of survey transects.

Fish abundance, described as density (fish/100 m^2), was estimated by species for each survey period. Mean fish density was calculated for all combined survey transects as the sum of fish counted divided by the sum of surveyed area. Comparison of mean density estimates among survey periods were completed using confidence bounds estimated around mean densities. Confidence bound were described as one standard error about mean estimates. The standard error of the density ratio was calculated as described by Hansen et al. (2007). We also calculated density by survey transect, calculated as the number of fish counted in an individual transect divided by the area of that transect. Density estimates for individual transects were used to describe patterns of distribution across the portion of the river surveyed. We hypothesized longitudinal variation in water temperature would influence distribution of salmonids differently in June than August. To facilitate a description of distribution we summed density estimates of all salmonid species. Coarse patterns of salmonid density were then described by plotting transect density against river kilometer.

Trends in fish density were evaluated to describe changes in the fish community over time. We evaluated trends by comparing mean density estimates by species from the August survey period with results from an August 2011 snorkel survey of the Priest River (Fredericks et al. 2013). Mean density estimates were compared using confidence bounds around mean density estimates described as one standard error about mean estimates.

RESULTS

Six fish species were observed in both June and August snorkel surveys of the Priest River including Largescale Sucker, Mountain Whitefish, Northern Pikeminnow, Rainbow Trout, Smallmouth Bass, and Westslope Cutthroat Trout (Table 14, Table 15). Four additional species, including Brown Trout (*n* = 1), Tench *Tinca tinca* (*n* = 2), and Pumpkinseed *Lepomis gibbosus* (*n* = 1) were observed in limited abundance and only in standard transects surveyed in August. Also, a single Largemouth Bass *Micropterus salmoides* was observed in coldwater transect 15 (Table 16).

We observed a range of fish lengths of all species in snorkel surveys of the Priest River (Figure 35). While large (i.e., >381 mm) Westslope Cutthroat Trout and Mountain Whitefish were observed, a majority were smaller fish less than 305 mm. In contrast, a majority of Rainbow Trout observed in standard transects were >305 mm, but few total individual were seen among all survey efforts.

Mean densities of all fish species in standard transects were low (≤ 0.10 fish/100m^2) in both June and August sampling periods (Table 14, Table 15). Largescale Sucker were the most commonly observed species at a density of 0.08 and 0.10 fish/100 m^2 in June and August survey periods, respectively. Mountain Whitefish were also commonly observed relative to other species with estimated densities of 0.06 and 0.07 fish/100m^2 in June and August, respectively. Variability among transects was high in both sample periods with coefficient of variation (CV) values of transect counts ranging from 115% to 299. Salmonid densities were coarsely segregated along the river corridor (Figure 36). We found salmonid densities were greatest in the upper river section above river kilometer 47. Conversely, salmonid densities were lowest mid-river between river kilometer 47 and the mouth of the East River (river kilometer 34). Below the confluence of the East River salmonid densities were moderate relative to the upper river segment. In general, the pattern of distribution was consistent between June and August surveys.

Mean density estimates for most species were similar between sampling periods (Figure 37). As an exception, non-overlapping confidence bounds around mean density estimates of Northern Pikeminnow and Smallmouth Bass suggested densities of both species increased from the June to August survey period (Table 17). Comparison of density estimates from standard transects surveyed in August and coldwater transects also surveyed in August, suggested densities were similar among transect types apart from Largescale Sucker (Table 17; Figure 38). Fewer Largescale Sucker occupied coldwater transects. Our estimate of Mountain Whitefish density among coldwater transects was four times greater than density estimated among standard transects in August. However, counts of Mountain Whitefish were highly variable across coldwater transects which inflated error around the mean density estimate. As such, significant difference between estimates was not inferred. We found density estimates of Mountain Whitefish, Rainbow Trout, and Brown Trout from standard transects surveyed in August 2019, were lower than previously described in 2011 (Figure 37). In contrast, Northern Pikeminnow were estimated at greater density in 2019. Density of Largescale Sucker, Smallmouth Bass, and Westslope Cutthroat Trout were not found to be significantly different between survey years.

Water temperature varied among transects in both survey periods. In general water temperature increased from June to August. Mean water temperature was 17°C in June and 19°C in August. Mean water temperature among coldwater transects was 20°C.

DISCUSSION

Densities of all fish species in the Priest River were low relative to similar sized rivers in the region. For example, densities of Mountain Whitefish in the lower monitored segments of the Coeur d'Alene and St. Joe rivers in 2018 were up to 34 times greater than what we observed in the Priest River (Camacho et al. 2021). Similarly, Westslope Cutthroat Trout densities in these same systems were up to 18 times greater than our observations of the Priest River. This pattern, although less dramatic, held true for Largescale Sucker as well. Largescale Sucker, although more tolerant to an array of habitat qualities (Hillman et al. 1999), also exhibited densities in the Priest River two to three times less than other regional rivers including the lower St. Joe River and Moyie River (Camacho et al. 2021; Ryan et al. 2020$_b$). We detected both increases and decreases in fish densities in 2019 as compared to a similar survey of the Priest River conducted in 2011(Fredericks et al. 2013). While changes in density were detected, abundance in 2011 was also low relative to other rivers in the region, suggesting the general status of Priest River populations was consistent over time.

Summer water temperature near or beyond thermal tolerance is the limiting condition for salmonids (Hillman et al. 1999, Wehrly et al. 2007) in the Priest River (IDFG 2019, Rothrock 2003). As such, we hypothesized longitudinal variation in water temperature would influence distribution of salmonids differently in June than August. We found water temperatures at survey transects were warm in both June ($\bar{x}$ = 17°C) and August ($\bar{x}$ = 19°C) and notable re-distribution of fish from June to August was not observed. As an exception, we found some higher use of coldwater transects primarily by Mountain Whitefish. Our observations suggested coldwater areas may be helpful to a small number of fish, but water temperatures were not cooled enough throughout the river to provide suitable habitat for higher densities of salmonids. As such, we recommend efforts to improve habitat in the Priest River should focus on reducing water temperature as the most influential method to improve fish abundance and subsequent fishery quality.

We observed minimal differences in water temperature among survey periods (i.e., June, August) and transect types (i.e., coldwater). Most notably, mean water temperature at coldwater transects was warmer ($\bar{x}$ = 20°C) than observed at standard transects ($\bar{x}$ = 19°C). Despite our inability to detect lower water temperatures at coldwater transects, we did observe some higher use of those areas by Mountain Whitefish suggesting unique habitat availability was present in these reaches. We hypothesize this divergence in results reflected our method of measuring water temperature. Specifically, water temperature was measured at the upstream most point of each transect and may have not captured coldwater influences lower in a sample transect. Our surveys were not focused on monitoring water temperature, but a more descriptive estimate of water temperature by transect could improve our understanding of fish distribution in the river. As such, we recommend water temperature sampling methods include a more comprehensive approach where a fine scale evaluation of temperature influences on fish distribution is desired.

Fish densities in the Priest River suggest poor recreational fishing opportunities exist. Consistency among this survey and prior investigations confirmed our observations were not unique and limiting conditions were inherent to the Priest River through time (Fredericks et al. 2013; Irizarry 1974$_b$). Previous attempts to improve recreational fishing opportunities in the river were not productive. For example, regular stocking of Rainbow Trout and periodic stocking of Brook Trout and Brown Trout historically occurred in the Priest River to provide recreational fishing opportunities (IDFG, unpublished data). However, stocking was insufficient to substantially improve the recreational fishery (Horner et al. 1987) and was eventually discontinued. Hatchery trout stocked in lotic waters generally perform poorly with limited survival (Dillon et al 2000; High and Meyer 2009) and we assume warm water temperature in the Priest River further limited their survival. The focus of our survey was primarily on salmonids. However, we also observed low densities of Smallmouth Bass, providing some indication that habitat in the Priest River was also less than ideal for coolwater fish communities. We speculate that a combination of water temperature (e.g., cold winter water temperatures) and system productivity may limit coolwater fish abundance.

We did not evaluate angler use of the Priest River fishery nor the potential influence of harvest on fish abundance. However, several factors suggest angler harvest was not the primary cause of low fish densities. For example, staff observations and angler reports indicated few anglers currently utilize the river for fishing. Furthermore, conservative harvest regulations (i.e., no harvest of Westslope Cutthroat Trout or Bull Trout) limited the potential of harvest related influences. In comparison, other regional rivers of similar size are managed under common harvest restrictions and host robust salmonid populations (Camacho et al. 2021). Specific to our survey, densities of all species, including game and non-game fishes, were low and suggest influences on abundance go beyond those species most targeted by anglers. As such, we concluded that habitat quality (e.g., warm water temperature) is limiting the salmonid fishery.

MANAGEMENT RECOMMENDATIONS

1. Efforts aimed at improving fish abundance and subsequent fishery quality in the Priest River should focus on reducing summer water temperature.

2. Incorporate a more comprehensive water temperature sampling method where fine-scale evaluation of temperature effects on fish distribution is desired.

Table 14. Site location (river km), area surveyed, and counts of primary species observed from snorkel surveys of the Priest River, Idaho in June 2019.

			Count					
Stream	Site	Area (m^2)	LSS	MWF	NPM	RBT	SMB	WCT
Priest River	10.5	6,591	0	4	0	0	0	0
Priest River	13.5	7,572	0	0	0	3	4	0
Priest River	23.0	8,531	1	3	0	1	0	0
Priest River	23.5	13,640	6	1	0	0	0	0
Priest River	26.0	5,898	16	5	9	0	1	0
Priest River	28.5	10,485	0	3	1	0	0	0
Priest River	30.5	9,562	7	6	0	1	0	2
Priest River	33.0	15,819	0	0	0	0	0	1
Priest River	36.0	7,528	2	4	0	0	0	0
Priest River	37.5	16,466	0	2	3	1	0	0
Priest River	39.0	7,142	6	0	0	0	1	0
Priest River	39.5	13,166	1	0	0	0	0	1
Priest River	42.0	16,519	2	1	2	0	0	0
Priest River	43.0	9,499	0	0	0	0	0	0
Priest River	45.5	14,758	14	2	8	0	2	0
Priest River	49.0	19,434	14	10	4	0	4	0
Priest River	50.0	18,819	56	7	2	0	0	0
Priest River	51.5	13,303	7	26	0	0	1	0
Priest River	54.5	4,704	42	3	2	0	0	1
Priest River	58.0	5,168	15	11	0	0	0	0
Priest River	58.5	9,620	1	17	1	0	0	2
Priest River	63.0	4,582	1	10	0	0	0	0
Priest River	63.5	4,700	4	21	0	0	0	1
Priest River	67.5	2,520	2	5	0	1	0	2
Priest River	68.5	7,227	0	6	0	0	0	4

LSS = Largescale Sucker; MWF = Mountain Whitefish; NPM = Northern Pikeminnow; RBT = Rainbow Trout;
SMB = Smallmouth Bass; WCT = Westslope Cutthroat Trout; Salmonids = all salmonid species combined

Table 15. Site location (river km), area surveyed and counts of primary species observed from snorkel surveys of the Priest River, Idaho in August 2019.

			Count					
Stream	Site	Area (m^2)	LSS	MWF	NPM	RBT	SMB	WCT
Priest River	10.5	11,925	0	0	0	0	3	0
Priest River	13.5	7,150	0	1	0	0	4	0
Priest River	16.5	7,550	0	3	2	1	0	1
Priest River	23.0	10,550	1	33	80	0	5	0
Priest River	23.5	9,500	17	2	31	0	2	0
Priest River	26.0	8,314	0	0	3	0	3	0
Priest River	28.5	3,313	1	0	0	0	18	0
Priest River	30.5	11,550	0	1	0	0	0	0
Priest River	33.0	2,739	0	0	0	0	0	1
Priest River	36.0	1,397	0	0	0	0	0	0
Priest River	37.5	11,814	15	0	6	0	0	0
Priest River	39.0	4,692	0	0	7	0	2	0
Priest River	39.5	8,507	2	0	1	0	3	1
Priest River	42.0	14,921	2	0	1	1	2	0
Priest River	45.5	5,383	0	0	0	0	0	0
Priest River	49.0	8,536	3	0	7	3	1	3
Priest River	50.0	13,416	22	0	0	0	0	0
Priest River	51.5	9,917	34	0	0	0	1	0
Priest River	54.5	8,058	100	68	0	1	1	0
Priest River	58.0	4,755	0	0	0	0	0	0
Priest River	58.5	3,451	0	0	1	0	0	1
Priest River	63.0	3,240	2	0	0	0	0	0
Priest River	63.5	7,200	16	0	1	0	0	3
Priest River	67.5	2,738	0	5	0	1	0	5
Priest River	68.5	6,103	0	11	0	1	0	16

LSS = Largescale Sucker; MWF = Mountain Whitefish; NPM = Northern Pikeminnow; RBT = Rainbow Trout;
SMB = Smallmouth Bass; WCT = Westslope Cutthroat Trout; Salmonids = all salmonid species combined

Table 16. Site location (river km), area surveyed, and counts of primary species observed from snorkel surveys of coldwater transects in the Priest River, Idaho in August 2019.

			Count					
Stream	Site	Area (m^2)	LSS	MWF	NPM	RBT	SMB	WCT
Priest River	CWT1	3,863	0	18	0	0	0	1
Priest River	CWT2	4,575	0	117	7	1	2	0
Priest River	CWT3	6,018	1	0	1	0	0	0
Priest River	CWT4	2,938	0	0	3	0	0	1
Priest River	CWT5	9,843	0	95	5	0	4	2
Priest River	CWT6	2,812	0	7	4	1	0	0
Priest River	CWT7	3,246	0	0	0	0	6	0
Priest River	CWT8	2,556	0	0	41	0	1	0
Priest River	CWT9	4,574	0	0	0	0	3	0
Priest River	CWT10	10,675	0	1	3	0	1	0
Priest River	CWT11	10,975	0	3	1	0	0	0
Priest River	CWT12	10,325	0	0	0	0	5	0
Priest River	CWT13	10,250	6	0	15	1	16	0
Priest River	CWT15	4,988	0	5	0	1	0	1

LSS = Largescale Sucker; MWF = Mountain Whitefish; NPM = Northern Pikeminnow; RBT = Rainbow Trout;
SMB = Smallmouth Bass; WCT = Westslope Cutthroat Trout; Salmonids = all salmonid species combined

Table 17. Mean density (fish/100 m^2) by species, sample period, and transect type from June and August snorkel surveys of the Priest River, Idaho. Numbers in parentheses represent one standard error about mean density estimates. Mean density values in bold represent significantly greater values in density comparisons.

