2015 Lake Pend Oreille Nearshore Spring Index Netting Survey

Dissolved Gas Supersaturation Control, Mitigation, and Monitoring: TDG Alternative Mitigation and Monitoring Program

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February 2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Population monitoring has routinely occurred for kokanee *Oncorhynchus nerka*, Rainbow Trout *O. mykiss*, and Bull Trout *Salvelinus confluentus* in Lake Pend Oreille (LPO). In contrast, adfluvial Westslope Cutthroat Trout (WCT) *O. clarkii lewisi* have not been monitored in the lake. Previously, WCT monitoring has been limited to LPO tributaries that are sampled on a 5-year rotational basis. Monitoring WCT within the lake has not occurred, largely because of the challenges associated with sampling such a large lake using traditional abundance estimation techniques. We established an index gillnetting survey protocol that could be implemented relatively quickly and inexpensively. Although this approach did not allow abundance to be estimated, it provided age and size structure data for WCT and relative abundance for several nearshore species. Additionally, repeating the survey systematically in future years will allow WCT population trends to be monitored. The LPO Nearshore Spring Index Netting Survey was implemented June 8-11, 2015. Three boats were used to set 20 standardized floating gill nets nightly for three nights (60 net-nights) around the shoreline of LPO. A total of 2,301 individual fish were caught as part of our survey, the majority of which were Northern Pikeminnow *Ptychocheilus oregonensis* (n = 1,364), Peamouth Chub *Mylocheilus caurinus* (n = 484), Smallmouth Bass *Micropterus dolomieu* (n = 220) and WCT (n =108). The majority of WCT were caught mid-lake along both the eastern and western shores. Of the commonly caught species, catch rates ranged from 22.7 fish/net-night for Northern Pikeminnow to 1.8 fish/net-night for WCT. Estimated ages of WCT varied from 2 to 10 years, with the majority of fish being ages 3- 8, and lengths ranged from 163 to 454 mm TL. Annual mortality (A) of WCT was estimated at 40%. We recommend periodic replication of this survey protocol to provide standardized monitoring data for WCT in LPO.

INTRODUCTION

Lake Pend Oreille (LPO) is Idaho's largest (36,000 surface ha) and deepest (360 m) natural lake. The native salmonid species assemblage consists of Bull Trout *Salvelinus confluentus,* Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, Mountain Whitefish *Prosopium williamsoni*, and Pygmy Whitefish *P. coulteri.* LPO also supports numerous non-native species, including Rainbow Trout *O. mykiss*, Lake Trout *S. namaycush*, kokanee *O. nerka,* Smallmouth Bass *Micropterus dolomieu*, Largemouth Bass *M. salmoides*, Yellow Perch *Perca flavescens*, Black Crappie *Pomoxis nigromaculatus*, Lake Whitefish *P. clupeiformis*, Walleye *Sander vitreus*, Bluegill *Lepomis macrochirus*, and Pumpkinseed *L. gibbosus*.

The LPO recreational fishery has been dominated by kokanee and Rainbow Trout for most of the past 75 years. Additionally, Westslope Cutthroat Trout (WCT) and Bull Trout have been a relatively stable component of the fishery since at least the 1950s (Ellis and Bowler 1981, Bowles et al. 1986, Paragamian and Ellis 1994, Fredericks et al. 2003, Ryan and Jakubowski 2009, Bouwens and Jakubowski 2016a). Intensive monitoring has been conducted for kokanee, Rainbow Trout, and Bull Trout populations in LPO (see Wahl et al. 2015). In contrast, adfluvial WCT monitoring within the lake is primarily limited to information from creel surveys. Contemporary (e.g., 2000-2014) WCT angler catches of roughly one to two thousand fish annually were lower than the estimated five to eight thousand fish caught annually in the early 1950s (Bouwens and Jakubowski 2016a). A notable decline in angler catch occurred about 10 years after the completion of Cabinet Gorge Dam on the Clark Fork River in 1952, which blocked upstream migration for adfluvial WCT in LPO. This reduction in habitat availability is thought to have led to lower adfluvial WCT abundance. However, reduced catches may not be directly proportional to abundance, instead being influenced by varying levels of fishing effort. Regardless, available creel data and anecdotal catch reports together suggest that population abundance of WCT in LPO is lower than it was historically.

The WCT in LPO exhibit an adfluvial life history and are not known to spawn in lacustrine environments. These fish are hatched and rear in tributary streams for one to several years before migrating to the lake to mature and then return to tributaries to spawn. The majority of the LPO tributaries that support WCT are monitored on a 5-year rotational basis to assess trends in salmonid abundance, species composition and size structure. The WCT populations in most tributaries are generally considered abundant and stable (Bouwens and Jakubowski 2016b, Bouwens and Jakubowski 2015, Ryan et al. 2014). At least some of these tributary streams likely support a mixture of stream resident and adfluvial WCT, as evidenced by strong WCT populations above migration barriers that preclude access from the lake (e.g., Bouwens and Jakubowski 2016b). Therefore, stream monitoring alone is inadequate for monitoring adfluvial WCT population trends in LPO.

Traditional techniques to estimate population size, such as mark-recapture, have been difficult to implement for WCT in LPO given the large size of the lake. Standardized surveys using randomized sampling with sinking gillnets were successfully implemented in LPO during 2011 and 2014 to monitor a relatively low density Walleye population

(Ryan and Fredericks 2012, Watkins et al. *in prep*). This technique was modified using floating gill nets to monitor WCT on Priest Lake with similar success in 2014 (Watkins et al. *in prep).* These types of index netting surveys do not allow for abundance estimation; however, they can be implemented relatively quickly and inexpensively, fish age and size structure can be evaluated, and systematically repeating these surveys over time allows population trends to be monitored. Thus, we chose to use index gillnetting as a technique to begin a monitoring program for WCT (and other nearshore species) in LPO. Our objectives were to 1) develop a standardized survey protocol for WCT that can be periodically repeated, and 2) implement the survey to collect baseline data that can be used to monitor population trends in the future.

