Lake Pend Oreille Nearshore Index Netting 2015-2022

Comprehensive Report

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

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ABSTRACT

The 2022 Lake Pend Oreille (LPO) Nearshore Index Netting Survey focused on monitoring relative abundances of adfluvial Westslope Cutthroat Trout (WCT) *Oncorhynchus clarkii lewisi* and was implemented to both continue a WCT population monitoring program that began in 2015 and to determine optimal timing (spring or fall) for future surveys. Optimal sampling timing was determined by evaluating seasonal differencing in species composition, catch rates, and population demographics (e.g., size classes, mortality and growth rates). Sampling was conducted in two events, the first from June 6 to 10 (spring) and the second from October 30 to November 3, 2022 (fall). For each survey, the goal was to use three boats to set 20 standardized floating gill nets nightly for three nights (60 net-nights) at randomly selected locations of the LPO shoreline. However, due to weather conditions and interference from the public, not all locations were sampled during the fall survey. A total of 2,681 fish were sampled during both surveys, the majority of which were Northern Pikeminnow *Ptychocheilus oregonensis* (n = 989), Peamouth *Mylocheilus caurinus* (n = 460), kokanee *Oncorhynchus nerka* (n = 300), and WCT (n = 142). There was no difference in population demographic estimates or catch rates (1.5 fish/net-night) for WCT between seasons. Catch rates for the other most commonly-caught species were different between seasons and varied from 14.7 fish/net-night for Northern Pikeminnow in the spring to <0.01 fish/net-night for Lake Trout *Salvelinus namaycush* in the fall. Estimated ages of WCT varied from 3 to 10 years with most being ages 4 to 6, and lengths ranged from 165 to 555 mm TL. Catch-rates, growth, and annual mortality of WCT in 2022 was not different than those estimated in 2015 and 2019. We recommend periodic replication of this survey in the spring to monitor trends for WCT in LPO while allowing us to monitor other forage fish species, such as Peamouth and Northern Pikeminnow that are not routinely sampled during fall surveys.

INTRODUCTION

Lake Pend Oreille (LPO) is Idaho's largest (36,000 surface ha) and deepest (360 m) natural lake. The native species assemblage consists of Bull Trout *Salvelinus confluentus*, Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, Mountain Whitefish *Prosopium williamsoni*, Pygmy Whitefish *P. coulteri*, Northern Pikeminnow *Ptychocheilus oregonensis,* and Peamouth *Mylocheilus caurinus.* Lake Pend Oreille 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 *Coregonus clupeaformis*, Walleye *Sander vitreus,* Bluegill *Lepomis macrochirus*, Pumpkinseed *L. gibbosus*, Northern Pike *Esox lucius*, and Brown Trout *Salmo trutta.*

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, 2020). Intensive monitoring has been conducted for kokanee, Rainbow Trout, and Bull Trout populations in LPO (see Rust et al. 2022). 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 1,000 to 2,000 fish annually were lower than the estimated 5,000 to 8,000 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 a portion of the adfluvial WCT in LPO. This reduction in habitat availability and addition of non-native species 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 (Frawley et al. 2019). The majority of the LPO tributaries that support WCT are monitored on a five-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. 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 (Ransom et al. 2022). 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 and relatively low fish densities. To improve on this evaluation, a monitoring program was initiated in 2015 using nearshore floating gillnets (Bouwens and Jakubowski 2017). Although these types of index netting surveys don't allow for abundance estimation, 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. The first round of index netting in 2015 occurred in the spring (June) after it was assumed that most adult WCT had returned to the lake after spawning. However, movement data collected by remote passive integrated transponder (PIT) arrays in two tributaries to LPO indicated that some adult WCT may still be upstream during June (Bouwens and Jakubowski 2016b). As such, sampling in 2019 was delayed until fall to minimize this potential source of bias. This resulted in similar WCT catch rates as in 2015, but markedly lower catch rates of native non-game species, such as Peamouth and Northern Pikeminnow (Ransom et al. 2021). It seemed likely the spring bias on WCT catch rates was negligible, but fall sampling did not provide an opportunity to collect information on other species. Given these samples were taken three years apart, it was still necessary to sample during both seasons within the same year to determine if that was an important factor when sampling WCT. Our objective for 2022 was to provide an update on the current population status of WCT in LPO and to compare catch, size, and age composition between the fall and spring netting seasons within the same year to make recommendations for future sample timing.