Species	June	August	August - Coldwater
Largescale Sucker	0.08(0.03)	0.12(0.06)	**0.01(0.01)**
Mountain Whitefish	0.06(0.02)	0.07(0.04)	0.28(0.14)
Northern Pikeminnow	0.01(<0.01)	**0.07(0.04)**	0.09(0.04)
Rainbow Trout	<0.01(<0.01)	<0.01(<0.01)	<0.01(<0.01)
Smallmouth Bass	0.01(<0.01)	**0.02(0.01)**	0.04(0.01)
Westslope Cutthroat Trout	0.01(<0.01)	0.02(0.01)	0.01(<0.01)
Brown Trout	--	<0.01(<0.01)	--

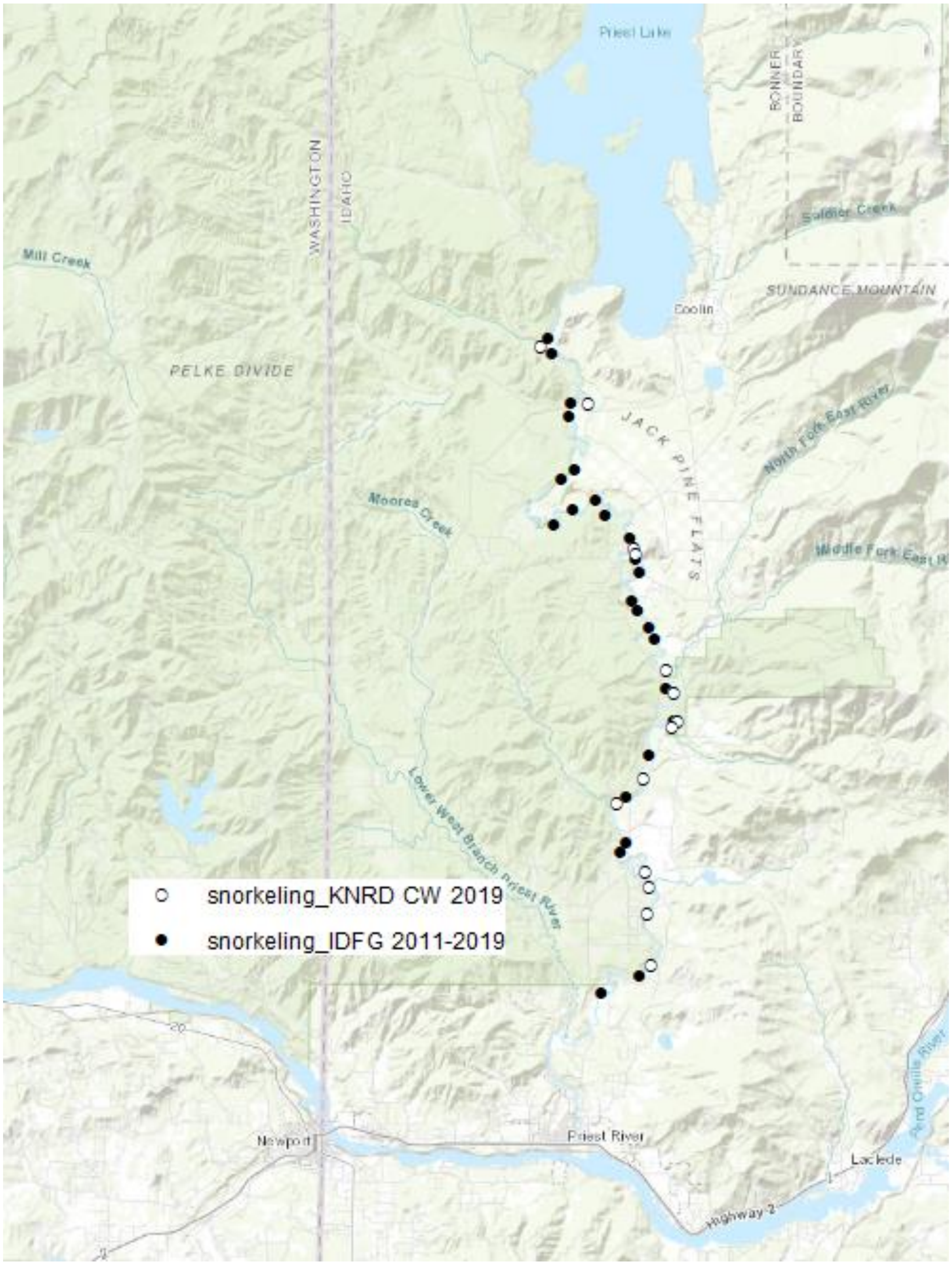

Figure 36. Locations of standard monitoring transects (IDFG 2011-2019) and coldwater transects (KNRD CW) surveyed in 2019 on the Priest River, Idaho.

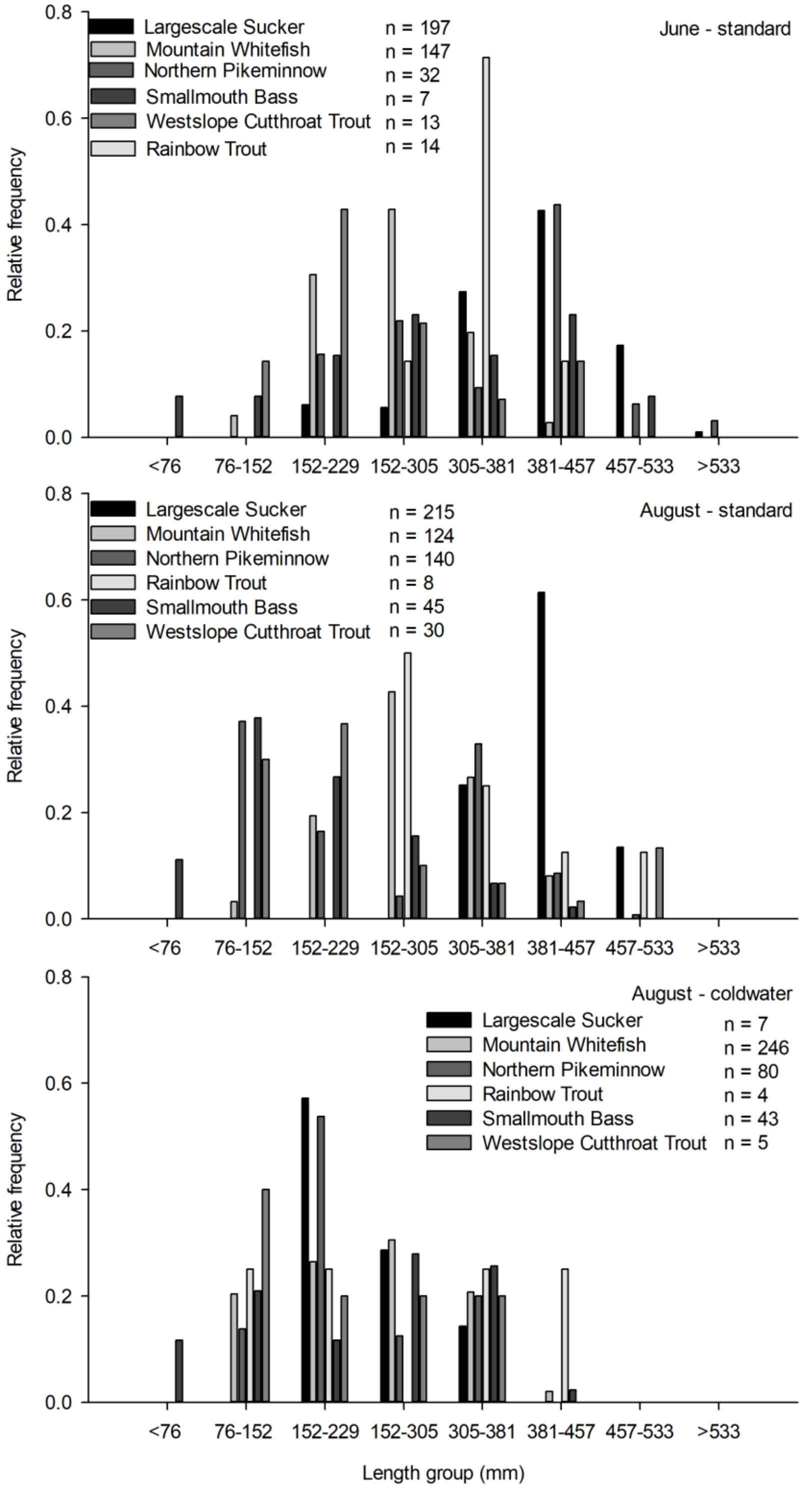

Figure 37. Relative frequency by length group (mm) of fish observed in snorkel surveys of standard transects on the Priest River, Idaho in June and August 2019 and targeted sites designated as coldwater transects, also surveyed in August 2019.

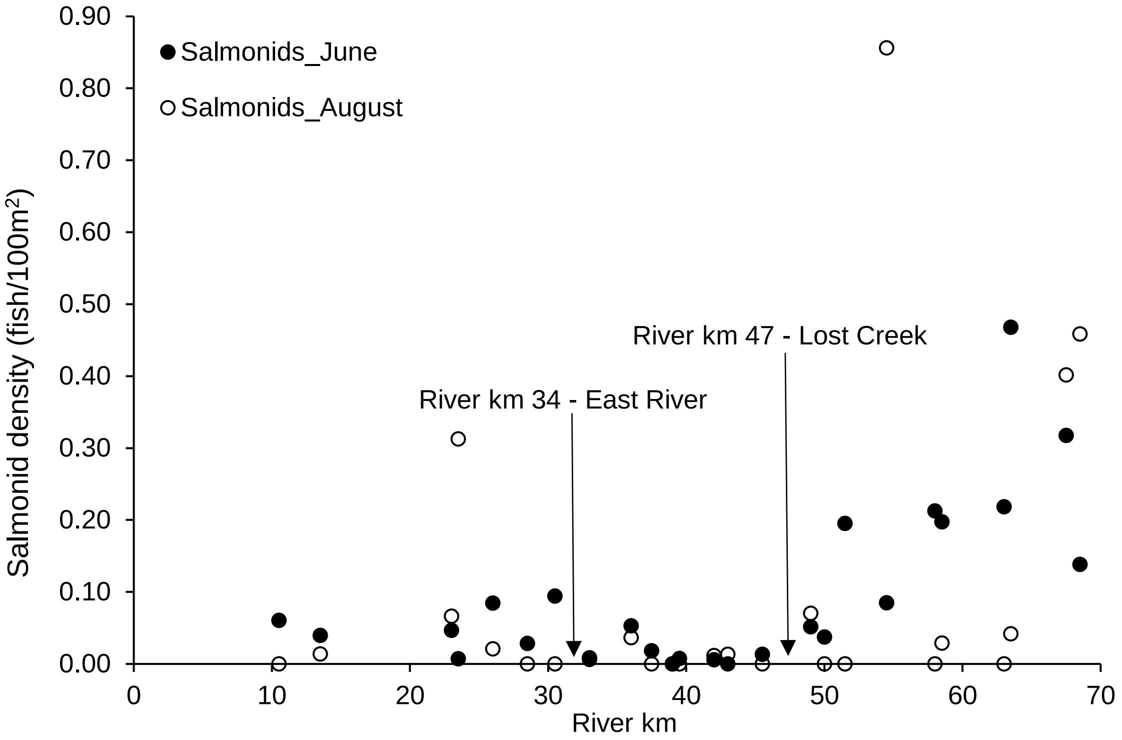

Figure 38. Estimated density of all salmonids by transect from June and August 2019 snorkel surveys of the Priest River, Idaho. River kilometer zero represents the confluence of the Priest River and Pend Oreille River.

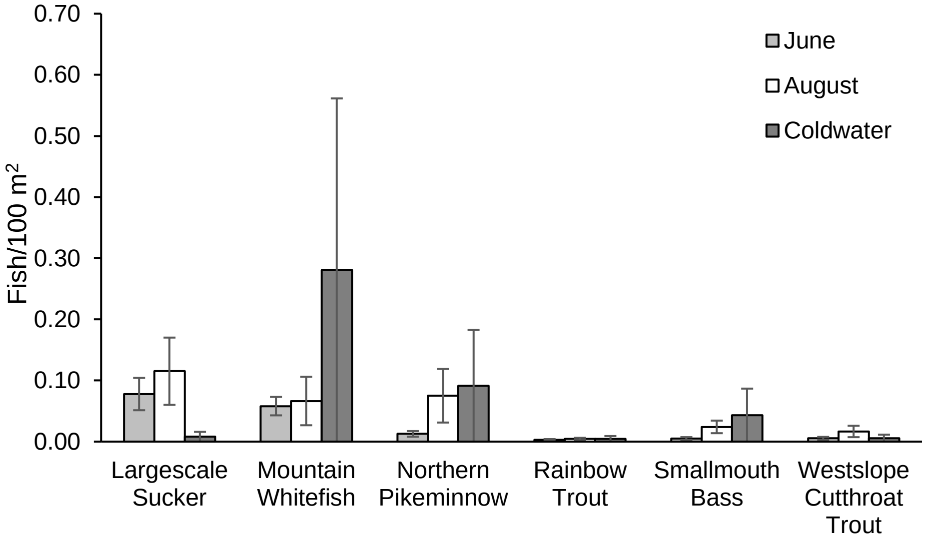

Figure 39. Mean density (fish/100 m^2) of primary species observed in snorkel surveys of standard transects on the Priest River, Idaho in June and August 2019 and targeted sites designated as coldwater transects, also surveyed in August 2019. Error bars represent one standard error about mean density estimates.

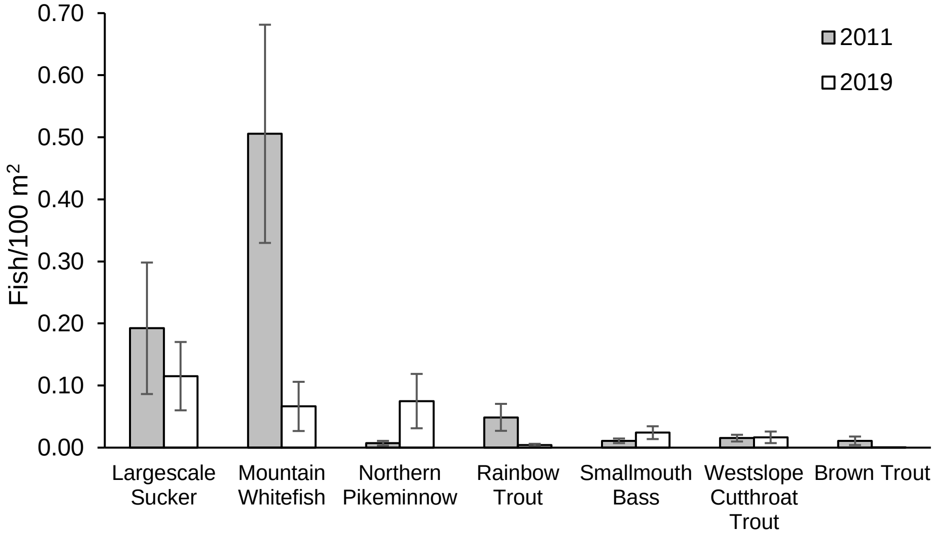

Figure 40. Mean density (fish/100 m^2) of primary species observed in snorkel surveys of standard transects on the Priest River, Idaho in August 2011 and 2019. Error bars represent one standard error about mean density estimates.