METHODS

The LPO Nearshore Spring Index Netting Survey was implemented from June 8-11, 2015. Sampling was timed to occur after the majority of mature WCT had presumably returned to LPO from spawning tributaries and while water temperatures were suitable for WCT to occupy shallow, nearshore habitats. Three boats were used to set 20 standardized, floating, monofilament gill nets nightly for three nights (60 net-nights) around the shoreline of LPO. Nets were 45 m in length and 1.8 m deep. Each net consisted of 6 panels, each 7.6 m in length and designed from smallest mesh to largest mesh (1.9, 2.5, 3.2, 3.8, 5.1, and 6.4 cm bar-measure) size. The monofilament twine diameter for the three smallest mesh sizes was 0.28 mm, 0.33 mm for the 5.1 cm mesh, and 0.40 mm for the 6.4 cm mesh.

Sampling locations were determined using a *1-in-k* systematic sampling design (Scheaffer et al. 1990), with one net set about every two linear miles of shoreline (Figure 1). The beginning point was randomly selected. Nets were not set near stream outlets, including the Clark Fork River, to prevent net-fouling from moving water and debris. The nets were set such that the inshore end of the net was set in approximately 2 m of water and perpendicular to the shoreline. The small mesh end was anchored inshore and the large mesh end was anchored offshore. Nets were set in the late-afternoon and retrieved mid-morning of the next day, and effort was standardized into net-nights because it was assumed the nets fished most efficiently during the darker hours.

All fish captured were identified to species and measured for total length (TL). Relative abundance was described as average catch-per-unit-effort (CPUE; catch/net-night). Eighty percent confidence intervals were calculated for mean CPUE estimates. A power analysis using IDFG standardized lowland lake protocols was performed using 2015 survey data to determine the sample size necessary in future surveys to detect changes in CPUE (IDFG 2012; Parkinson et al. 1988).

Otoliths were also taken from all WCT for age and growth analysis. Otoliths were prepared for age estimation by mounting in epoxy, cross–sectioning using an Isomet saw, mounting cross-sections to a slide with thermoplastic cement, sanding, and viewing under a compound microscope at 10x power. Each otolith was aged by two independent readers. In the cases where there was not agreement among the two readers, a third experienced reader was consulted. If consensus could not be reached among the three readers, that otolith was excluded from the study.

A von Bertalanffy growth model was fitted to the length-at-age data using the Fishery Analysis and Modeling Simulator (FAMS Version 1.64.4, Slipke and Maceina 2014). Mortality and survival were estimated using a weighted catch curve (Miranda and Bettoli 2007).

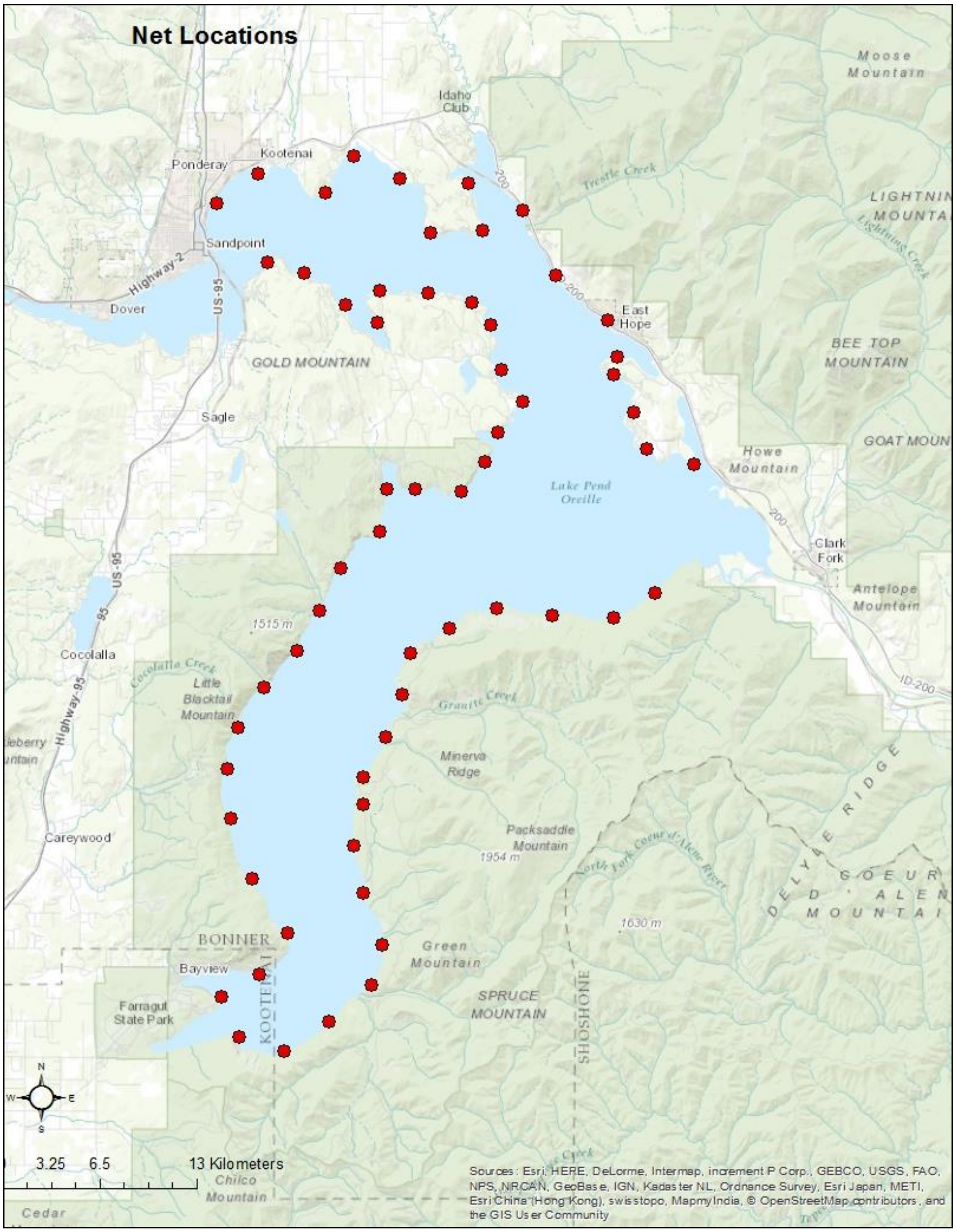

FIGURE 1. Locations sampled (n=60) during June 2015 in Lake Pend Oreille, Idaho.