METHODS

The 2022 LPO Nearshore Index Netting Survey was implemented in the spring from June 6 to 10 and in the fall from October 30 to November 3 to compare catch rates and population demographics between seasons. Sampling was timed to occur when the lake was not thermally stratified and water temperatures were suitable for WCT to occupy shallow, nearshore habitats to increase sampling efficiency (Littlefair et al. 2021). Consistent with previous sample events, 60 standardized floating gillnets were set over a week-long period around the shoreline of LPO (Bouwens and Jakubowski 2017). Nets were made of monofilament mesh and were 45 m in length and 1.8 m deep. Each net consisted of six panels 7.6 m in length and mesh sizes of 1.9, 2.5, 3.2, 3.8, 5.1, and 6.4 cm bar-measure size.

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). Nets were not set near stream outlets, including the Clark Fork River, to prevent net-fouling from moving water and debris. Net locations have remained consistent between years. 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; mm). Characteristics used in identifying Rainbow Trout x Westslope Cutthroat Trout hybrids included throat slashes typically of light intensity or broken in form and exhibiting heavy spotting below the lateral line and toward the anterior end of the fish (Bouwens and Jakubowski 2016b). Relative abundance was described as average catch-per-unit-effort (CPUE; catch/net-night) and was compared between year and season (i.e., spring and fall 2022) using an ANOVA and Tukey's HSD (honestly significant difference) test (Kahilainen and Lehtonen 2003) with $\alpha = 0.05$. However, due to weather conditions and interference from the public not all net locations were sampled during the fall season. Subsequently, temporal comparisons in catch rates were only performed on locations sampled in both seasons whereas all net data was used for assessing demographic rates.

Otoliths were also taken from 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 read blind three times by a single reader and assigned an age when they agreed at least two times. When agreement was not met two or more times, the otolith was excluded from the analyses. Finally, an age-length key was constructed to assign ages to all unaged fish to assess population demographics (DeVries and Frie 1996).

To assess WCT growth, a von Bertalanffy growth function was fit to the length-at-age data for all fish assigned ages from the age-length key (Ogle et al. 2017; Beverton and Holt 1957). Growth between sample years was evaluated by comparing theoretical maximum length (L_∞), body growth coefficient (K), and the theoretical age at which length was zero (t_0) of the von Bertalanffy model using a suite of nested non-linear regression models fit with combined data from all years. This same process was repeated for the spring and fall of 2022 to compare the von Bertalanffy parameters between the spring and fall seasons. Individual models controlled for sample year/season for each parameter were assessed for best model fit first using likelihood ratios (Kimura 1980) and secondarily with Akaike's Information Criterion corrected for small sample size (AIC_c; Burnham and Anderson 2002). Mortality and survival were estimated using a weighted catch curve (Miranda and Bettoli 2007) and compared to 2015 and 2019 estimates using an analysis of covariance (ANCOVA; $\alpha = 0.05$).