PRIEST LAKE FISHERY INVESTIGATIONS

ABSTRACT

In 2019, we investigated Priest Lake kokanee *Oncorhynchus nerka* abundance in an effort to describe population trends. We conducted a lakewide 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. In addition, we estimated mysid shrimp *Mysis diluviana* density from vertical plankton tows. Estimated density of Priest Lake kokanee in August 2019 was 16.2 fry/ha and 6.0 age-1 to age-4 kokanee/ha. A total of 7,046 kokanee adults were observed along five shoreline areas of Priest Lake in November. Mean density of immature and adult mysids was 4.9 ± 1.9 mysids/m^2. The combined observations from kokanee surveys suggestdensity remains low. Estimated mysid density suggests the population is at low abundance and declining.

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INTRODUCTION

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

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

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

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

Current management of the Priest Lake fishery is primarily focused on providing a yield fishery for Lake Trout, which makes up most of the fishing effort. To the extent possible, management also strives to provide a mix of angling opportunities to include species such as kokanee and Westslope Cutthroat Trout. In 2019, we conducted surveys of kokanee abundance to describe current population trends and the opportunity kokanee provide to anglers. We also investigated mysid densities in Priest Lake to better understand how mysid densities relate to abundance trends.

METHODS

Acoustic Kokanee Survey

We conducted a lake wide mobile acoustic survey on Priest Lake to estimate kokanee abundance on the night of August 7, 2019. We used a Simrad EK60 split-beam, scientific echosounder with a 120 kHz transducer to estimate kokanee abundance. Ping rate was set at 0.3 to 0.5 seconds per ping. A pole-mounted transducer was located 0.66 m below the surface, off the port side of the boat, and pointed downward. The echosounder was calibrated prior to the survey using a 23 mm copper calibration sphere to set the gain and to adjust for signal attenuation to the sides of the acoustic axis. Prior to our survey we measured one temperature profile as a calibration of signal speed and as a reference of the expected zone of occupancy for kokanee. Water temperatures were measured at one-meter intervals for 15 meters using a YSI 85-50 dissolved oxygen temperature meter (YSI Incorporated). Mean water temperature for depths from zero and ten meters was used in system calibration. We used Simrad ER60 software (Simrad Yachting) to determine and input the calibration settings.

Standardized transects were followed during our acoustic survey (Maiolie et al. 2013). We followed a uniformly spaced zigzag pattern of 15 transects stretching from shoreline to shoreline (Figure 39). The zigzag pattern was used to maximize the number of transects that could be completed in one night. The pattern followed the general rule of using a triangular design (zigzags) when the transect length was less than twice the transect spacing (Simmonds and MacLennan 2005). The starting point of the first transect at the northern end of the lake was originally chosen at random. Boat speed was approximately 2.4 m/s.

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

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

where:

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

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

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

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

Shoreline Kokanee Count

Shoreline kokanee abundance was estimated in Priest Lake on November 5, 2019. Spawning kokanee were observed and counted at five standard nearshore areas, including Copper Bay, Hunt Creek, Cavanaugh Bay, Indian Creek, and Huckleberry Bay. We collected a sample of spawning kokanee adjacent to the mouth of Hunt Creek using a monofilament gill net. One gill net was set for 15 minutes. The monofilament gillnet was 46 m long with variable mesh panels from 1.9- to 6.4-mm bar mesh. Sex of each kokanee was determined by examining external characteristics. All fish were measured to total length (mm). We used average total length of male kokanee to describe trends in spawner size.

Mysid Survey

Mysid shrimp were sampled to estimate their density in Priest Lake on May 28, 2019. All sampling occurred at night during the dark phase of the moon. A total of twelve random sites was sampled. We attempted to select sites *a priori* from a depth zone equal or greater than 46 m. Vertical net tows were made from a depth of 46 m to the surface. In the field, if a selected site was not 46 m deep, we looked for the desired depth range in close proximity to the site or made a tow from the maximum depth available if no deeper zone was present. A 1-m hoop net of 1,000 micron mesh and a 500 micron bucket was used for all tows. Area of the net mouth was 0.8 m^2. Each mysid collected was counted and classified as either young-of-the-year (YOY) or immature/adult based on relative size. We calculated density as mysids per square meter based on the area of the net mouth. We reported arithmetic mean density and 80% confidence intervals around each estimate.

RESULTS

Acoustic Kokanee Monitoring

Estimated density of Priest Lake kokanee in August 2019 was 16.2 fry/ha ± 6.2 (80% C.I.; Table 18) and 6.0 age-1 to age-4 ± 3.1 kokanee/ha (Table 18; Figure 40). Expanding these densities generated total lakewide estimates of 132,488 kokanee fry and 74,631 kokanee ages 1 to 4. Kokanee density estimates from acoustic surveys over-time remained low and reflected a stable trend (Figure 40).

Shoreline Kokanee Count

We counted a total of 7,046 kokanee along five shoreline areas of Priest Lake in 2019 (Table 19; Figure 41). Length of spawning adult kokanee collected near Hunt Creek varied from 323 mm to 430 mm. Average total length was 368 mm (n = 20) and 342 mm (n = 8) for males and females, respectively. Shoreline kokanee counts and length measures were variable from year to year, but generally reflected a stable trend in abundance (Figure 41).

Mysid Survey

Density of immature and adult mysids in Priest Lake varied by sample location from zero to 14.7 mysids/m^2 (Table 20) with a mean of 4.9 ± 1.9 mysids/m^2 (Figure 42). Mysid density estimates from 2013 to 2019 represented a declining trend in abundance ($r^2 = 0.46$; Figure 42). The mysid density estimate from 2019 was the lowest in monitoring history.

DISCUSSION

Kokanee abundance and other metrics described in our surveys continued to reflect a low-density kokanee population in Priest Lake. Our acoustic estimate of kokanee abundance was within the observed variability of recent estimates and limited our ability to conclude abundance changed significantly (Figure 41; Camacho et al. 2021). Kokanee spawner counts increased from 2018, but remained low relative to peak counts observed between 2011 and 2014 (Figure 40; Camacho et al. 2021). Average length of male kokanee declined marginally from 2018, likely reflecting a small increase in abundance. This is a typical pattern observed over the time series of spawner counts (Figure 42).

We described a continued decline in Priest Lake mysid density and observed that the population is now at an exceptionally low density (4.9 mysids/m^2). The cause of this decline is not known. Water chemistry, water temperature, and fish community structure all potentially influence mysid population productivity (Ball et al. 2015, Devlin et al 2017). An understanding of factors influencing mysid abundance in Priest Lake would be valuable as mysids strongly influence the fish community of the lake. We recommend an in-depth review of factors influencing mysid abundance be completed as a means for guiding future investigations of site-specific factors affecting mysid abundance.

Mysids are the primary forage of Lake Trout in Priest Lake (Ng 2015). As such, declining mysid abundance has potential implications for Lake Trout growth, condition, and survival. Lake Trout in Priest Lake generally exhibit slow growth at as a result of forage quality (i.e., mysid-based; Ng 2015). Declining mysid density may further reduce Lake Trout growth rate. In addition, declining forage availability may negatively influence condition and population productively. Skip spawning, a reduction in the frequency of gonad development in females, is believed to be linked to fish condition and has been observed in Priest Lake Lake Trout (Ng 2015). We hypothesize that a further reduction in body condition will exacerbate the occurrence of skip spawning in the population and subsequently reduce population productivity. Therefore, reductions in both growth and condition have negative implications for recreational fishery quality. Currently, no standard monitoring effort is in place to describe Lake Trout population level changes that may be occurring in response to the mysid decline. As such, we recommend a strategy for monitoring Lake Trout population dynamics and evaluating the effect of declining mysid density on the population be identified and implemented.

MANAGEMENT RECOMMENDATIONS

1. Continue utilizing acoustic surveys as a tool for monitoring Priest Lake kokanee abundance in low-density conditions to better understand trends in abundance and provide information that may be used to inform angler expectations.

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

3. Complete an in-depth review of factors influencing mysid abundance.

4. Identify and implement a strategy for monitoring Lake Trout population dynamics and evaluating the effect of declining mysid density on the population.

Table 18. Acoustic kokanee survey results from Priest Lake, Idaho on August 7, 2019.

Transect	Single Targets	NASC	Mean TS	Total Density (fish/ha)	% Fry	Fry Density	%Ages 1-4	Age 1-4 Density
1	0	3.00	0.00	0	0%	0	0%	0
2	3	0.19	-52.22	7	0%	0	0%	0
3	5	0.87	-55.33	69	100%	69	0%	0
4	4	5.93	-31.52	2	0%	0	100%	2
5	8	9.76	-43.11	46	63%	29	38%	6
6	15	7.44	-40.37	19	67%	13	33%	6
7	13	12.36	-39.20	24	62%	15	38%	9
8	15	8.84	-37.88	13	40%	5	60%	8
9	14	14.82	-37.80	21	50%	10	50%	10
10	53	49.05	-37.59	65	55%	36	45%	30
11	28	29.39	-38.91	53	57%	30	43%	23
12	15	28.83	-36.88	33	33%	11	67%	22
13	12	10.26	-37.71	14	50%	7	50%	7
14	0	0.00	0.00	0	0%	0	0%	0
15	9	11.23	-40.87	32	56%	18	44%	14
Mean				27		16		9

Table 19. Kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 to 2019.

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

Table 20. Mysid density estimates from Priest Lake on May 28, 2019. Densities were listed by sample location (UTM, zone 11, WGS84) and life stage (young-of-year (YOY) and combined immature/adult).

Sample Site	Latitude	Longitude	YOY/m^2	Immature and Adult/m^2
1	48.69992	-116.84776	1.2	7.3
2	48.68216	-116.87552	0.0	8.6
3	48.66442	-116.85066	0.0	4.9
4	48.63652	-116.85791	1.2	14.7
5	48.61052	-116.87714	2.4	9.8
6	48.58261	-116.85108	2.4	4.9
7	48.56513	-116.90790	0.0	2.4
8	48.55167	-116.87752	0.0	3.7
9	48.55634	-116.85088	8.6	1.2
10	48.51097	-116.85129	0.0	0.0
11	48.50232	-116.87905	0.0	1.2
12	48.59182	-116.83867	0.0	0.0
		Mean Density	1.3	4.9

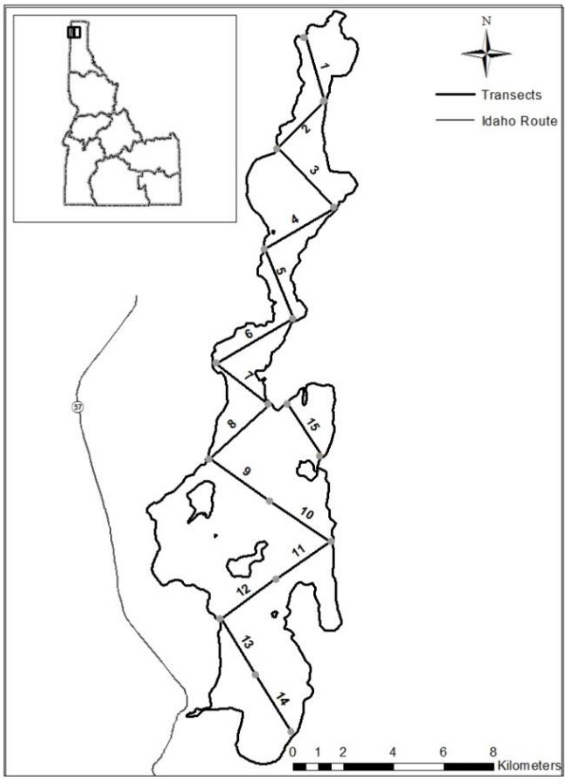

Figure 41. Standard transects on Priest Lake, Idaho used in an acoustic survey of kokanee abundance on August 7, 2019.

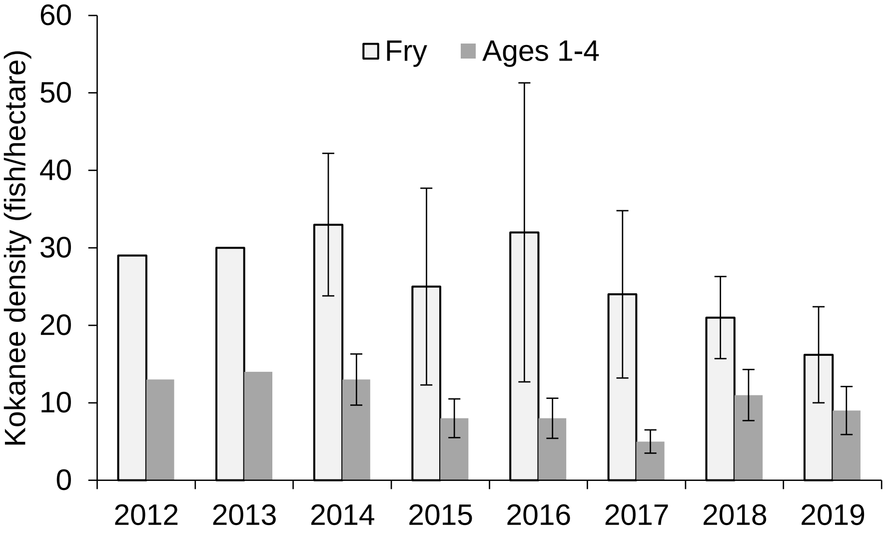

Figure 42. Kokanee density estimates from Priest Lake, Idaho acoustic surveys from 2012 through 2019.