RESULTS

A total of 2,301 individual fish were caught as part of our survey, the majority of which were Northern Pikeminnow *Ptychocheilus oregonensis*, Peamouth Chub *Mylocheilus caurinus*, Smallmouth Bass, and WCT. Fish species caught in low numbers included Largescale Sucker *Catostomus macrocheilus*, Rainbow Trout, Walleye, Brown Bullhead *Ameiurus nebulosus*, Yellow Perch, kokanee, Tench *Tinca tinca*, Black Crappie, Brown Trout *Salmo trutta,* Lake Whitefish, Brook Trout *S. fontinalis* x Bull Trout hybrids, and Pumpkinseed *L. gibbosus* (Table 1). Based on the power analysis, we estimated that future surveys would require 62 net-nights of sampling effort to detect a 50% change in WCT CPUE with 80% confidence.

TABLE 1. Total numbers of fish caught, catch-per-unit-effort (CPUE) and 80% confidence intervals (80% CI), and total length data for each species sampled during the Lake Pend Oreille Nearshore Index Netting Survey in June 2015.

	Total Catch			Total Length (mm)			
Species	Number	CPUE	80% CI	Min	Max	Average	80% CI
Northern Pikeminnow	1,364	22.7	2.9	161	620	337	3
Peamouth	484	8.1	1.5	165	371	279	3
Smallmouth Bass	220	3.7	0.9	105	411	196	5
Westslope Cutthroat	108	1.8	0.4	163	454	328	8
Largescale Sucker	36	0.6	0.2	230	521	412	14
Rainbow Trout	25	0.4	0.1	165	441	310	26
Walleye	15	0.3	0.1	350	664	433	31
Yellow Perch	14	0.2	0.2	169	282	237	13
Brown Bullhead	13	0.2	0.1	138	229	165	10
Kokanee	11	0.2	0.1	179	263	230	13
Tench	5	0.1	0.0	342	470	428	32
Black Crappie	2	<0.1	0.0	224	244	234	13
Brown Trout	1	<0.1	0.0	345	345		
Lake Whitefish	1	<0.1	0.0	354	354		
Brook x Bull hybrid	1	<0.1	0.0	400	400		
Pumpkinseed	1	<0.1	0.0	154	154		
Total	2,301	38.4	3.9	105	664	310	2

Of the most commonly caught species, Northern Pikeminnow and Peamouth Chub were the most well-distributed among sampling locations. Smallmouth Bass were captured at many sampling locations, but their catch rates were more variable. The majority of WCT were caught mid-lake off both the eastern and western shores, with few fish caught from the northern and southern ends of the lake (Figure 2).

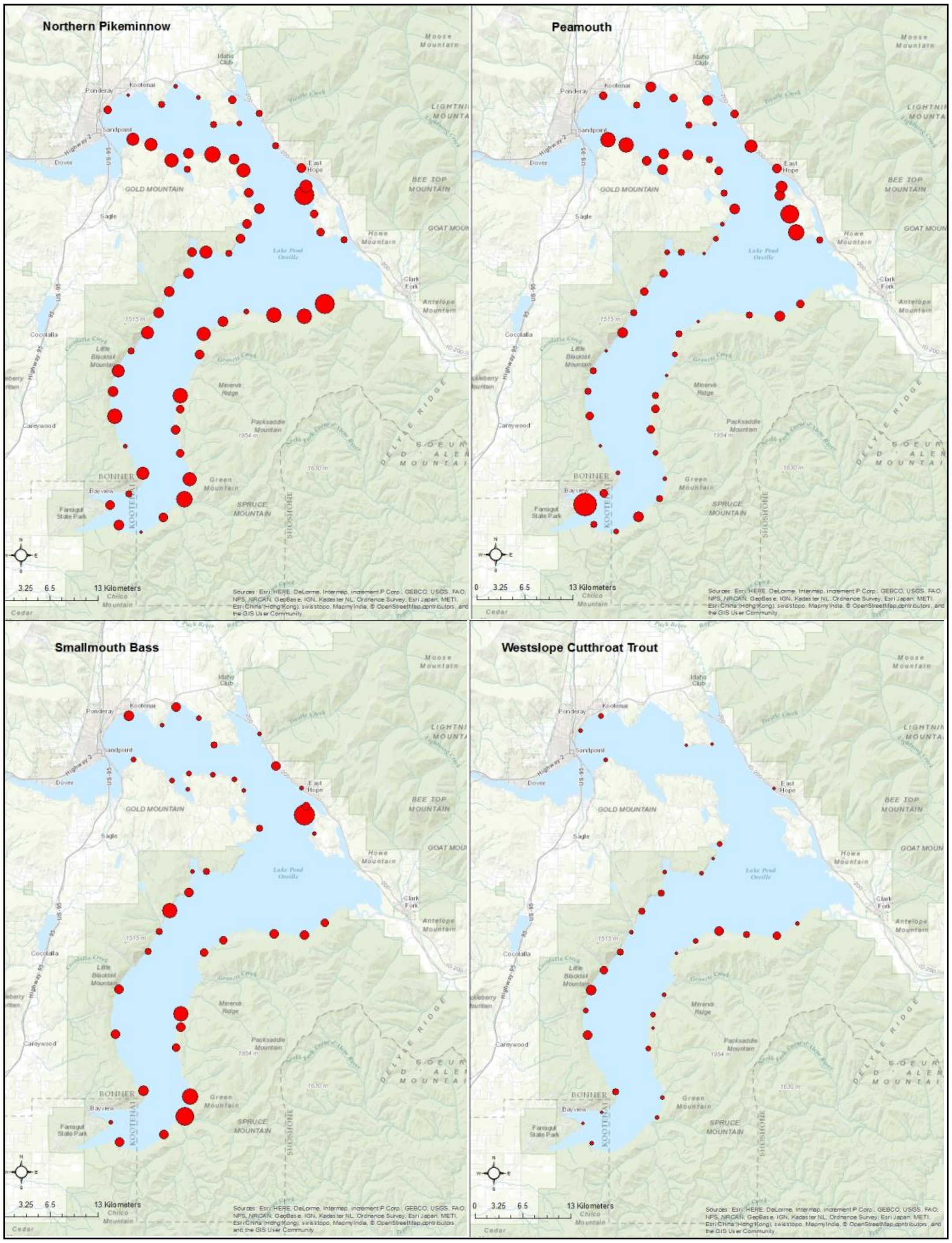

FIGURE 2. Catch rates at each sampling location for the four most commonly caught species during the Lake Pend Oreille Nearshore Index Netting Survey. Larger circles indicate higher catch rates.