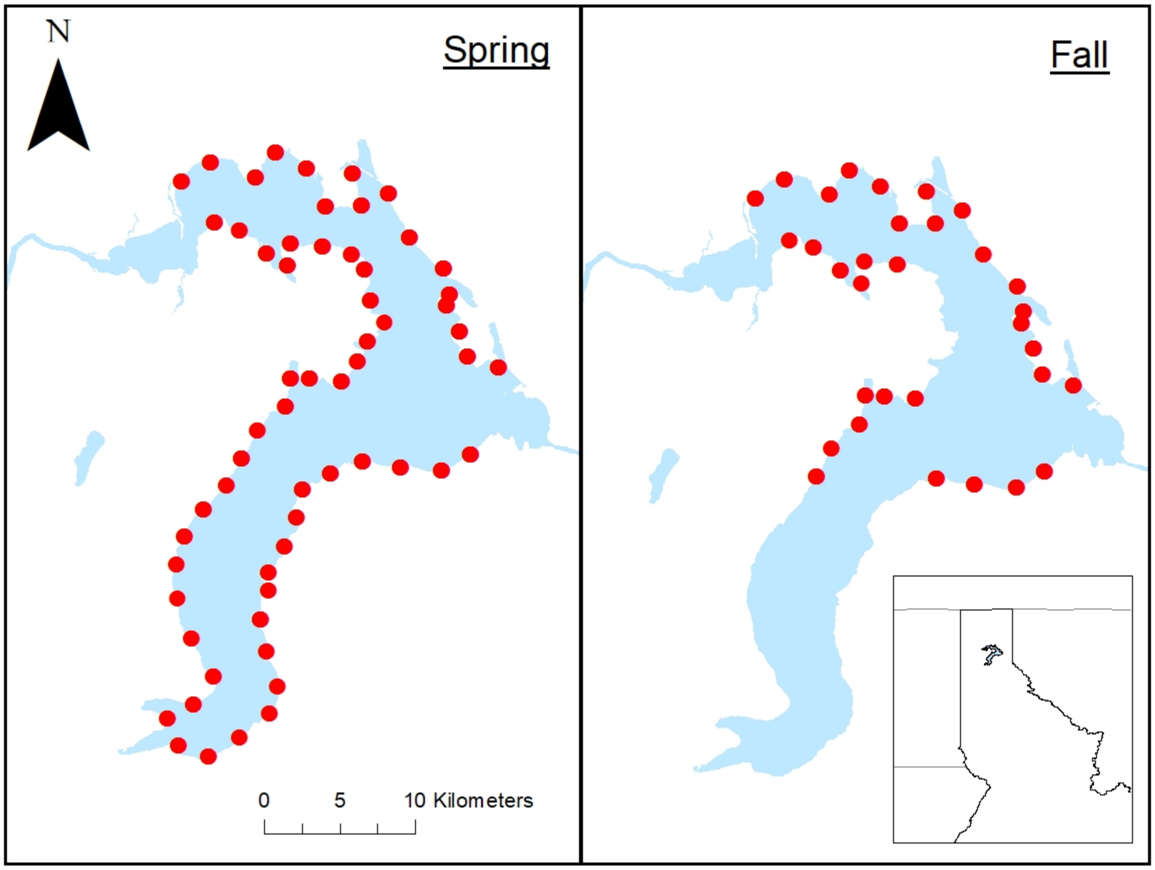

Figure 1. Locations sampled (n = 60) in the spring and fall (n = 32) 2022 Nearshore Index Netting Survey in Lake Pend Oreille, Idaho.

RESULTS

A total of 2,681 fish (spring = 1,804; fall = 877) were caught as part of the 2022 Nearshore Netting survey, the majority of which were Northern Pikeminnow (n = 989), Peamouth (n = 460), kokanee (n = 300), and WCT (n = 142). Fish species caught in lower numbers included Northern Pike, Bull Trout, Mountain Whitefish, Largescale Sucker *Catostomus macrocheilus*, Rainbow Trout, Bullhead *Ameiurus spp*, Yellow Perch, Smallmouth Bass, Largemouth Bass, Black Crappie, Tench *Tinca tinca*, Brook Trout *S. fontinalis*, Pumpkinseed, Walleye, Brown Trout, and WCT x Rainbow Trout hybrids (Table 1).

Table 1. Total number of fish caught, catch-per-unit-effort (CPUE; fish per net-night), and length data for each species sampled during the Lake Pend Oreille Nearshore Index Netting Survey in spring and fall of 2022.