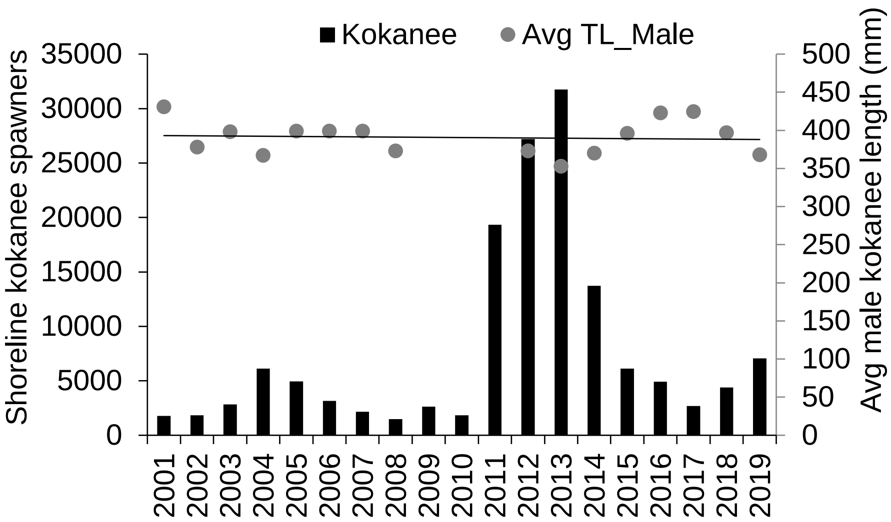

Figure 43. Adult kokanee spawner counts at five standard locations on Priest Lake, Idaho from 2001 through 2019 and corresponding length of male kokanee spawners.

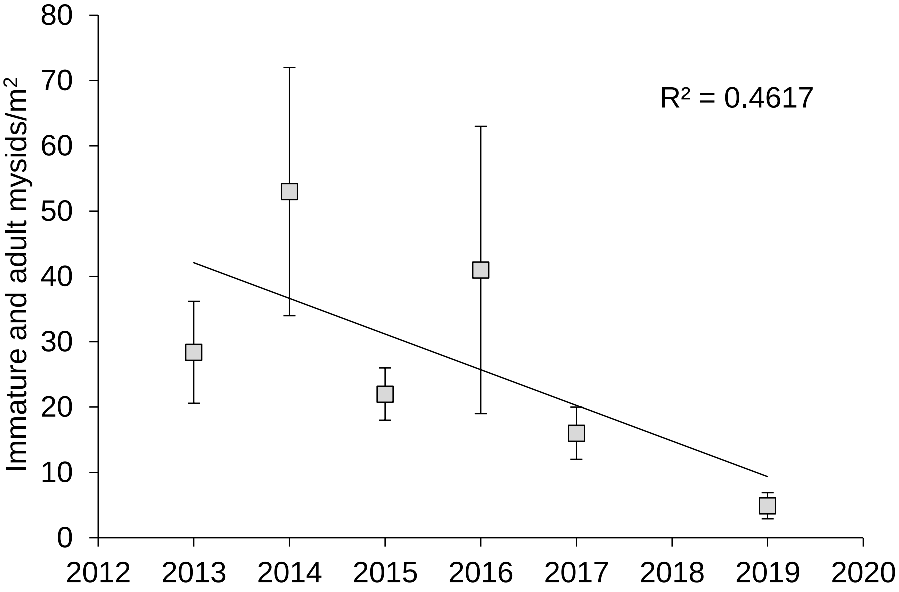

Figure 44. Estimated mean densities of immature and adult mysids in Priest Lake from 2013 through 2019. Error bars represent 80% confidence intervals. No survey was conducted in 2018.

PRIEST AND UPPER PRIEST LAKES MANAGEMENT PUBLIC OPINION SURVEY

ABSTRACT

Management of the Priest Lake and Upper Priest Lake fisheries is challenging in large part due to a long history of divergent management focus between these lakes. Although an understanding of the biological issues associated with managing fisheries in Priest Lake and Upper Priest Lake exists, angler desires and expectations have been unclear. In 2018, we completed a multi-year public engagement process designed to guide fishery management into the future. We formed a stakeholder group in 2013 and met regularly until 2018. Ultimately, the stakeholder group developed three management alternatives for consideration by the broader angling public. We conducted a public opinion survey to estimate the proportion of anglers that supported each management alternative. Four methods were used to survey public opinion including a mail survey, email survey, web-based survey, and surveys collected opportunistically from various events (e.g., fairs, walk-ins, public meetings). A total of 2,340 survey responses was received across all survey methods. No single management alternative was supported by a majority of survey participants across all survey methods. Our recommendation, based on results of this survey, is to continue status quo management of Priest Lake and Upper Priest Lake. This involves managing Priest Lake primarily as a high-yield Lake Trout *Salvelinus namaycush* fishery with limited fishing opportunity for historically more abundant fish species (i.e., kokanee *Oncorhynchus nerka*, Westslope Cutthroat Trout *Oncrohynchus clarkii lewisi*, Bull Trout *Salvelinus confluentus*). Upper Priest Lake will continue to be managed for native fishes. The recommended management strategy was incorporated in the 2019-2024 Idaho Fisheries Management Plan.

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INTRODUCTION

Management of the Priest Lake and Upper Priest Lake fisheries is challenging in large part due to a long history of divergent management focus between these lakes. Priest Lake is managed primarily as a high-yield Lake Trout *Salvelinus namaycush* fishery while Upper Priest Lake management prioritizes fisheries for native fish species like Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* and Bull Trout *Salvelinus confluentus* (IDFG 2013). The Lake Trout focused fishery in Priest Lake remains popular with a core group of anglers (Watkins et al. 2018). However, public scoping associated with the development of the 2013-2018 Idaho Fisheries Management Plan (IDFG 2013) suggested angler opinion regarding management of the Priest Lake fishery is diverse. Specifically, some anglers indicated they would prefer Priest Lake fishing opportunities be more similar to historic conditions. In particular, interest in restoring a kokanee *Oncorhynchus nerka* fishery was a common sentiment and likely was motivated in large part by the success of kokanee recovery efforts in nearby Lake Pend Oreille occurring at the time. Divergent management strategies for Priest and Upper Priest lakes also add complexity for fishery managers. Lake Trout move freely between the lakes and hinder native fish conservation efforts in the upper lake. Thus, current objectives could more easily be met in Upper Priest Lake if a similar management approach was adopted for Priest Lake.

Although an understanding of the biological issues associated with managing fisheries in Priest Lake and Upper Priest Lake exists, angler desires and expectations have been unclear. As a result, the 2013-2018 Idaho Fisheries Management Plan set direction to improve understanding of the Priest Lake fish community, fishery, and public opinions surrounding the fishery for the purpose of developing a management plan for the 2019-2024 period. Investigations aimed at improving current knowledge included a Lake Trout population dynamics study, kokanee monitoring, initiating Westslope Cutthroat Trout monitoring, and an angler creel survey (Watkins et al. 2018, Ryan et al. 2018, Ryan et al. 2020$_a$, Ryan et al. 2020$_b$). In addition, the Priest Lake Fishery Advisory Committee (PLFAC) was established in 2013. Approximately a dozen individuals were selected for the PLFAC to represent the diversity of views surrounding management of the fishery. Committee members represented anglers with preferences for either contemporary or historical Priest Lake fisheries, fishing guides, business owners associated with Priest Lake, and agency representatives of the U.S. Fish and Wildlife Service and Kalispel Tribe. The purpose of the PLFAC was to assist IDFG in development of a long-term management plan (8-12 years) for Priest Lake and Upper Priest Lake. The stakeholder group met regularly between 2013 and 2018 to identify information needs, review new and existing information, and assist in development of fishery management alternatives for consideration by the broader angling public. The final product of the stakeholder group process was the development of management alternatives for consideration by the broader angling public.

METHODS

The PLFAC collaboratively developed three management alternatives that had reasonable implementation potential and would provide desirable fishing opportunities in Priest and Upper Priest lakes. Management alternatives represented the varied interests of PLFAC participants and included a “no change” alternative, “traditional fishery restoration” alternative, and “mixed species fishery” alternative. Each alternative included species-specific actions, expected outcomes, associated timelines, expected economic impacts, and potential limiting factors for targeted sportfish populations. An alternative summary was created to highlight the key components of each alternative (Table 21). Additionally, all three alternatives included the continued management of Upper Priest Lake to benefit native species. This resulted from the

PLFAC unanimously agreeing that this management approach should continue regardless of the alternative chosen for Priest Lake.

We conducted a public opinion survey to estimate the proportion of anglers that supported each management alternative. A survey questionnaire was used to elicit input from participants (Appendix A). The questionnaire requested participants identify which of three developed management alternatives they preferred. Supplemental questions provided context to survey responses by gauging each participant's familiarity with the Priest Lake and Upper Priest Lake fishery and their residence by state and county.

Four survey methods were employed to deliver the public opinion survey. Methods included a mail survey, email survey, web-based survey, and surveys collected opportunistically from various events (e.g., fairs, walk-ins, public meetings). Mail surveys were sent via the U.S. Postal Service to 5,000 randomly selected Idaho fishing license buyers. Participants were randomly selected from the IDFG license database and included only residents of Benewah, Bonner, Boundary, Kootenai, and Shoshone counties in Idaho and Pend Oreille and Spokane counties in Washington. The total number of mail surveys was proportionally allocated by the number of license buyers in each county. However, because allocation based solely on proportions of license buyers was small (<10) for some counties (e.g., Benewah) a modified allocation approach was implemented. Specifically, the mean of the proportional allocation method and a five percent minimum allocation per county was used to increase sample sizes in counties with fewer fishing license buyers. Email surveys were sent to 10,003 fishing license buyers in the IDFG license database who declared residency in Benewah, Bonner, Boundary, Kootenai, and Shoshone counties in Idaho or Pend Oreille and Spokane counties in Washington. Only fishing license buyers who provided an email address when purchasing a license and did not receive a mail survey were included in the email survey. Two emails, approximately three weeks apart, were sent to email survey participants to encourage completion of the survey. The web-based survey was made available on the IDFG website. Participation in the web-based survey was available to anyone. Web-based survey responses were uniquely identified by a survey identification number and internet protocol address. Duplicate web-based survey responses by a single individual were removed prior to summarization. Non-random survey responses were collected at multiple other events including one of three public meetings held in Coolin, Priest River, and Coeur d'Alene; at the Bonner County fair IDFG booth; and from individuals who contacted regional fishery staff directly via email, phone, or an in-person office visit.

We calculated proportional response by question to describe angler opinions. Survey responses were summarized by survey method. Responses from all survey methods were valuable. However, we anticipated non-random surveys incorporated inherent participation bias. Random survey methods were generally considered to be less biased and were relied upon more heavily in gauging broad public opinion, although no specific weight metric was used.

RESULTS

A total of 2,340 survey responses were received across all survey methods. Those surveyed by mail returned 1,030 surveys (21%). Four percent (408) of emailed surveys were completed. An additional 770 web-based and 132 opportunistic survey responses were also received. Survey participants represented two countries, 26 states, and 15 Idaho counties. Idaho residents represented 73% to 80% of survey participants in email, mail, and opportunistic surveys

(Table 22). In contrast, residents provided only 41% of responses associated with the online survey.

Angler fishing experience on Priest Lake varied among survey participants and survey method (Figure 43). In random surveys (i.e., mail, email) a combined total of 33 to 54% of respondents indicated they were occasional (fished one to five times per year) or avid (fished more than five times per year) anglers on Priest Lake. Non-random survey (i.e., web-based and opportunistic) participants generally indicated they were more experienced anglers with 80 to 83% indicating they were occasional or avid Priest Lake anglers. Among all survey methods, the proportion of responses indicating an angler previously fished Priest Lake, but no longer did varied little from 7 to 9%. Lake Trout were consistently listed as the most targeted fish species by those who indicated they participated Priest Lake fishing (Table 22).

Angler fishing experience on Upper Priest Lake was generally lower than that reported for Priest Lake (Table 22). Among all surveys, anglers reporting they fished Upper Priest Lake occasionally or were avid anglers and fished it often varied from a combined 26 to 45%. A majority of email, mail, and opportunistic survey respondents indicated they never fished on Upper Priest Lake. Those surveyed who did fish Upper Priest Lake did not clearly target one species. Although Lake Trout were listed as a commonly targeted fish, Westslope Cutthroat Trout were also sought by Upper Priest Lake anglers.

No single Priest Lake management alternative was supported by a majority of survey participants across all survey methods (Figure 44). Survey participants that preferred no change to Priest Lake fishery management represented 36 to 74% of survey responses. Random survey methods represented lower support for the no change alternative (36-41%) than non-random survey methods (48-74%). Survey participants supporting a change in fishery management represented 33 to 50% of survey responses. Of those survey participants that indicated they preferred a change to Priest Lake fishery management, a majority (65-85%) supported the traditional fishery restoration alternative (Figure 45).

DISCUSSION

We did not identify majority support for change in management direction of the Priest Lake fishery. Opinions captured by our survey suggested both anglers that prefer the current fishery and those that would like to see it change were well-represented. Our recommendation, based on results of this survey, is to continue managing Priest Lake primarily as a high-yield Lake Trout fishery with limited fishing opportunity for historically more abundant fish species (i.e., Westslope Cutthroat Trout, kokanee, Bull Trout). We also recommend that management of Upper Priest Lake continue to focus on native species conservation because of strong support by both the PLFAC and comments received during the public opinion survey. A native species focus on Upper Priest Lake provides a conservation benefit for native species while also offering opportunity for anglers who value the traditional fishery. Additionally, conserving native populations in the system will allow for a traditional restoration approach to be considered in Priest Lake at some point in the future if public sentiment changes. These recommendations will be incorporated into the 2019-2024 Idaho Fish Management Plan; however, results from this intensive multi-year pubic engagement process are intended to set long-term direction (8-12 years) for management of these lakes.

We observed participation bias in our non-random surveys, especially our online survey. Non-random survey participants identified themselves as occasional and (or) avid anglers at a higher proportion than either random survey method. We speculated this type of response could occur because anglers who currently participate in the in the Priest Lake fishery likely find value in its current status (i.e., Lake Trout dominant fishery). We found a higher level of support for the existing fishery management direction in non-random surveys than random surveys suggesting our speculation was accurate. We also found the online survey had disproportional participation of non-residents relative to other survey methods. Several factors may have influenced non-resident participation. For example, the Priest Lake area is a vacation destination and the fishery has high non-resident participation (Watkins et al. 2018). Our random surveys included the two northeast counties of Washington, but did not account for non-resident participants from other areas. Our non-random online survey provided an opportunity for broad input from any non-resident fishery participants to share their opinions. We were also aware of a social media campaign by a Priest Lake fishing guide. The campaign encouraged support for the “no change” alternative and encouraged participation in the online survey. We assume non-resident anglers on Priest Lake seek guide services at a disproportionally higher rate than residents and this campaign may have resulted in proportionally higher non-resident participation in the online survey. While our non-random survey efforts provided valuable perspectives from survey participants, our experience highlights the potential challenges in conducting public opinion surveys and the need to diversify survey methods where possible.