Sampled fish varied from 105 mm TL (Smallmouth Bass) to 664 mm TL (Walleye; Table 1). Northern Pikeminnow varied from 161 to 620 mm TL (Figure 3), while Peamouth varied from 165 to 371mm TL (Figure 4). The majority of Smallmouth Bass were under 250 mm TL (Figure 5), while the majority of WCT exceeded 310 mm TL (Figure 6).

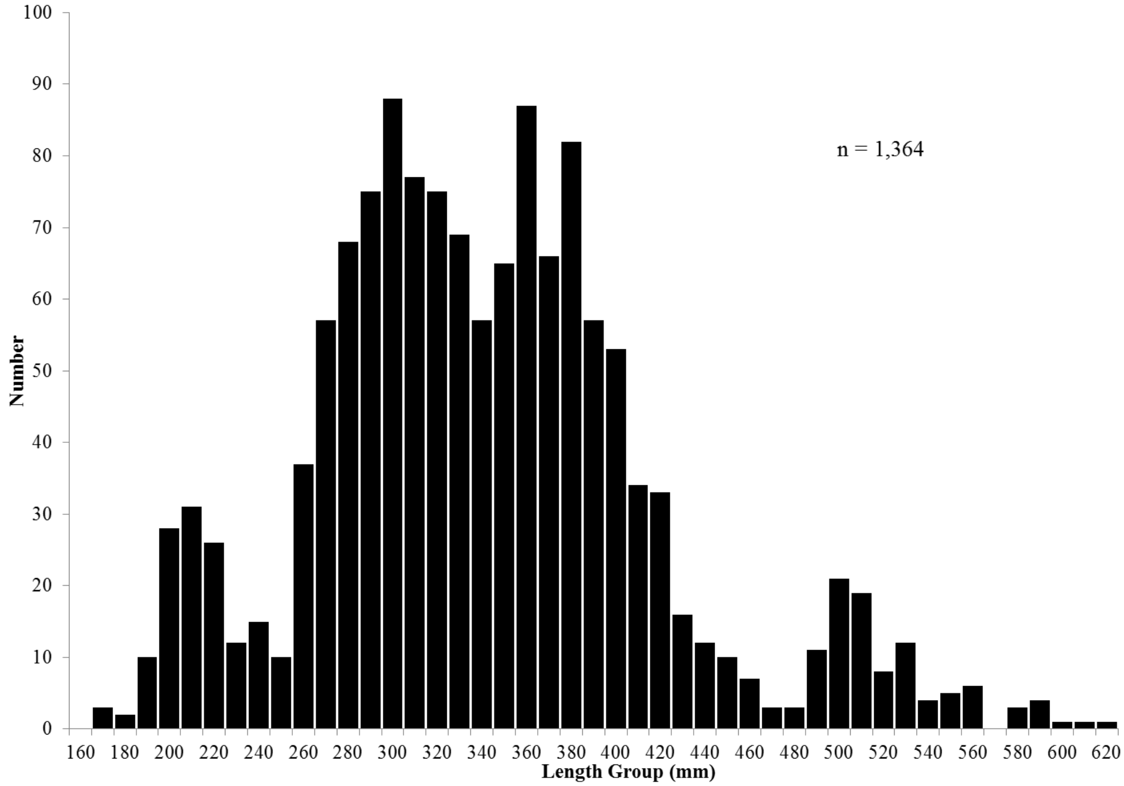

FIGURE 3. Length-frequency of Northern Pikeminnow sampled during the Lake Pend Oreille Nearshore Index Netting Survey.

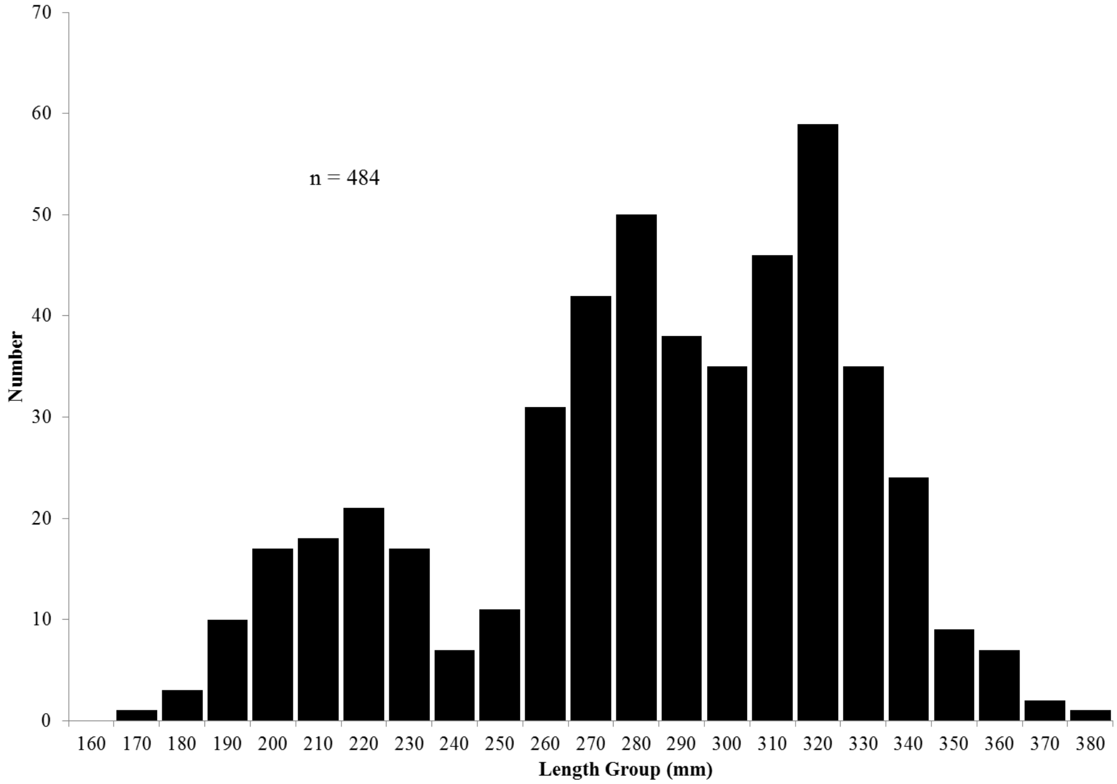

FIGURE 4. Length-frequency of Peamouth Chub sampled during the Lake Pend Oreille Nearshore Index Netting Survey.