		Total Catch		Total Length (mm)			
	Species	Number	CPUE	Min	Max	Average	*sd*
Spring 2022	Northern Pikeminnow	884	14.7	100	654	395.7	95.6
	Peamouth	455	7.6	198	395	327.6	32.7
	Smallmouth Bass	135	2.3	142	514	287.2	92.9
	Westslope Cutthroat	88	1.5	165	555	371.5	76.6
	Northern Pike	64	1.1	265	1020	509.7	184.3
	Walleye	46	0.8	175	727	342	159.5
	Rainbow Trout	33	0.6	162	810	406.4	174
	Lake Whitefish	23	0.4	277	575	390.9	67.6
	WCT x RBT hybrid	18	0.3	222	502	388.2	73.8
	Brown Trout	11	0.2	250	686	478.2	124.8
	Largescale Sucker	11	0.2	455	530	504.9	32.3
	Mountain Whitefish	6	0.1	248	281	261.3	12.1
	Bullhead spp.	5	<0.1	205	310	281.6	43.8
	Bull Trout	5	<0.1	336	580	464.6	102.1
	Kokanee	5	<0.1	199	262	238.4	27.8
	Longnose Sucker	4	<0.1	425	481	459.5	25.2
	Tench	3	<0.1	280	495	363.3	115.4
	Yellow Perch	3	<0.1	146	245	180.3	56
	Black Crappie	2	<0.1	198	344	271	103.3
	Brook Trout	1	<0.1	282	282	282	-
Fall 2022*	Kokanee	296	9.3	202	330	281.9	15
	Yellow Perch	143	4.5	132	257	157.8	20.4
	Northern Pikeminnow	105	3.3	177	607	328.5	122.3
	Northern Pike	71	2.2	343	1040	668.9	126.5
	Lake Whitefish	64	2	264	483	392.7	45.7
	Westslope Cutthroat	54	1.5	265	463	371.4	56.1
	Largescale Sucker	35	1.1	389	590	498.1	38.3
	Rainbow Trout	23	0.7	242	858	521.9	211.1
	Bullhead spp.	20	0.6	160	281	213.3	34.4
	Black Crappie	11	0.3	158	260	176	29.4
	Brown Trout	10	0.3	334	691	526.9	107.1
	Mountain Whitefish	10	0.3	202	430	336.8	66.3
	Pumpkinseed	9	0.3	98	158	129.1	16.8
	Largemouth Bass	5	0.2	131	347	200.2	97
	Peamouth	5	0.2	341	374	356.8	14.6
	Tench	5	0.2	171	485	271.2	122.7

Table 1. continued.

		Total Catch		Total Length (mm)			
	Species	Number	CPUE	Min	Max	Average	*sd*
Fall 2022*	Bull Trout	2	<0.1	396	571	483.5	123.7
	Lake Trout	1	<0.1	573	573	573	-
	Smallmouth Bass	1	<0.1	148	148	148	-
	Walleye	1	<0.1	385	385	385	-

*Only 32 nets were set in the fall of 2022.

Of the most commonly caught species, Northern Pikeminnow, and Peamouth, and WCT were widely distributed among sampling locations with some observed differences between seasons (Figures 2–4). However, few WCT were captured in the eastern end of the lake and were more broadly distributed. Peamouth and Northern Pikeminnow were broadly distributed throughout the lake in the spring, with Peamouth exhibiting higher densities in the northern portion of the lake, whereas Northern Pikeminnow were more evenly distributed (Figures 3–4). Both Peamouth and Northern Pikeminnow were sparsely distributed in the fall, with Peamouth captured at only a few locations and Northern Pikeminnow primarily captured in the eastern and northeastern portions of the lake. Northern Pike were patchy in distribution and were captured mainly in the northern end of the lake and were more congregated in the northern bays in the fall (Figure 5).