MANAGEMENT RECOMMENDATIONS

1. Over the next 8-12 years, continue managing Priest Lake as a high-yield Lake Trout fishery with limited fishing opportunity for historically more abundant fish species (i.e., Westslope Cutthroat Trout, kokanee, Bull Trout). Additionally, continue managing Upper Priest Lake with an emphasis on native species conservation.

2. Establish specific management objectives and strategies for Priest and Upper Priest lakes in the 2019-2024 Idaho Fish Management Plan that are consistent with the recommended management direction.

3. Evaluate existing fishery monitoring methods and modify as needed to provide the information necessary to accomplish management objectives and strategies for Priest and Upper Priest lakes.

4. Attempt to secure a more stable funding source to support Lake Trout suppression on Upper Priest Lake now that clear direction exists to continue long-term implementation of this management action.

Table 21. Proposed Priest Lake fishery management alternatives summarizing management actions and related details.

Alternative	Actions	Expected Outcome	Timeline	Expectation of Success	Economic Impact	Limiting Factors
No Change	Lake Trout -MAINTAIN a high density high catch rate Lake Trout fishery for 15" to 25" fish Kokanee - MAINTAIN a low density low catch rate kokanee fishery for larger (14"-16") fish Westslope Cutthroat Trout - MAINTAIN a low to moderate density and low to moderate catch rate cutthroat fishery Bull Trout - Largely absent in Priest Lake and would be expected to remain absent	All Species - Fishery would be consistent with what is experienced now	No Time Frame - Objectives already met	High	Maintain a similar economic value of the fishery	Biological - Lake Trout would continue to be limited by slow growth rates, impacting the ability to provide trophy size fish; Kokanee abundance would continue to be limited by abundant Lake Trout Social - Mostly appeals to Lake Trout anglers, less overall angler effort potential; less fishery diversity than historically; limited support from anglers who desire the traditional fishery at Priest Lake (i.e. Kokanee, native species) Financial - Low; continued funding for native species conservation work in Upper Priest Lake is uncertain
Restore Traditional Fishery	Lake Trout -REDUCE (remove as many Lake Trout as possible; Lake Trout removal by netting, unlimited harvest, angler incentives) Kokanee - ENHANCE (Likely would include stocking)	Lake Trout -Low density, low catch rates Kokanee - high density, high catch rate kokanee fishery for 9" to 11" fish	5 - 10 Years - to transition to kokanee fishery, increased native species abundance may take longer	Moderate	Increased fishery value	Biological - Full replacement of the fishery to historical levels may not be possible because the system is altered (i.e. Mysis shrimp, Smallmouth Bass) Social - Would require public acceptance of Lake Trout removal and more active management of the fishery by IDFG; Requires acceptance of short term reduction in fishing quality during transition

Table 21. (continued)

Alternative	Actions	Expected Outcome	Timeline	Expectation of Success	Economic Impact	Limiting Factors
	Westslope Cutthroat Trout - ENHANCE (tributary improvements were feasible)	Westslope Cutthroat Trout - improved fishery with moderate to high densities and moderate to high catch rates; harvest opportunity				Financial - High, but declining cost over time
	Bull Trout - ENHANCE (tributary improvements were feasible; potentially conservation stocking)	Bull Trout - Rebuild population; provide trophy opportunity for anglers (low to moderate density, low to moderate catch rates); meet ESA recovery criteria				
Mixed Species Fishery	Lake Trout - PARTIALLY REDUCE (limited reduction by netting, unlimited harvest, angler incentives)	Lake Trout -moderate density, moderate catch rates	Difficult to predict; ongoing management activity	Low - high uncertainty and high instability expected under this alternative	Increased fishery value - fluctuating with fishery quality	Biological - Uncertainty of biological response to partial Lake Trout removal is high
	Kokanee - ENHANCE (likely would include stocking)	Kokanee - moderate density, moderate catch rate kokanee fishery for 11"-14" fish				Social - Would require public acceptance of Lake Trout removal and more active management of the fishery by IDFG; Ongoing management needed; Would require tolerance of a less stable fishery
	Westslope Cutthroat Trout - ENHANCE (tributary improvements were feasible)	Westslope Cutthroat Trout - improved fishery with moderate densities and moderate catch rates; potential for limited harvest				Financial - High and ongoing
	Bull Trout - ENHANCE (tributary improvements were feasible)	Bull Trout - increased density; some trophy opportunity				
		All Species - balance in abundance is expected to be unstable and difficult to predict				

Table 22. Proportional survey responses by survey method to questions asked in a 2017-2018 opinion survey used to estimate angler preferences for fishery management of Priest Lake and Upper Priest Lake, Idaho.

Question	Response	Email	Mail	Opportunistic	Online
How often do you fish Priest Lake each year?	I don't regularly fish on Priest Lake	0.226	0.202	0.042	0.071
	I fish on Priest Lake 1-5 times per year	0.350	0.260	0.364	0.393
	I fish on Priest Lake more than 5 times per year	0.189	0.096	0.466	0.402
	I have never fished on Priest Lake	0.149	0.363	0.042	0.041
	I used to fish Priest Lake regularly, but no longer do	0.087	0.069	0.085	0.093
	No response	0.000	0.010	0.000	0.000
What species do you most often target when fishing Priest Lake?	Anything that will bite	0.170	0.158	0.227	0.200
	I don't fish on Priest Lake	0.172	0.397	0.070	0.051
	Kokanee	0.117	0.101	0.218	0.116
	Lake Trout	0.409	0.260	0.420	0.568
	Smallmouth Bass	0.045	0.017	0.001	0.017
	Westslope Cutthroat Trout	0.087	0.033	0.067	0.047
How often do you fish Upper Priest Lake each year?	I don't regularly fish on Upper Priest Lake	0.328	0.217	0.244	0.295
	I fish on Upper Priest Lake 1-5 times per year	0.211	0.157	0.252	0.339
	I fish on Upper Priest Lake more than 5 times per year	0.047	0.017	0.101	0.114
	I have never fished on Upper Priest Lake	0.365	0.567	0.286	0.203
	I used to regularly fish Upper Priest Lake, but no longer do	0.050	0.031	0.118	0.049
	No Response	0.000	0.011	0.000	0.000
What species do you most often target when fishing Upper Priest Lake?	Anything that will bite	0.166	0.134	0.151	0.211
	I don't fish on Upper Priest Lake	0.466	0.638	0.471	0.307
	Kokanee	0.039	0.042	0.067	0.059
	Lake Trout	0.153	0.088	0.151	0.302
	Smallmouth Bass	0.018	0.011	0.017	0.009
	Westslope Cutthroat Trout	0.158	0.055	0.143	0.113
	(blank)	0.000	0.032	0.000	0.000

Table 22. (continued)

Question	Response	Email	Mail	Opportunistic	Online
Are you an Idaho Resident?	No	0.198	0.267	0.212	0.594
	Yes	0.802	0.733	0.788	0.406
Do you want the Priest Lake fishery to be maintained as it is now?	I have no opinion	0.090	0.650	0.023	0.011
	No - I would like a different type of fishery	0.496	0.333	0.432	0.245
	Yes - I support the No Change fishery	0.414	0.356	0.477	0.744
	No response	0.000	0.246	0.068	0.000
If you answered "No" in Question 10, which alternative do you support?	Mixed Species Fishery	0.294	0.257	0.143	0.198
	Traditional Fishery Restoration	0.706	0.743	0.839	0.802
	No response	0.000	0.000	0.018	0.000

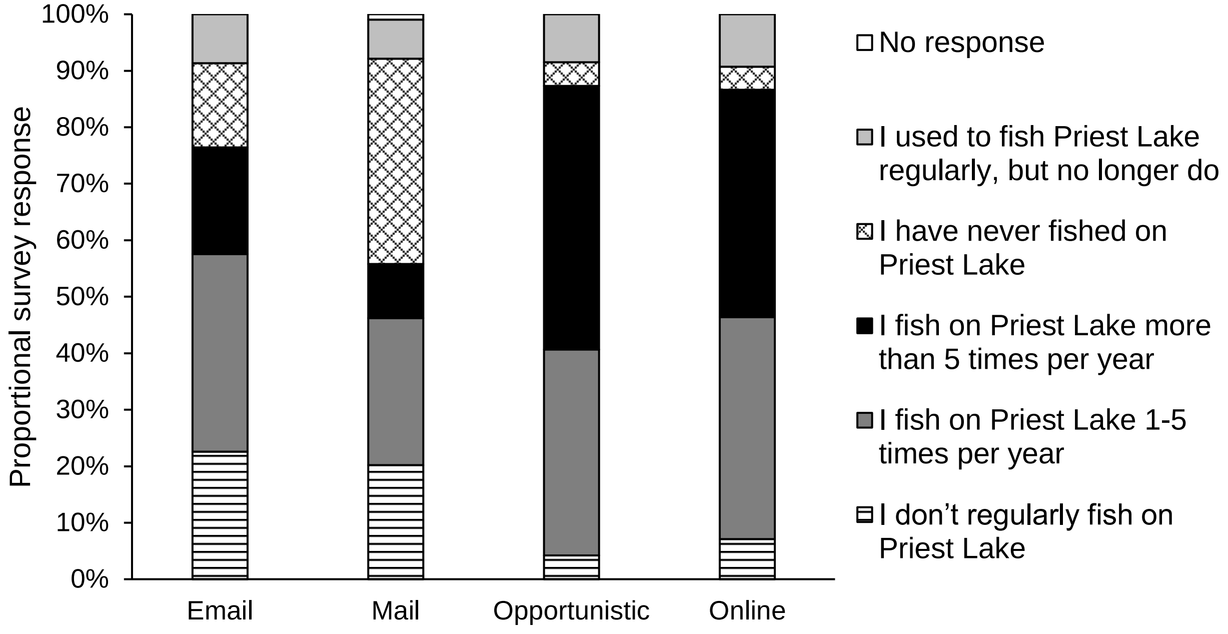

Figure 45. Proportional survey response by survey method gauging angler experience fishing Priest Lake, Idaho from a 2017-2018 opinion survey used to estimate angler preferences for management of the Priest Lake fishery.

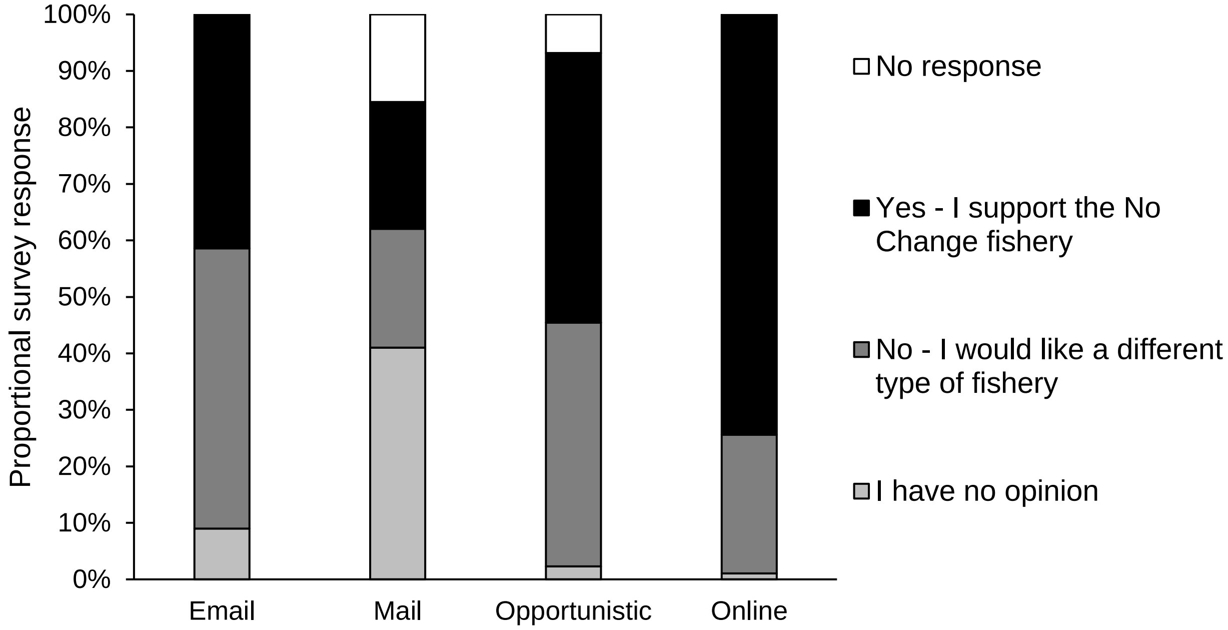

Figure 46. Proportional survey response by survey method gauging angler preference for proposed fishery management alternatives of Priest Lake, Idaho from a 2017-2018 opinion survey.

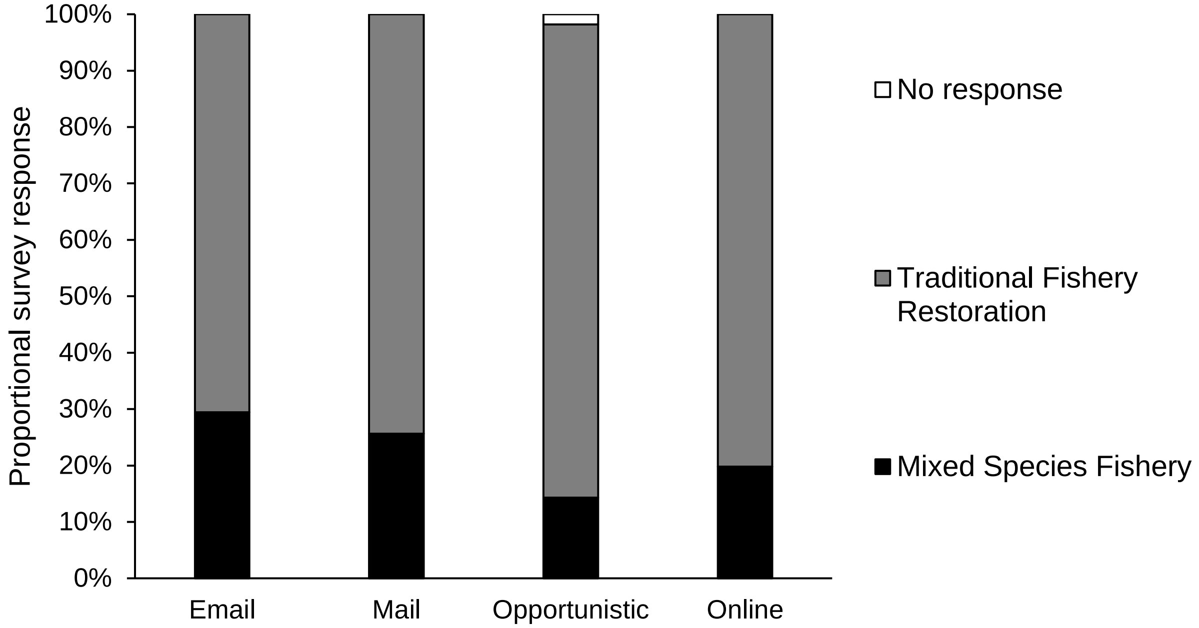

Figure 47. Proportional survey response by survey method gauging angler preference for proposed fishery management alternatives of Priest Lake, Idaho from a 2017-2018 opinion survey. Responses represent preferences for new management direction from those survey participants who indicated they desired a different management alternative than the status quo.