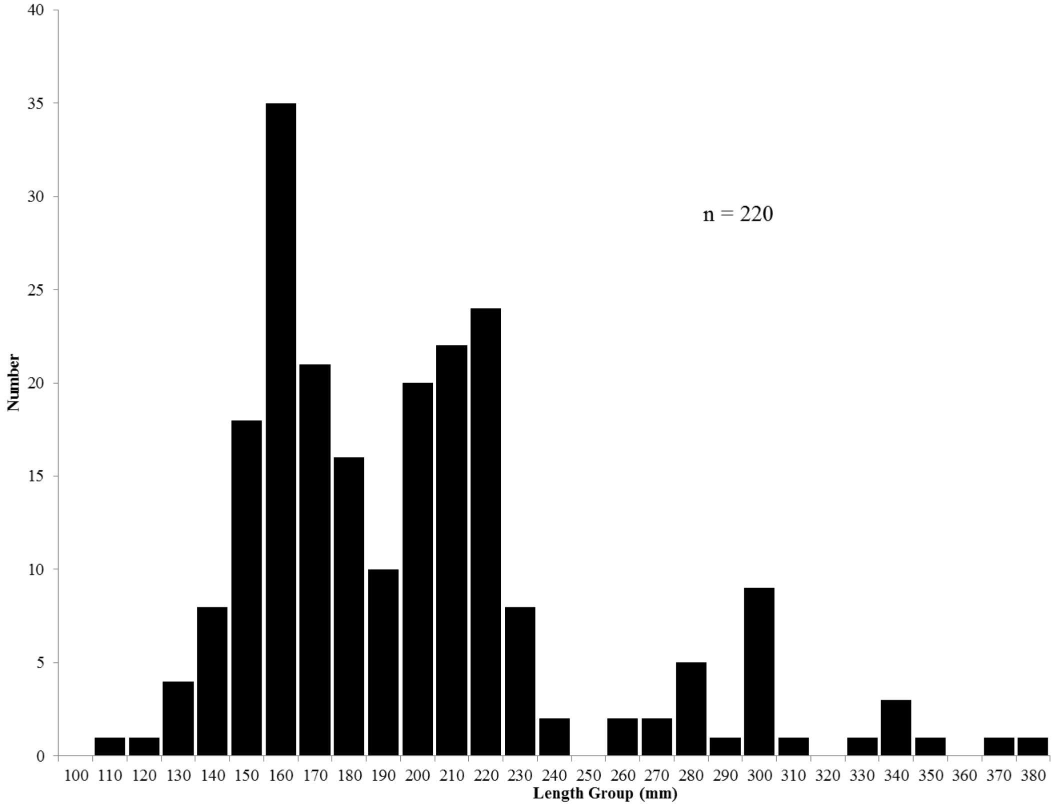

FIGURE 5. Length-frequency of Smallmouth Bass sampled during the Lake Pend Oreille Nearshore Index Netting Survey.

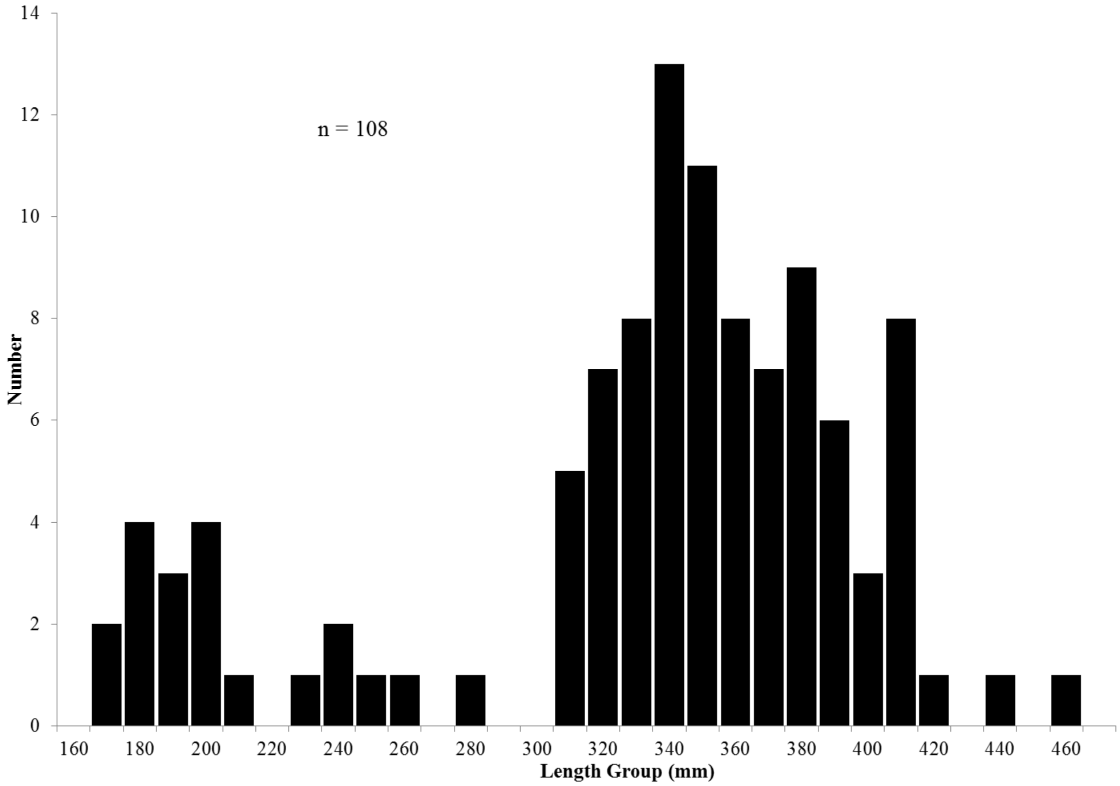

FIGURE 6. Length-frequency of Westslope Cutthroat Trout sampled during the Lake Pend Oreille Nearshore Index Netting Survey.