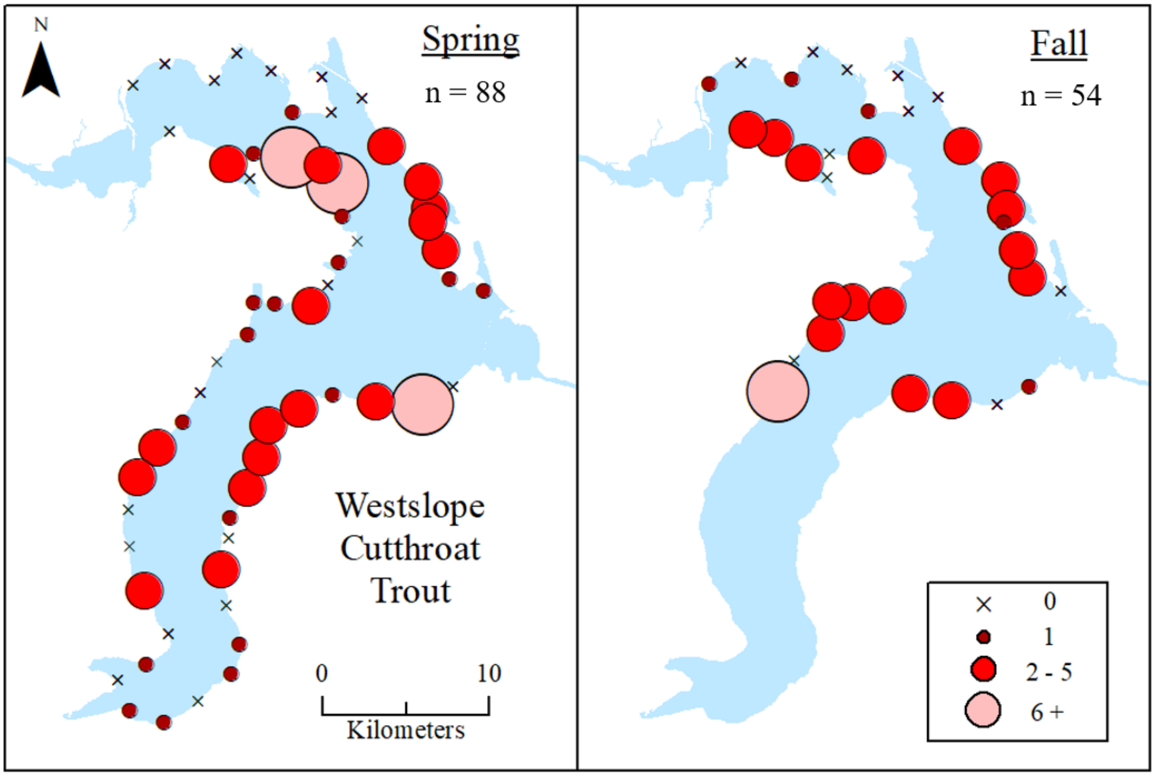

Figure 2. Catch rates (fish/net) at each sampling location for Westslope Cutthroat Trout during the spring (left) and fall (right) Lake Pend Oreille Nearshore Index Netting Survey in 2022. See legend for detailed catch data in each net.