APPENDICES

Appendix A. Opinion survey used to gauge angler preferences for fishery management of Priest Lake and Upper Priest Lake, Idaho in 2017-2018.

Dear Angler,

The Idaho Department of Fish and Game (IDFG) would like your input to help guide management of the Priest Lake and Upper Priest Lake fisheries. Your input will be used to help establish goals and objectives for managing fishing opportunities, including those for Priest Lake and Upper Priest Lake. Since 2013, IDFG has worked with local stakeholders – mostly residents of the Priest Lake area – to identify key issues affecting the Priest Lake and Upper Priest Lake fisheries. This group of local stakeholders used both historical and new information to develop three long-term fisheries management alternatives. Your participation in this survey will help us understand public support for each of these management alternatives and is important in deciding how to manage these fisheries in the future. Thank you for taking the time to provide your opinion!

1) For Priest Lake, how often do you go fishing there each year? (Choose one).

☐ **I fish Priest Lake 1-5 times per year**
☐ **I fish Priest Lake more than 5 times per year**
☐ **I don't regularly fish on Priest Lake**
☐ **I used to fish Priest Lake regularly, but no longer do (see below)**
☐ **I have never fished on Priest Lake**

If you used to fish Priest Lake but no longer do, please describe why you stopped fishing on Priest Lake.

____

____

2) For Upper Priest Lake, how often do you go fishing there each year? (Choose one).

☐ **I fish Upper Priest Lake 1-5 times per year**
☐ **I fish Upper Priest Lake more than 5 times per year**
☐ **I don't regularly fish Upper Priest Lake**
☐ **I used to regularly fish Upper Priest Lake, but no longer do (see below)**
☐ **I have never fished Upper Priest Lake**

If you used to fish Upper Priest Lake, but no longer do, please note why you stopped fishing on Upper Priest Lake.

____

____

3) For Priest Lake, please choose which species you *most* often target.

☐ **Lake Trout**
☐ **Kokanee**
☐ **Westslope Cutthroat Trout**
☐ **Smallmouth Bass**
☐ **Anything that will bite**
☐ **I don't fish on Priest Lake**

4) For <u>Upper Priest Lake</u>, please choose which species you *most* often target.

- ☐ **Lake Trout**
- ☐ **Kokanee**
- ☐ **Westslope Cutthroat Trout**
- ☐ **Smallmouth Bass**
- ☐ **Anything that bites**
- ☐ **I don't fish on Upper Priest Lake**

5) Are you an Idaho Resident?

☐ **Yes**
If Yes, in what Idaho county do you live in?
____
☐ **No**
If No, in which state/country are you a resident?
____

Three alternatives were developed by the Priest Lake Fishery Advisory Committee. **Each includes maintaining the current native species conservation emphasis on Upper Priest Lake.** As a result, the main focus is to determine the management direction for Priest Lake. Each alternative is summarized below.

No Change: *Maintain the current Priest Lake management direction. Maintain consistent harvest of lake trout, typically 15-25 inches in size. Management actions, fishing rules, and the fishing experience under this alternative would generally be similar to the current conditions. Financial cost of implementing this alternative is low.*

Traditional Fishery: *Restore a kokanee fishery with high catch rates and consistent harvest. Enhance native westslope cutthroat trout to allow limited harvest. Enhance native bull trout to restore trophy fishing opportunity. This alternative requires significantly reducing lake trout abundance through removal efforts, while also stocking kokanee. For this alternative to be successful, it would require public support for removing lake trout, a short-term reduction in fishing quality during the fishery transition, and a reliable funding source for implementation. Financial cost of this alternative would be high at first, but would decline over time.*

Mixed Species Fishery: *This is a middle ground between the previous alternatives. Provide moderate catch rates and some harvest for lake trout. Try to improve kokanee fishing by having fewer lake trout. Provide some added conservation benefit and improved fishing for cutthroat trout and bull trout. This alternative would require modest reduction in lake trout abundance through removal efforts, while also stocking kokanee. Success of this alternative would require public support to reduce lake trout density, tolerance for less consistent fishing for both lake trout and kokanee, and require a reliable funding source for implementation. Examples from other lakes suggest this alternative is the most difficult to successfully implement. Financial cost of this alternative is high and expected to remain high because of the ongoing management actions needed to maintain a balanced fishery.*

6) Do you want the Priest Lake fishery to be maintained as it is now?

- ☐ **Yes – I support the No Change alternative**
- ☐ **No – I would like a different type of fishery (continue to question 7)**
- ☐ **No Opinion**

7) If you answered **"No"** in the previous question, which alternative do you support? (Choose one).

- ☐ **Traditional Fishery**
- ☐ **Mixed Species Fishery**

LAKE TROUT MANAGEMENT IN UPPER PRIEST LAKE

ABSTRACT

Upper Priest Lake is currently managed for the conservation of native species. In support of this objective, removal of non-native Lake Trout *Salvelinus namaycush* has occurred since 1998. In 2019, gill nets were used to remove 2,621 Lake Trout during a two-week period from May 14 through May 24. Average daily catch rate from standard mesh sizes was 9.4 fish/box (± 3.4, 80% C.I.), which was similar to recent years. Lake Trout catch was comprised of a higher proportion of larger (≥ 450 mm) fish than the previous year. Bull trout catch rate (0.06/box) continued to represent a stable trend, but was low relative to peak catches observed during previous annual efforts. Trend data suggested Lake Trout abundance remained relatively stable and supported continuation of removal efforts to benefit native fishes in Upper Priest Lake.

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INTRODUCTION

Native fishes, including Bull Trout *Salvelinus confluentus* and Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi,* played an important role in the history of Priest and Upper Priest lake fishing. Historically, Bull Trout provided a harvest-oriented trophy fishery in Priest and Upper Priest lakes (Bjornn 1957). However, harvest opportunities were discontinued in 1984 following declines in Bull Trout abundance. Although the influence of fishing mortality on the population was removed, a positive population response did not occur (Mauser et al. 1988). Today, the Bull Trout population in Upper Priest Lake is considered depressed while the population in Priest Lake is considered functionally lost (Liter et al. 2008). Native Westslope Cutthroat Trout were also historically abundant in Priest Lake and Upper Priest lakes and provided the primary fishery in both lakes prior to the 1950s (Mauser et al. 1988). Westslope Cutthroat Trout harvest opportunities were closed in 1988, following a perceived decline in overall abundance. Overharvest, interspecific competition, predation, and degradation of spawning habitat were all believed to contribute to the decline of native fish in this system.

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

Native fish conservation has been an ongoing management focus on Upper Priest Lake. In an effort to reduce the potential impacts of Lake Trout on native fish populations in Upper Priest Lake, the Idaho Department of Fish and Game (IDFG) began a Lake Trout removal program in 1998. Gill nets have been used annually to remove Lake Trout and reduce their abundance in the lake. These management efforts have removed 150 to 5,000 Lake Trout annually from Upper Priest Lake (Fredericks et al. 2013). In 2019, we continued Lake Trout reduction efforts in Upper Priest Lake with the intent of benefiting native fish species.

OBJECTIVE

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

STUDY SITE

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

METHODS

We completed the 2019 Upper Priest Lake Lake Trout removal effort from May 14 to May 24. Hickey Brothers Research, LLC was contracted to provide equipment and labor for the netting project. An 11 m commercial gill net boat was used to complete removal efforts. Funding for completion of the Lake Trout removal effort was provided by the Kalispel Tribe and Idaho Department of Fish and Game. Historically, the U.S. Fish and Wildlife Service has provided financial support of this project, but chose not to provide support in 2019. Total cost of the contract with Hickey Brothers Research for commercial fishing services was $31,000.

We used monofilament sinking gill nets to capture and remove Lake Trout from Upper Priest Lake. Individual gill net dimensions were 91 by 2.7 m. Multiple nets were tied together end-to-end to create a single net gang. Collectively the net gang was comprised of a range of mesh sizes. Standardized mesh sizes (stretch-measure) included 45, 51, 64, 76, 89, 102, 114, and 127 mm (Table 23). Fishing effort was measured in units defined as net boxes. Boxes were used to transport nets onboard the boat, and each box of net was equivalent to approximately 273 m or three 91 m nets. Daily effort was split between morning and afternoon sets each day. The combined effort per day was 30 boxes of gill net. A total of 240 boxes of gill net were placed over ten days. Both morning and afternoon sets were made on each day, except the first and last days of each work week during which only one set was made on each date. The combined total effort for the first and last day of each work week was 30 boxes of net. Typically 18 boxes of net were set in the morning and 12 boxes of net were set in the afternoon. The combined effort by mesh size was consistent within morning and afternoon sets, respectively. The time between net placement and initiating net lifting varied from two to five hours for all sets. Gill net was set throughout Upper Priest Lake over the course of the sampling period at depths varying from 10 to 31 m. Placement of nets in and around the primary inlets and outlet of Upper Priest Lake was avoided to reduce bycatch of Bull Trout and Westslope Cutthroat Trout.

Relative abundance of Lake Trout in Upper Priest Lake was measured as average daily catch per unit of effort (CPUE) or fish per net box per day for catch associated with 51-, 64-, and 76-mm mesh sizes. These mesh sizes were selected as standards because they represented the longest time series of mesh sizes fished during Upper Priest Lake removal efforts. We compared these standardized catch rates to prior years to evaluate trends in abundance. We only used data from 2010 to 2018 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 to 2019. Prior to 2014, a standard set of mesh sizes was not used and limited complete comparisons with prior years.

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

Bycatch of non-target species associated with the removal effort was generally noted and fish were released if alive, though not all individuals were recorded. However, total length and condition were collected from all Bull Trout. Bull Trout condition was ranked from zero to three, with zero representing mortality and three representing excellent condition. We reported Bull Trout catch rate as the average of daily catch per unit of effort or fish per net box per day among all mesh sizes and compared catch rates from 2007 to 2019. Variance around catch rate estimates was described using 80% confidence bounds. Confidence bounds were only estimated for years during which standardized gill net effort and mesh were used (i.e. 2014-2017).

RESULTS

We removed 2,621 Lake Trout during the ten-day gillnetting effort. Average daily catch rate from combined 51-, 64-, and 76-mm mesh sizes was 9.4 fish/box (± 3.4, 80% C.I.; Figure 46). Catch rate from these mesh sizes was comparable to those observed in years since 2015 (Figure 46). Mesh-specific catch rates were variable among mesh sizes and within mesh size among years (Figure 47). Proportional increase in catch rates in large meshes (102, 114, and 127 mm) represented the most dramatic variation observed between 2018 and 2019 (Figure 47).

Total lengths of Lake Trout varied from 131 to 885 mm (Table 23; Figure 48). In general, fish length increased with increased gill net mesh size. Small mesh sizes (45, 51, and 64 mm) caught the majority of Lake Trout and accounted for 75% of the total catch. These mesh sizes also represented 60% of total effort expended.

Incidentally caught species included Bull Trout, Kokanee *Oncorhynchus nerka*, Longnose Sucker *Catostomus catostomus*, Largescale Sucker *Catostomus macrocheilus*, Northern Pikeminnow *Ptychocheilus oregonensis*, Peamouth *Mylocheilus caurinus*, and Westslope Cutthroat Trout. We caught 15 Bull Trout among all netting efforts, representing an average daily catch rate of 0.06 Bull Trout per box of net. Observed catch continued to be low relative to peak rates observed from 2014 through 2016 (Figure 49). Bull Trout caught varied from 238 to 745 mm.

DISCUSSION

Lake Trout catch rate trend suggested our Upper Priest Lake management program aimed at controlling Lake Trout abundance to benefit native fish species was successful. Catch rates were generally believed to reflect stable relative abundance in the Lake Trout population. Although our total catch was greater than 2018 the general trend in daily catch rate from 2010 through 2019, suggested abundance in Upper Priest Lake followed a similar pattern.

Mesh-specific catch rates generally suggested relative abundance of larger Lake Trout in Upper Priest Lake increased from 2018 (Camacho et al. 2021). Catch rates within large mesh sizes have been stable since 2015. However, we observed average catch rate in 89-, 102-, 114-, and 127-mm mesh sizes increase above rates previously observed. However, overlap of confidence intervals around those catch rate estimates limit interpretation suggesting significant increase in relative abundance occurred. A trend in size structure was not evident in prior annual removal efforts (Watkins et al. 2018, Ryan et al. 2018, Ryan et al. 2020_a, Ryan et al. 2020_b, Camacho et al. 2021). As such, no strong size class of fish was present or expected to grow into a vulnerable size range for large gill net mesh sizes. Immigration of Lake Trout from Priest Lake remains a possible source of Lake Trout for Upper Priest Lake. Movement of Lake Trout between Priest Lake and Upper Priest Lake is known to occur (Fredericks and Venard 2001) and has been assumed to be a factor influencing stability in Lake Trout abundance in Upper Priest Lake.

Bull Trout catch in our netting effort continued to be low. Bull Trout redd counts, the primary monitoring tool for Bull Trout, continued to suggest adult Bull Trout abundance in the system was stable to improving (Camacho et al. 2021). This inconsistency highlighted a need to cautiously interpret Bull Trout catch resulting from this survey. Inherently, concerted effort to avoid by-catch of Bull Trout limits the utility of this metric for evaluating trends in abundance.

Irrespective of annual variation in observed Bull Trout catch rates, Lake Trout presence in Upper Priest Lake is the primary concern relative to the conservation of native species. Currently, our data suggest the Lake Trout population in Upper Priest Lake remains low and the threat they pose to native species is being minimized. As such, we recommend continuation of Lake Trout removal efforts in Upper Priest Lake as a tool for conserving native fishes.