Estimated ages of WCT varied from 2 to 10 years, with the majority of fish being ages 3-8. Length-at-age of WCT was variable, especially for ages 3 and 4 (Table 2; Figure 7). Von Bertalanffy growth parameters are listed in Figure 7.

TABLE 2. Average total length (TL) and coefficient of variation (CV) by estimated age at capture for Westslope Cutthroat Trout sampled during the Lake Pend Oreille Nearshore Index Netting Survey.

Age	n	Average TL	CV of TL
2	3	172	0.03
3	11	236	0.24
4	30	333	0.13
5	21	350	0.10
6	3	372	0.07
7	7	398	0.10
8	3	379	0.04
9	0	-	-
10	1	405	-

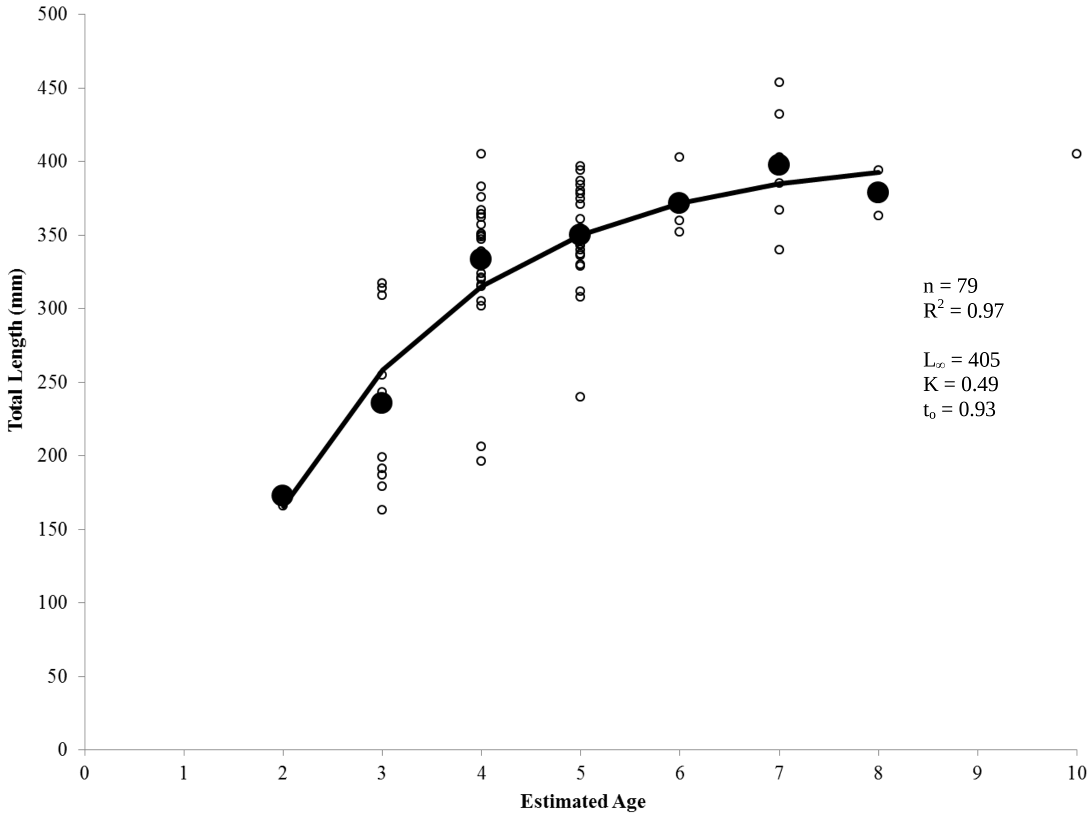

FIGURE 7. Estimated length-at-age (open circles), mean length at age (closed circles), and von Bertalanffy growth model parameters for Westslope Cutthroat Trout sampled during the Lake Pend Oreille Nearshore Index Netting Survey.

Only age-4 and older WCT appeared to be fully recruited to the sampling gear, so a weighted catch-curve regression was fitted to WCT ages 4-10 (Figure 8). The estimated total annual mortality rate (A) was 40.2% (95% CI = 20.17 - 55.23) and instantaneous mortality rate (Z) was 0.514 (95% CI = 0.225 - 0.804).