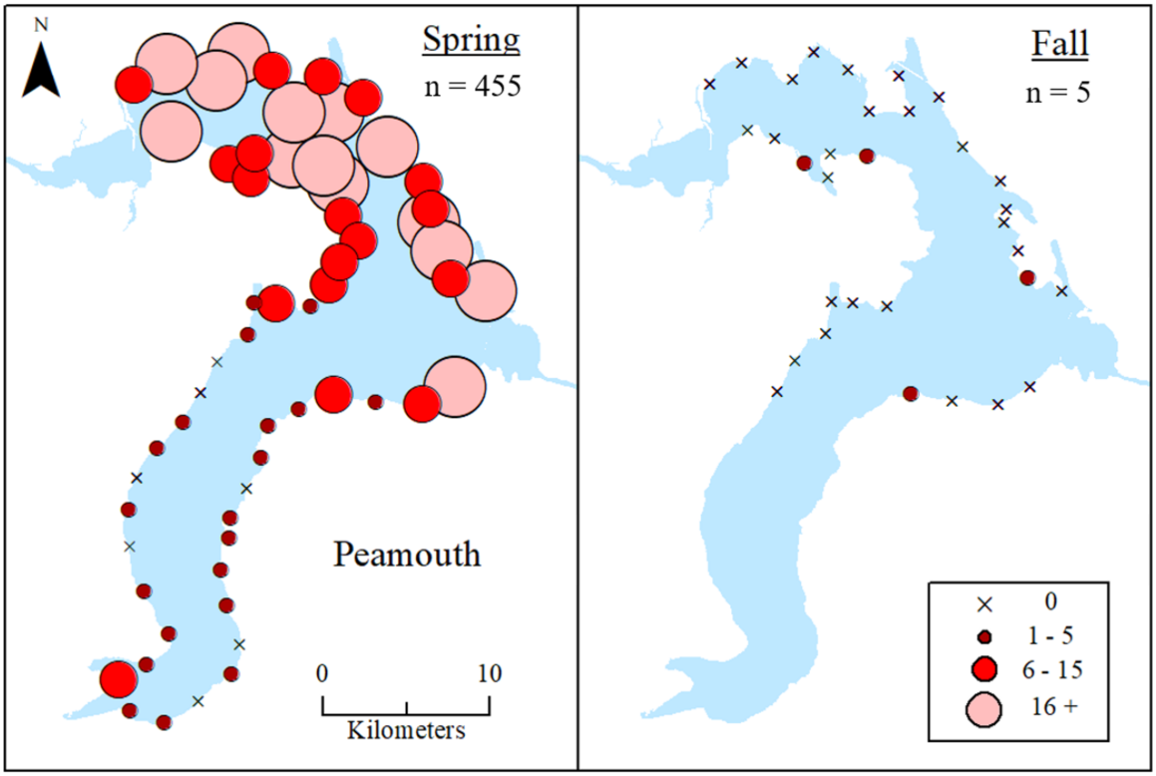

Figure 3. Catch rates (fish/net) at each sampling location for Peamouth during the spring (left) and fall (right) Lake Pend Oreille Nearshore Index Netting Survey in 2022. See legend for detailed catch data in each net.

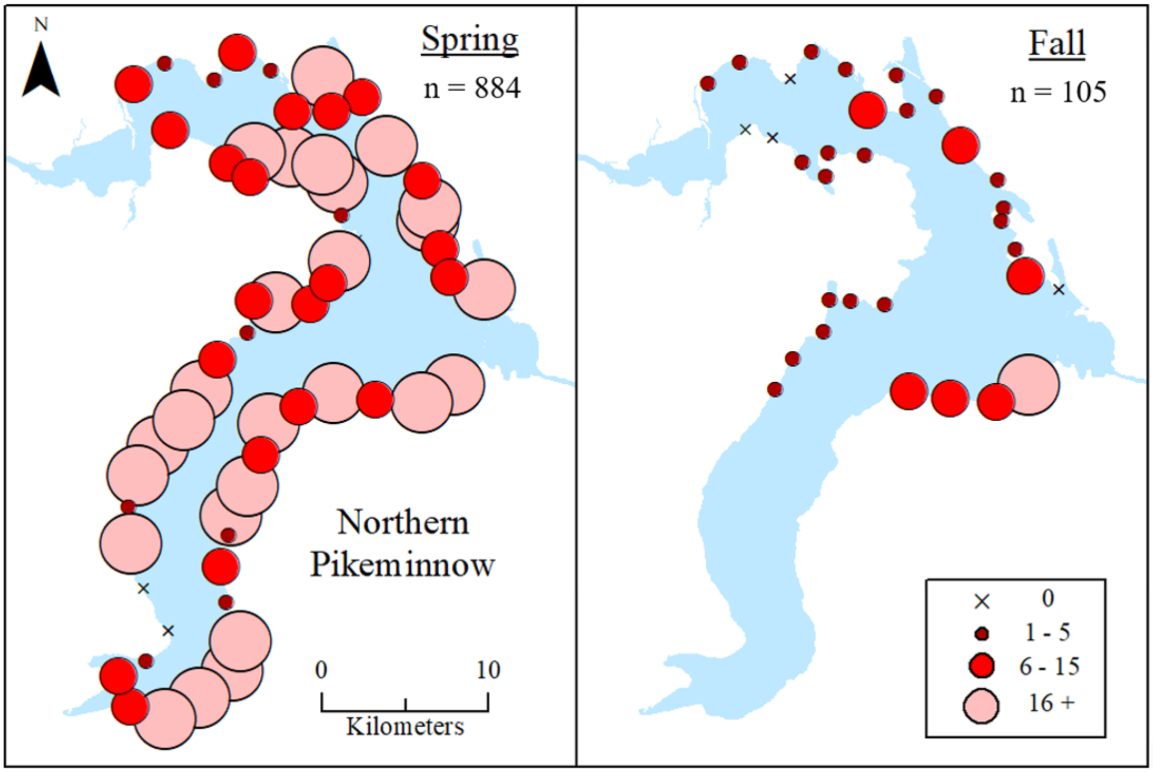

Figure 4. Catch rates (fish/net) at each sampling location for Northern Pikeminnow during the spring (left) and fall (right) Lake Pend Oreille Nearshore Index Netting Survey in 2022. See legend for detailed catch data in each net.