MANAGEMENT RECOMMENDATIONS

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

Table 23. Gill net effort and Lake Trout (LKT) catch by gill net mesh size in Upper Priest Lake, Idaho in 2019. Total length ranges of Lake Trout caught were reported by associated gill net mesh sizes.

Mesh (mm)	Effort (ft.)	% of Total Effort	LKT Caught	LKT/Box	Min TL	Max TL
45	43,200	20%	878	18.3	200	849
51	43,200	20%	521	10.9	207	814
64	43,200	20%	570	11.9	191	778
76	14,400	7%	71	4.4	186	710
89	14,400	7%	136	8.5	409	796
102	28,800	13%	247	7.7	131	814
114	14,400	7%	106	6.6	491	885
127	14,400	7%	92	5.8	216	881

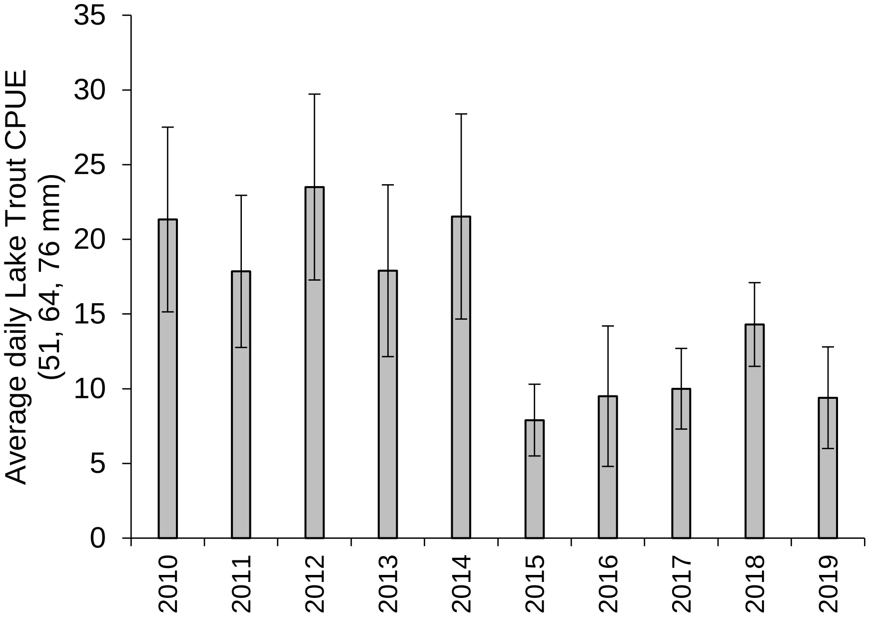

Figure 48. Average daily Lake Trout catch rates (± 80% CI) by year from combined standard gill net mesh sizes (51, 64 , and 76 mm) fished in Upper Priest Lake, Idaho between 2010 and 2019.

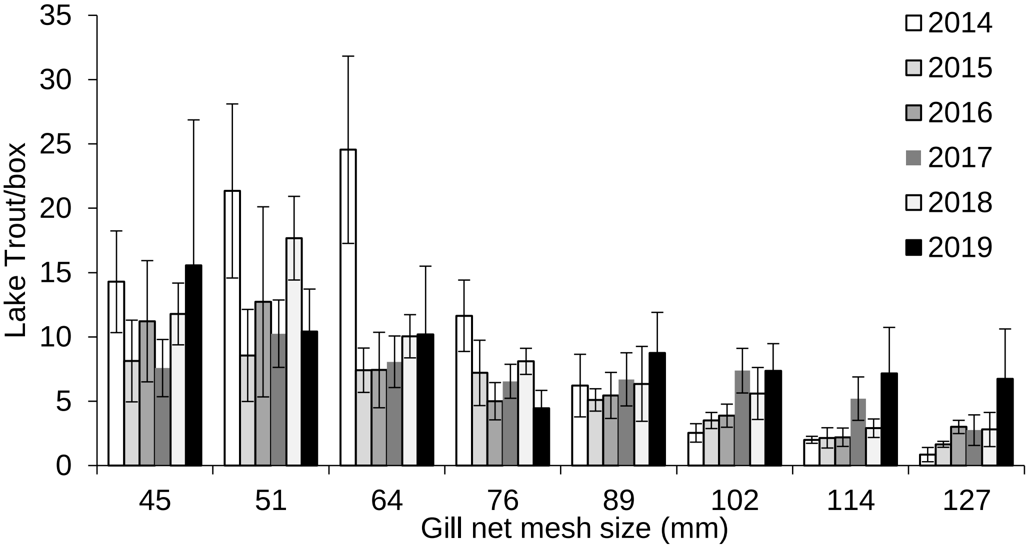

Figure 49. Average daily Lake Trout catch rate (Lake Trout/box (± 80% CI) by mesh size from all standardized gill nets fished in Upper Priest Lake, Idaho from 2014 to 2019.

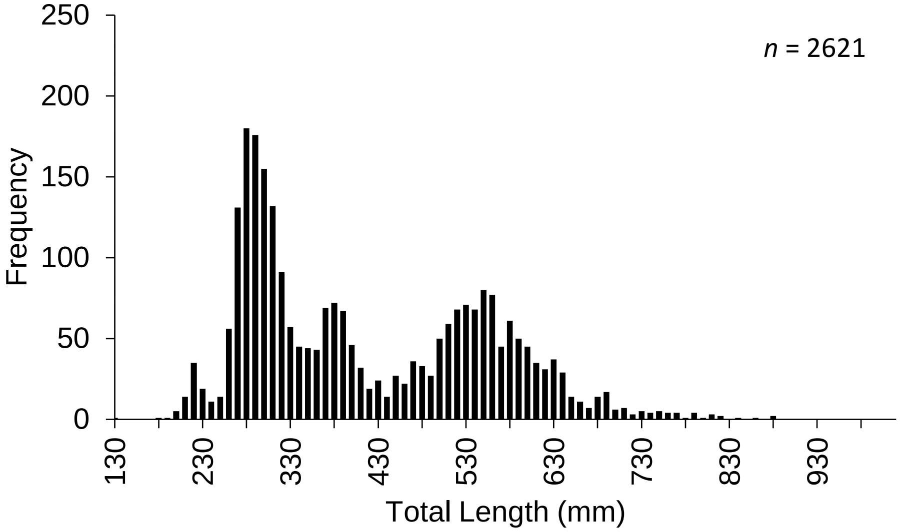

Figure 50. Size structure of Lake Trout sampled in Upper Priest Lake, Idaho in 2019.

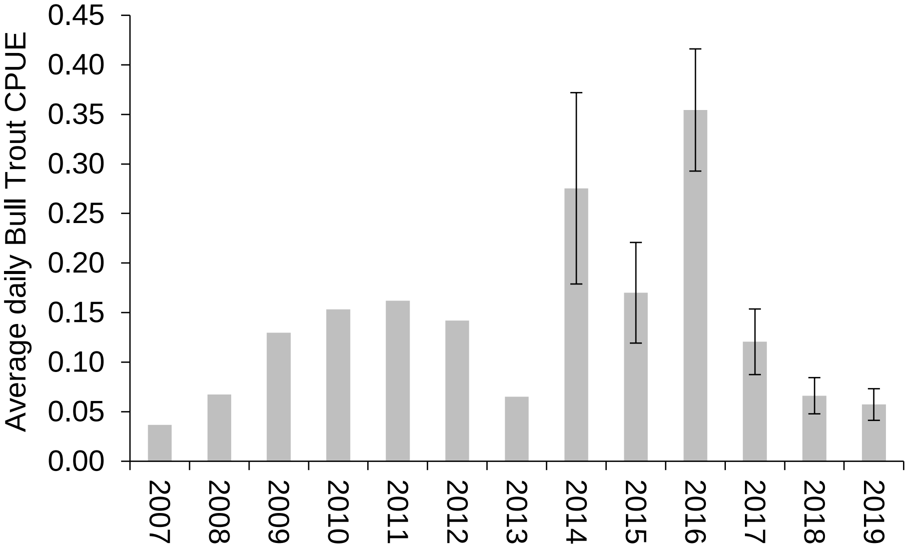

Figure 51. Average daily Bull Trout catch rate (Bull Trout/box ± 80% CI) from all mesh sizes fished in Upper Priest Lake, Idaho from 2007 to 2019. Confidence intervals were only estimated for years in which gill nets mesh and effort were standardized.

BONNER LAKE BURBOT STOCKING EVALUATION

ABSTRACT

The Kootenai Tribe of Idaho and Idaho Department of Fish and Game developed a Burbot *Lota lota* hatchery supplementation program to increase their abundance in the Kootenai River system and restore angling opportunity. Excess hatchery Burbot were available from 2013 through 2019 and were stocked in Bonner Lake. In 2021, we sampled Burbot in Bonner Lake to assess the effectiveness of the supplementation effort. We caught 3.5 (± 1.3; 80% C.I.) Burbot per net night in trammel nets. Burbot collected in our survey were assigned by parental based tagging to the 2015 year class. Our observations suggest Burbot post-stocking survival was poor for most cohorts. We recommend discontinuation of Burbot stocking in Bonner Lake. If stocking continues, we recommend not promoting Bonner Lake as a Burbot fishery in order to manage angler expectations.

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INTRODUCTION

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

Bonner Lake is located in Boundary County, Idaho, 14 km east of Bonners Ferry, Idaho. The 9.7 ha lake has a mean depth of 6.7 m and a maximum depth of 18 m. Bonner Lake is managed as a mixed species fishery. Rainbow Trout *Oncorhynchus mykiss* and Kokanee *Oncorhynchus nerka* are stocked annually in the lake. A compliment of warmwater fish species are also present and include Largemouth Bass *Micropterus salmoides*, Yellow Perch *Perca flavescens*, and Pumpkinseed *Lepomis gibbosus*. Excess Burbot production from the KTOI hatchery program was available from 2013 to 2019. In an effort to utilize excess production and provide additional angling opportunity, Burbot were stocked in Bonner Lake. Bonner Lake was selected as a stocking location primarily because of its location within the Kootenai drainage and potential to provide adequate over summer habitat (i.e., ~18 m max depth).

In 2021, we sampled Burbot in Bonner Lake to assess the effectiveness of the supplementation effort. We previously documented poor performance of hatchery Burbot in Bonner Lake (Camacho et al. 2021), but had subsequently received angler reports suggesting angler success had improved. We sampled Bonner Lake to evaluate angler reports and identify if Burbot stocked in Bonner Lake survived and grew to adequate size to provide angling opportunity.

METHODS

We sampled Burbot in Bonner Lake following ice-off on April 17 and April 18, 2019. Trammel nets were used in targeted collections. Sinking trammel nets were configured with two outer panels of 25.4 cm multifilament mesh and a single 2.5 cm inner multifilament mesh panel. Trammel nets were 48.8 m long and 1.8 m high. Nets were set perpendicular to shore at six randomly assigned locations (Table 24). We measured relative abundance of Burbot in Bonner Lake as catch per net night (CPUE).

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

Prior stocking events varied by time, age, and size at release (Table 25). Stocking success was evaluated by comparing the relative return of release groups. Parental based tagging (PBT) or passive integrated transponder (PIT) tags assigned individual fish to brood year. The PBT evaluations were completed by removing a fin clip from each Burbot collected. Fin clips were stored on Whatman paper prior to analysis. Analysis was completed by the IDFG Fish Genetics Laboratory. Half-duplex PIT tags were inserted in the abdominal cavity of some (2013 and 2014) cohorts prior to stocking by KTOI hatchery staff. All Burbot collected were scanned with a PIT tag reader upon collection. Detected PIT tags were referenced to a tagging database to assign individuals to brood year and stocking cohort.

RESULTS

We caught three Burbot among all nets (CPUE = 0.5 ± 0.3; 80% CI). Total lengths of Burbot caught were 240, 315, and 340 mm. All three fish caught in our survey were assigned by PBT to the 2015-year class. Relative abundance of the 2015-year class declined from 2017 to 2020 (Figure 50). Growth, described as mean length-at-age, was slow. Mean length increased approximately 100 mm since 2017 (Figure 50).

DISCUSSION

Our survey suggests few hatchery-origin Burbot survived from stocking cohorts released in Bonner Lake since 2013. Annual surveys from 2017 through 2019 demonstrated a rapid decline in abundance of the single cohort (2015) that exhibited significant survival after stocking (Ryan et al. 2020_a, Camacho et al. 2021).

A detailed growth analysis was not conducted for the 2015 cohort because three groups of Burbot from that cohort were stocked in Bonner Lake. Stocking groups included two release years and two release seasons. Juvenile Burbot in the 2015 year class were not segregated by parent at the hatchery prior to release, prohibiting the identification of individuals within the year class to release group. Although a growth analysis was not possible, growth rate of this cohort generally appeared to be slow.

Collectively, performance of hatchery Burbot in Bonner Lake appears to be poor and suggests stocking does not provide a viable Burbot fishery in Bonner Lake. We recommend discontinuation of Burbot stocking in Bonner Lake. However, Bonner Lake is currently the only available location where surplus hatchery production may be released. As such, there may be a need to stock Burbot in Bonner Lake despite their poor performance. We do not anticipate stocking to cause any problems for the overall fishery in the lake, but it may result in anglers targeting Burbot and having unsatisfying experiences. If Burbot stocking continues, we recommend not promoting Bonner Lake as a Burbot fishery to manage angler expectations.

MANAGEMENT RECOMMENDATIONS

1. Discontinue requests for hatchery Burbot in Bonner Lake.
2. Do not promote Bonner Lake as a Burbot fishery to manage angler expectations.

Table 24. Bonner Lake Burbot sampling locations from April 2019.

Water	Site	Date	Latitude	Longitude	Method
Bonner Lake	1	4/17/2019	48.726539	-116.111674	25.4mm Trammel Net
Bonner Lake	2	4/17/2019	48.726367	-116.109524	25.4mm Trammel Net
Bonner Lake	3	4/17/2019	48.725782	-116.108099	25.4mm Trammel Net
Bonner Lake	4	4/17/2019	48.725128	-116.106674	25.4mm Trammel Net
Bonner Lake	5	4/17/2019	48.723682	-116.106700	25.4mm Trammel Net
Bonner Lake	6	4/17/2019	48.723716	-116.104964	25.4mm Trammel Net

Table 25. Bonner Lake Burbot stocking history.