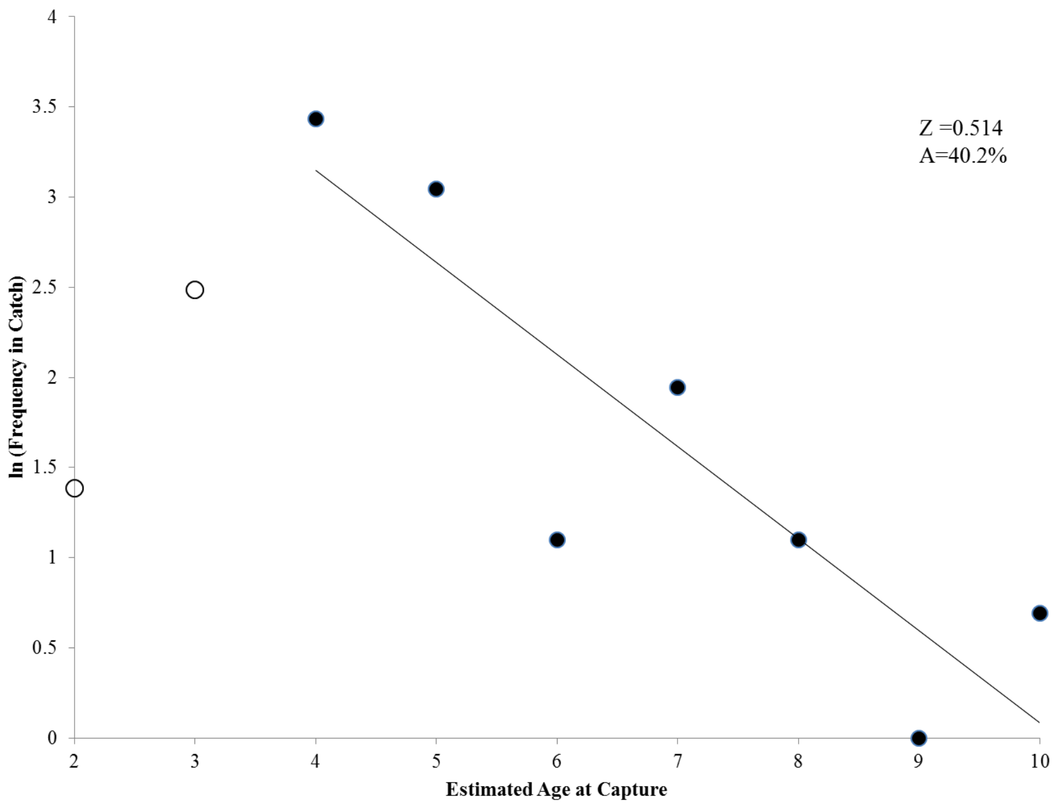

FIGURE 8. Catch curve used to estimate instantaneous (Z) and annual (A) mortality for Westslope Cutthroat Trout (n = 79) ages 4-10 that were sampled during the Lake Pend Oreille Nearshore Index Netting Survey. Open circles depict data not included in the analysis because fish at this age were not fully recruited to the sampling gear.

DISCUSSION

The survey protocol we developed and implemented appeared to be an effective approach for beginning a WCT monitoring program in LPO. Baseline data were obtained that described WCT distribution, relative abundance, size structure, age structure, growth rates, and mortality in LPO. Sampling a relatively low abundance species like WCT in a lake as large as LPO poses logistical challenges that can result in limited sample sizes. Thus, we used prior knowledge about WCT habitat use to narrow our spatial sampling frame to target habitats most likely to be occupied by WCT. Floating nets were appropriate gear because WCT in lacustrine environments are generally surface-oriented. Only 0.3 % of the total catch (6 fish) was WCT during a similar study in LPO targeting Walleye using sinking versions of the same nets used in this study (Ryan and Fredericks 2012). We sampled nearshore habitats since pelagic sampling was impractical and because WCT appear to occupy these areas more than pelagic habitats in LPO. A recent creel survey documented few WCT caught incidental to the pelagic Rainbow Trout and kokanee fisheries in LPO, despite high levels of effort (Bouwens and Jakubowski 2016a). Additionally, anglers targeting WCT regularly report that trolling along the shorelines provides the best success.

It is recognized that for spring spawning fish a fall survey is desirable, and a potential limitation of our survey design is that some spawning WCT might still have been in tributaries and not vulnerable to our sampling gear. However, due to logistical challenges such as conflicting sampling commitments and weather, we chose to perform our sampling in the early summer. We suspect the timing of our survey was reasonable and likely was minimally influenced by spawning distribution of WCT. A radio-tagging study performed in the spring of 2015 on WCT captured in the Clark Fork River and passed over Cabinet Gorge Dam suggested WCT radio-tagged in April and May tended to ascend spawning tributaries and display typical spawning behavior while fish tagged in June tended to fall back downstream, suggesting that the WCT spawning season ended in late May or early June (Bernall and Johnson 2016). Tributaries to LPO do not require WCT to make long spawning migrations, and post-spawning migrations should be fairly short in duration. Research in Wolf Lodge Creek, a tributary to nearby Coeur d'Alene Lake, found that although some fish may stay in tributary streams throughout the summer, most spawning WCT returned to the lake beginning early-May and the migration was complete by mid-June (Lukens 1978).

An additional benefit of our survey design was that it provided monitoring data for several other fish species. Specifically, Northern Pikeminnow, Peamouth Chub, and Smallmouth Bass were commonly sampled. It is likely that fairly representative samples were collected from the Northern Pikeminnow and Peamouth Chub populations because all expected sizes of fish were commonly sampled. In contrast, only smaller Smallmouth Bass were sampled. Smallmouth Bass generally have a benthic distribution and the size selectivity curve strongly suggests the results were strongly biased towards smaller fish (Hubert 1996). Thus, results for Smallmouth Bass should be interpreted cautiously with these sampling limitations in mind.

Our survey provided coarse-scale distribution information for several commonly sampled species. Although we did not collect specific habitat data, distribution of the two native minnow species (Northern Pikeminnow and Peamouth) appeared to be influenced by shoreline habitat type. Northern Pikeminnow were generally more abundant in steep, rocky shoreline habitats, while Peamouth were more prevalent in shallower, more vegetated shoreline habitats. Westslope Cutthroat Trout were generally found along shorelines in the mid-lake region and, like Northern Pikeminnow, were commonly associated with steeper shorelines. Our survey design and resultant catch rates should allow broad distribution patterns of surface-oriented, nearshore fish species to be monitored over time. For instance, WCT distribution patterns may shift in response to management actions (e.g., fish passage at Cabinet Gorge Dam, tributary habitat enhancement) or changes in the nearshore fish assemblage, such as relative abundance of non-native predators.

The sample size for Northern Pikeminnow, Peamouth Chub, Smallmouth Bass, and WCT was sufficient to adequately calculate catch rates with acceptable statistical power. Our power analysis indicated that the current effort level (60 net-nights) will be sufficient to detect a 50% change in WCT catch rate with 80% confidence in future surveys. A smaller change in catch rates would be detectible for the three species sampled more commonly than WCT. Although a 50% change seems substantial and it is tempting to increase sample sizes to improve statistical power, there is a tradeoff between increased sampling and cost in terms of time, financial resources, and the desire to limit mortality on both target and non-target species. In the short-term, less dramatic trends will likely be apparent without associated statistical significance, and in the long-term, as sampling is repeated and additional years are added to the data set, statistical power will increase. Additionally, assessing population stability (i.e., no change in CPUE) is likely feasible with current sampling levels. Current sampling effort strikes a reasonable balance between statistical power and cost for monitoring the four most commonly caught surface-oriented, nearshore fish species and will provide information to better guide management.

Our results were comparable to other studies in the area. WCT have been sampled using similar methods in Flathead Lake, Montana since the early 1980s (Hansen et al. 2014). Seasonal WCT catch rates in Flathead Lake varied from 0.5 fish/net to more than 3 fish/net. Catch rates of Yellowstone Cutthroat Trout in 2014 spring surveys of Henry's Lake, Idaho were approximately 4 fish per net in floating gill nets (personal communication, Jon Flinders, IDFG). Henry's Lake is a popular fishery known for high densities of Yellowstone Cutthroat Trout and quality fishing (High et al. 2015), and probably represents an index catch rate representing abundant populations.