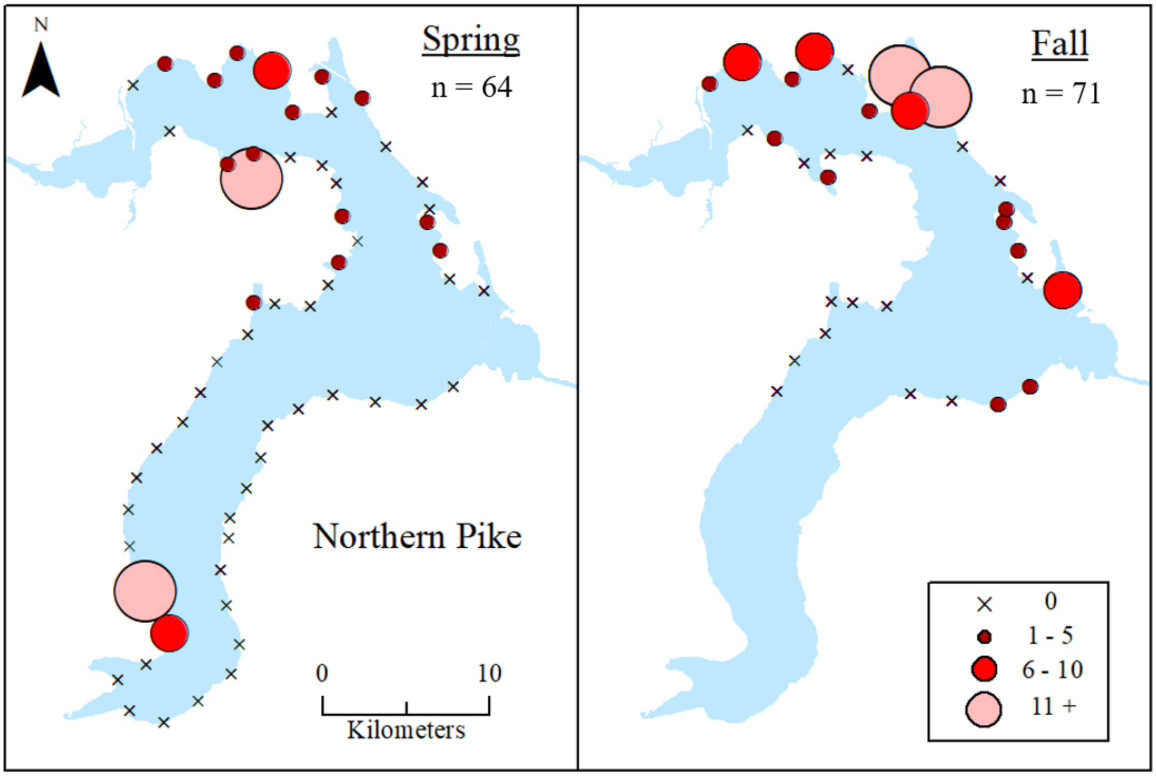

Figure 5. Catch rates (fish/net) at each sampling location for Northern Pike during the spring (left) and fall (right) Lake Pend Oreille Nearshore Index Netting Survey in 2022. See legend for detailed catch data in each net.

There was no significant difference (p = 0.29) in CPUE for WCT between the spring and fall seasons of 2022 or between the previous years (i.e., 20015, 2019 and 2022 (p = 0.35). However, there were significant differences in catch rates for Peamouth (p = <0.001) and Northern Pikeminnow (p = <0.001) between the spring and fall seasons with higher catch rates observed during the spring season.

The size structure of fish sampled was similar in the spring and the fall (Table 1), and the majority of WCT exceeded 300 mm TL in both seasons (Figure 6). Peamouth varied from 198 to 395 mm in the spring and from 341 to 374 mm in the fall (Figure 7). Northern Pikeminnow varied from 100 to 654 mm TL in the spring and from 177 to 607 mm in the fall (Figure 8), whereas Northern Pike varied from 265 to 1,020 mm TL in the spring and 343 to 1,040 mm in the fall (Figure 9).