Year Class	Stocking Year	Release Date	Total Released	Batch TL (mm)	PIT Tagged
2013	2014	10/30/2014	18	224	18
2014	2014	10/30/2014	82	110	82
2015	2015	10/16/2015	276	90	0
2015	2016	9/8/2016	430	265	0
2015	2016	5/12/2016	1452	210	0
2016	2016	10/11/2016	1882	80	0
2017	2017	10/11/2017	1400	96	0
2015	2017	10/11/2017	200	386	0
2018	2019	1/29/2019	4000	150	0
2019	2019	11/6/2019	2000	---	0

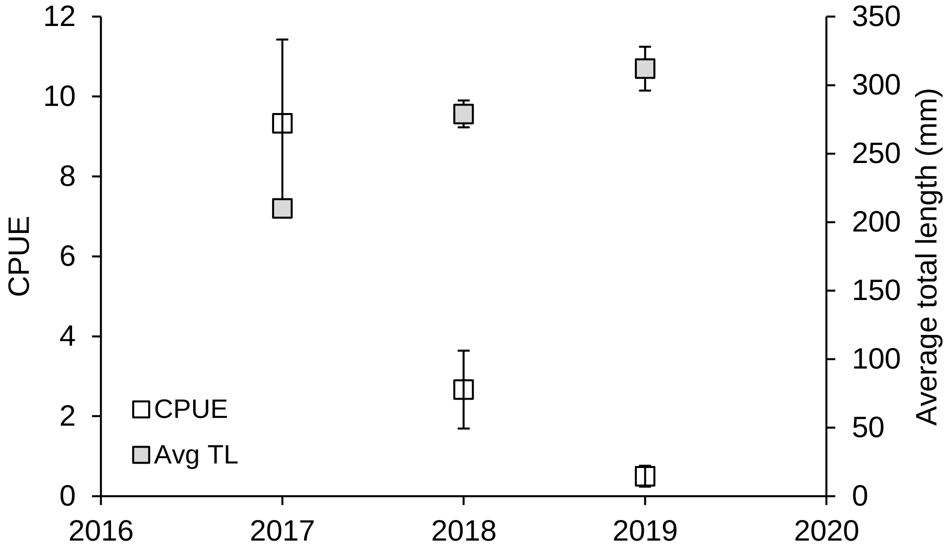

Figure 52. Burbot CPUE and average total length (TL) from spring sampling efforts in 2017, 2018, and 2019 on Bonner Lake, Idaho. Catch in all years was represented primarily by the 2015 cohort.

ROSE LAKE NORTHERN PIKE POPULATION EVALUATION

ABSTRACT

Northern Pike were sampled in Rose Lake during 2019 to complement previous surveys in the Panhandle Region. These surveys establish a baseline of information on population structure and dynamics that will be used to evaluate Northern Pike management effectiveness. Relative abundance (0.5 fish/net h) was moderate and similar to rates observed in the Chain Lakes and Lake Coeur d'Alene. Mean total length was 572 mm and varied from 332-859 mm. Northern Pike growth in Rose Lake was slow and similar to nearby Chain Lakes populations. Total annual mortality was 22%, which was the lowest among the Chain Lakes populations. Fishing was not an important mortality component, as annual angler exploitation was only 7%. Northern Pike do not appear to be having unacceptable impacts to the Rose Lake fishery, suggesting that management changes are not currently necessary.

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INTRODUCTION

Northern Pike *Esox lucius* were illegally introduced into the Chain Lakes along the Lower Coeur d'Alene River sometime during the early 1970s (Rich 1992). It is thought that Northern Pike were initially stocked in Cave Lake (Rich 1992) and subsequently expanded into the other nearby lateral lakes and downstream into Lake Coeur d'Alene. Northern Pike are now found throughout the Lake Coeur d'Alene system downstream of Cataldo in the Coeur d'Alene River drainage and downstream of Calder (including the lower St. Maries River) in the St. Joe River drainage. Northern Pike have been illegally transferred to other lowland lakes in the Panhandle Region where they are now established. Currently, the known distribution of Northern Pike in Idaho is relegated to Idaho's five northern counties. It is widely recognized that Northern Pike have strong potential to alter fish communities and negatively influence populations of native and nonnative sport fishes. However, Northern Pike also support popular fisheries in the Panhandle Region.

Northern Pike are formally recognized as a game fish by the State of Idaho and management policy focuses on preventing populations from reaching high density and limiting their distribution to its current extent. State management policy seeks to achieve this objective by using unlimited harvest regulations, promoting angler harvest, only allowing harvest-oriented tournaments, and not intentionally introducing Northern Pike to new waters. The overarching intent of current policy is to minimize negative impacts of Northern Pike on existing fisheries, while simultaneously providing angling opportunity for this popular sport fish.

It is hypothesized that Northern Pike populations in northern Idaho are controlled by a combination of angler harvest and environmental conditions. Angler exploitation rates are commonly high enough that they appear to be helping maintain low-density Northern Pike populations and reduce negative interactions with existing fish communities. Previous estimates of angler exploitation have typically been 30-40% and relative fish densities have generally been low (Rich 1992; Walrath 2013). However, contemporary estimates of angler exploitation and descriptions of population characteristics are lacking for some waters.

In 2019, we sampled the Northern Pike population in Rose Lake to complement studies conducted in Killarney Lake during 2014 (Watkins et al. 2018) and seven of the Chain Lakes during 2016–2018 (Camacho et al. 2021). Collectively, we sought to describe the structure and dynamics of Northern Pike populations in the Coeur d'Alene River drainage and evaluate how anglers interact with these fisheries.

OBJECTIVES

1. Describe Northern Pike population dynamics (i.e., growth, mortality) and structure (i.e., size distribution) in Rose Lake.

2. Estimate angler exploitation and use of Northern Pike in Rose Lake.

STUDY AREA

Rose Lake is located in Kootenai County approximately 10 km west of Cataldo. The lake has a surface area of 149 ha and elevation of 653 m. Rose Lake lies along the lower Coeur d'Alene River, but is not considered one of the "Chain Lakes" due to lack of connectivity with the river in all but high flood conditions. The lake is an important regional resource given its good angler access and close proximity to the city of Coeur d’Alene. It supports a warmwater fishery and has been stocked annually with Channel Catfish since 1999. Long-term fish monitoring has been infrequent; however, a standard lowland lake survey was completed in 2017 (Ryan et al. 2020_a).

METHODS

Sampling was conducted on April 09-10, 2019 to coincide with a period of assumed higher Northern Pike activity associated with spawning. A simple random sampling design was used to allocate effort to various 400 m long shoreline units in each lake. Sinking experimental gill nets (45 × 1.8 m; 5 panels with 50-, 64-, 76-, 88-, and 100-mm stretch-measure mesh) were used to capture fish. A single gill net was deployed perpendicular to the shoreline in each unit and fished for approximately 1–3 hours (mean = 2.2 h) to minimize capture mortality of Northern Pike.

Catch-per-unit-effort (CPUE) was summarized as the number of fish sampled per net/h and averaged among all deployments. Total length (TL; mm) was measured from all fishes and used to inform our understanding of Northern Pike population size structure. Two to three leading fin rays were removed from the pelvic fin of each fish for age estimation. Fin rays were allowed to air dry and subsequently mounted in epoxy using 2 mL microcentrifuge tubes following Koch and Quist (2007). Cross sections (0.9 mm thick) were cut near the base of each dorsal spine just distal to the articulating process using an Isomet low-speed saw (Buehler Inc., Lake Bluff, Illinois, USA). Resulting pelvic spine cross-sections were viewed using a dissecting microscope with transmitted light and an image analysis system (Image ProPlus; Media Cybernetics, Silver Springs, Maryland, USA). Annuli were enumerated on all structures by a single reader. Knowledge of biological information for each fish was unknown during the age estimation process to avoid bias.

Age structure of Northern Pike was summarized for each population. Total annual mortality (*A*) was estimated using a weighted catch curve (Miranda and Bettoli 2007). Northern Pike were typically fully-recruited to the sampling gear at age-2, so *A* was only estimated for fish older than 2 years of age. Mean length-at-age information was summarized and a von Bertalanffy growth function (von Bertalanffy 1938) was fitted to those data to assess patterns in growth.

Angler exploitation of Northern Pike was evaluated using tag return information. Fish were fitted with an orange, non-reward FD-94 T-bar anchor tag (76 mm; Floy Tag Inc., Seattle Washington, USA) after processing for biological information and then released. Tags were uniquely numbered and inserted near the posterior end of the dorsal fin of each Fish. 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,

$$\mu' = \mu / [\lambda\ (1–\mathrm{Tag}_l)(1–\mathrm{Tag}_m)]$$

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%). Annual angler exploitation rates were estimated for each lake following one year at-large.

RESULTS

A total of 29 Northern Pike were caught and tagged in 23 net sets. Relative abundance of Northern Pike in Rose Lake was 0.5 (±0.2 SE) fish/net h. The fish community was generally composed of a warmwater assemblage consisting of Brown Bullhead, Black Crappie, Bluegill, Channel Catfish, Largemouth Bass, Northern Pike, Tench, and Yellow Perch. Mean total length of Northern Pike was 572 mm (range = 332-859 mm, ±1SE= 29 mm; Figure 1). Ages estimates varied from 2 to 7 years, but old (i.e., age-5+) individuals were poorly represented. The von Bertalanffy growth equation for length was $L_{\text{age}} = 661(1 - e^{(-0.651(\text{age} - 0.111))})$. Total annual mortality was 22% and was not closely associated with estimates of harvest. Anglers only reported catching one fish, which was harvested, representing 3% of the tagged fish. Adjusted angler exploitation was estimated at 7%.

DISCUSSION

Northern Pike management has become an increasingly important focus for fishery professionals in the Pacific Northwest because of the threat the species can pose to existing fish communities. Fish and wildlife management agencies deal with a host of issues relative to nonnative piscivores, such as Northern Pike, but it is widely understood that the magnitude and importance of those issues are fishery- and system-specific. For example, in Lake Coeur d'Alene, Northern Pike occur at low density due in part to the patchiness of suitable habitat and fairly high rate of angler harvest. Our results differed substantially and were more similar to results from the neighboring Chain Lakes (Camacho et al. 2021) where estimated rates of exploitation and relative abundances were lower than expected for water bodies with abundant suitable habitat.

In general, the Northern Pike population in Rose Lake was characterized by slow growth, poor size structure, low longevity, and high mortality. Mean length and the theoretical maximum length estimate from the von Bertalanffy growth model in Rose Lake was lowest among the waterbodies in northern Idaho (Camacho et al. 2021). Size structure of Northern Pike in Rose Lake followed general expectations characterized by few preferred length and larger individuals, similar to the Chain Lakes (Camacho et al. 2021). Rich (1992) and Walrath (2013) reported good size structure of Lake Coeur d'Alene subpopulations and routinely sampled fish exceeding 1,000 mm TL. We did not sample any fish over 860 mm TL and estimated mean and maximum TL was well below that reported by Walrath (2013). Of course, length structure is often associated with fish age, and most fish in Rose Lake were ≤ 4 years old with only a few older individuals.

Although Rose Lake provides suitable Northern Pike habitat, relative abundance was similar to what has been documented in bays throughout Lake Coeur d'Alene (Rich 1992; Walrath 2013) and the Chain Lakes (Camacho et al. 2021). Walrath (2013) commented that high abundance Northern Pike populations are generally characterized by catch rates of 1.0 fish/net h and greater across the species' distribution, and Paukert and Willis (2003) provided a similar suggestion based on information from Nebraska pothole lakes populations. In comparison, Northern Pike in Rose Lake are at moderate abundance.

Results suggest Rose Lake supports a moderate density of slow growing Northern Pike, which isn't entirely consistent with management objectives (low density, fast growth; IDFG 2019). However, Northern Pike do not appear to be having any unacceptable impacts on the mixed species fishery, which is a management objective (IDFG 2019). Catch rates of panfish in Rose Lake a 2016 survey, such as Bluegill, Perch, and Black Crappie were generally similar or higher than other panhandle region lowland lakes without an *Esox spp.* present in the fish community

(Ryan et al. 2020$_b$). Forage abundance and low angler exploitation do not appear to be influencing Northern Pike abundance, size and age structure. Interactions with other predators such as stocked Channel Catfish, also do not appear to be influencing Northern Pike abundance, size and age structure in Rose Lake indicated by similar estimates being observed in the neighboring lateral lakes without Channel Catfish (Camacho et al. 2021). Other factors, such as habitat or availability of thermal refugia from warm summer temperatures may be contributing factors. The lateral chain lakes, which includes Rose Lake, are shallow waterbodies and may be experiencing impacts from warmer summer temperatures observed in Fernan, Hauser, and other lowland lakes in the Panhandle region. Periodic monitoring will be important to understand if and how Northern Pike populations change and assess potential impacts on fish communities.

MANAGEMENT RECOMMENDATIONS

1. Maintain existing regulations for Northern Pike in Rose Lake.
2. Periodically monitor the Northern Pike population and the broader fish community to assess changes and potential interspecific interactions.

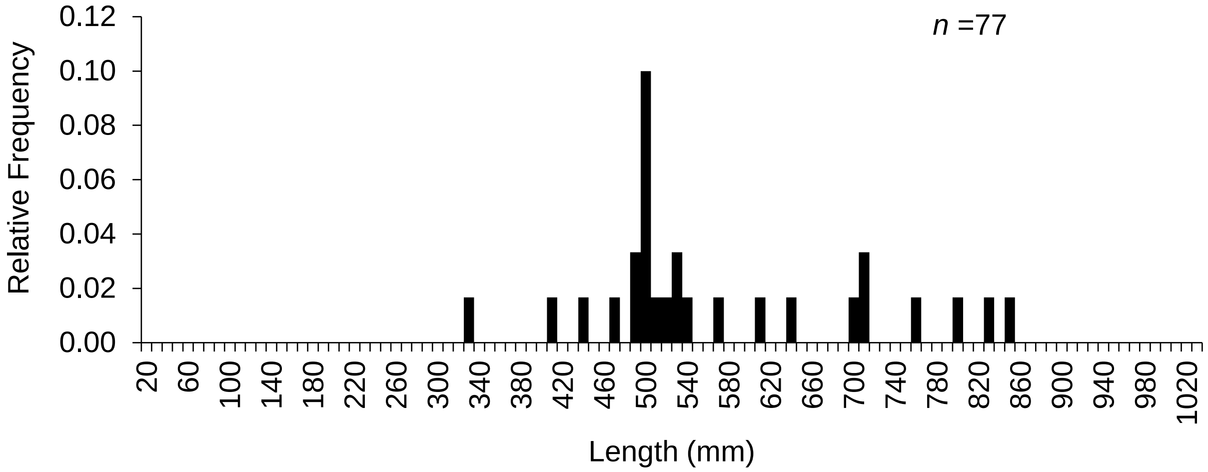

Figure 53. Length-frequency distribution for Northern Pike sampled from Rose Lake in April 2019.

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