Estimated catch rates from this study will serve as a baseline for comparison following future surveys in LPO and other regional lakes. Although we cannot yet make strong comparisons, we did examine results from a recent survey of Priest Lake that used the same survey design. Our catch rates for WCT did not differ (1.8± 0.4 80% CI WCT per net night) from those documented in Priest Lake during 2014 (1.8 ± 0.4 80% CI WCT per net night; Watkins et al. *in prep*). Conditions for WCT in Priest Lake are somewhat similar to LPO in that several non-native species (e.g., Lake Trout and Smallmouth Bass) were introduced into what was historically a primarily Bull Trout-WCT native fish assemblage. However, Priest Lake tributary habitat remains relatively well-connected compared to the LPO system. Regardless, historic creel data and other anecdotal accounts from both waters indicate that contemporary WCT populations are reduced from historical levels, but are likely stable (Bouwens and Jakubowski 2016a; Watkins et al. *in prep*).

Numerous management actions aimed at benefitting WCT are being taken in LPO. For example, Lake Trout suppression has occurred since 2006 and reduced the potential threat this non-native predator poses to WCT (Wahl et al. 2015). Additionally, WCT passage over Cabinet Gorge Dam is underway to reconnect historic spawning and rearing habitat for adfluvial WCT (Bernall and Johnson 2016). Future WCT surveys will be useful for evaluating the response of WCT to ongoing management actions.

Growth rates for WCT appeared to be highly variable in LPO and we considered whether this variation was explained by age estimation error. There were several fish where the otoliths were unreadable or the ageing team could not reach consensus; however, overall confidence in age estimation was fairly high for the otoliths where an age was assigned.

Instead, variability in individual fish life history strategies and associated growth differences may explain much of the observed growth variation. For example, some of the variation in length-at-age may be caused by differing growth conditions among juvenile WCT rearing streams. Similarly, residence time in rearing tributaries may have influenced growth rates for WCT within a particular cohort. Additionally, migration timing could have influenced growth rates. For instance, fish that outmigrated in the spring may have experienced better growth than fish of the same cohort that waited until the fall to enter the lake. Interestingly, a similar pattern showing large variability in length-at-age and potentially age at outmigration was also evident in WCT from Priest Lake (Watkins et al. *in prep*), and in Lake Coeur d'Alene (Lukens 1978).

Our catch curve suggests WCT were not fully recruited to the sampling gear until age-4 (average length: 333 mm TL). Gear selectivity influences when fish become vulnerable to sampling (Hubert 1996), but did not appear to fully explain our results. Northern Pikeminnow and Peamouth Chub in smaller size ranges (< 300 mm TL) were commonly sampled, suggesting smaller WCT would also have been sampled if present. We suspect that residence time in tributaries was the primary reason why WCT were not recruited to the gear at a younger age. It appears that adfluvial WCT in LPO reared in tributary streams from 1 to about 3 years before migrating to the lake based upon the large ranges in lengths at ages -2 to -4. Probable recent migrants were represented by a group of smaller fish ranging from approximately 150 to 250 mm TL, which corresponds roughly with the largest WCT measured in the tributaries (Bouwens and Jakubowski 2015, Bouwens and Jakubowski 2016b).

Despite the delayed recruitment to our sampling gear, our catch curve encompassed enough years to adequately represent mature WCT in LPO. Our estimated annual mortality rate (A = 40%) was similar to an estimate for WCT in Priest Lake WCT (A = 42%; Watkins et al. *in prep*). Although some older fish were sampled, most WCT in LPO do not live beyond seven or eight years. Catch and release fishing regulations have been in place since 2008, and low total angler catch was estimated from a recent creel survey (Bouwens and Jakubowski 2016a). As a result, angler harvest and delayed hooking mortality are likely negligible. The lack of fishing mortality allows our estimate of total annual mortality to effectively be an estimate of conditional natural mortality (natural mortality rate in the absence of fishing mortality).

Westslope Cutthroat Trout are found in many LPO and lower Clark Fork River tributaries, which presumably provide spawning and juvenile rearing habitat for adfluvial WCT (Pratt 1984). However, the relative contribution of each tributary to the LPO lakewide population is unknown. Naturally occurring geochemical signatures in fish otoliths can provide valuable information on natal origins and life histories of individual fish, which can then be extrapolated to make population-level inferences (Campana and Thorrold 2001; Kennedy et al. 1997; Thorrold et al. 2001). This technique has been widely-used for studies involving anadromous fish species; however, it has been used increasingly for studying natal origins and movement patterns of freshwater fishes (Muhlfeld et al. 2005; Munro et al. 2005; Wells et al. 2003). A similar approach may have application for determining the relative contribution of various tributaries to the adfluvial WCT population in LPO. Otoliths from this study have been archived for potential future analysis. This information would be valuable for identifying and prioritizing management actions within tributaries and for monitoring the response of WCT to actions that are implemented. In addition, it may be possible to determine age at outmigration from tributary streams using microchemical techniques, which would provide additional information to describe the large variation in length-at-age of younger WCT.

RECOMMENDATIONS

1) Continue sampling using the existing survey design on a 3-year rotation (next due Spring 2018) to begin identifying population trends.
2) Investigate otolith microchemistry technique for identifying stream of origin for adfluvial WCT in LPO. If feasible, initiate a project to evaluate relative contribution of various tributaries to the lakewide WCT population.

ACKNOWLEDGEMENTS

The authors would like to thank IDFG employees Rob Ryan, Nick Wahl, Bill Harryman, Dan Kaus, Kayla Griffin, and Mike Thomas, as well as Avista staff Wes Baker and Rex Philpot for help with sample collection and age estimation. We would also like to thank Paul Kusnierz, Eric Oldenburg, and Sean Moran (Avista), Jason Blakney (MWFP), Wade Fredenberg (USFWS), and Andy Dux (IDFG) for their review of previous versions of this report. We would also like to thank Avista employees Tim Swant, Joe DosSantos, Heide Evans, and Ceil Orr for their oversight and administrative support. This project was partially funded through Appendix F5 of the Clark Fork Settlement Agreement.

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