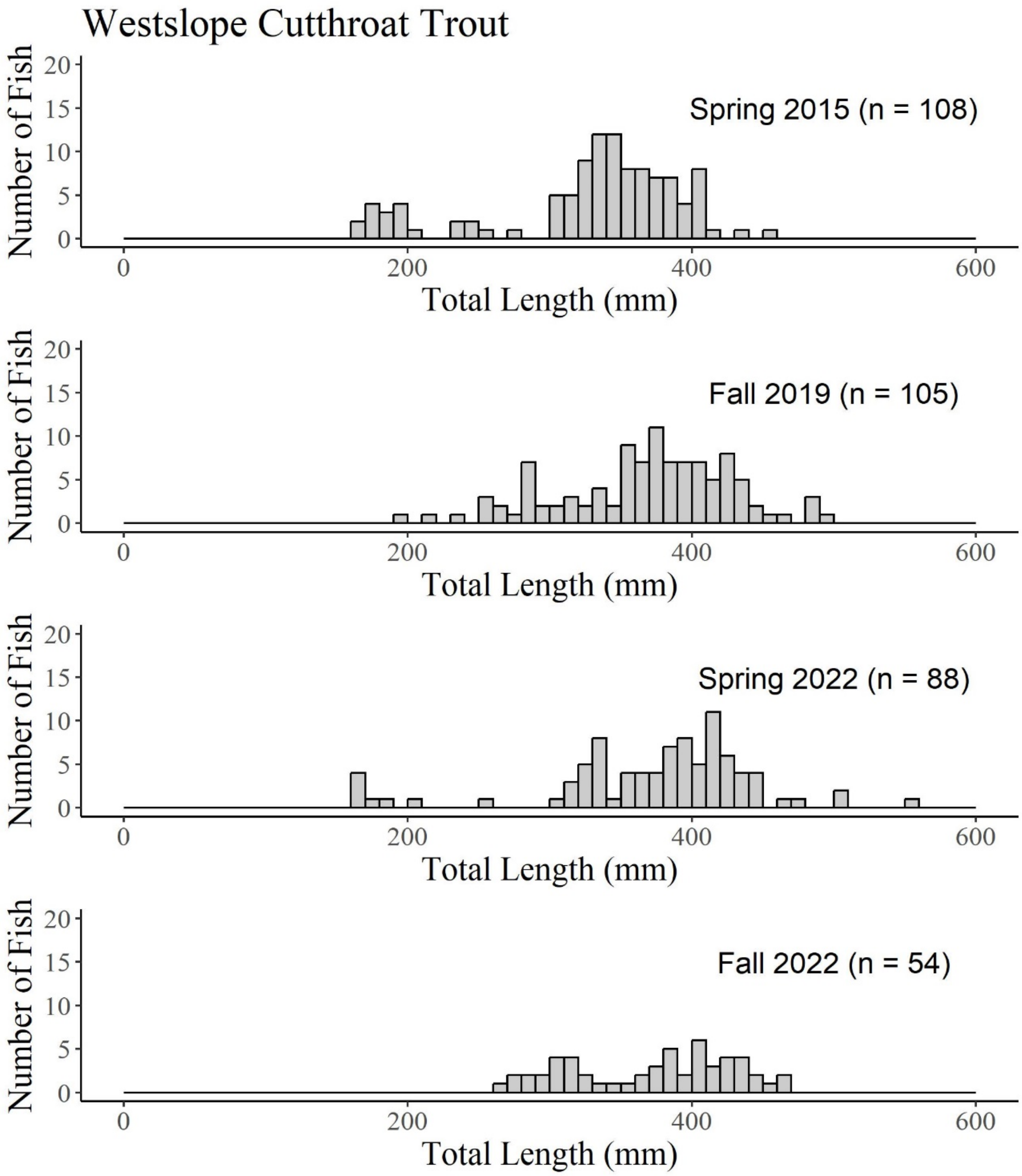

Figure 6. Length-frequency histogram (mm) of Westslope Cutthroat Trout sampled during the spring of 2015 (Bouwens and Jakubowski 2017), fall of 2019 (Ransom et al. 2021), spring of 2022, and fall 2022 in the Lake Pend Oreille Nearshore Index Netting Survey.

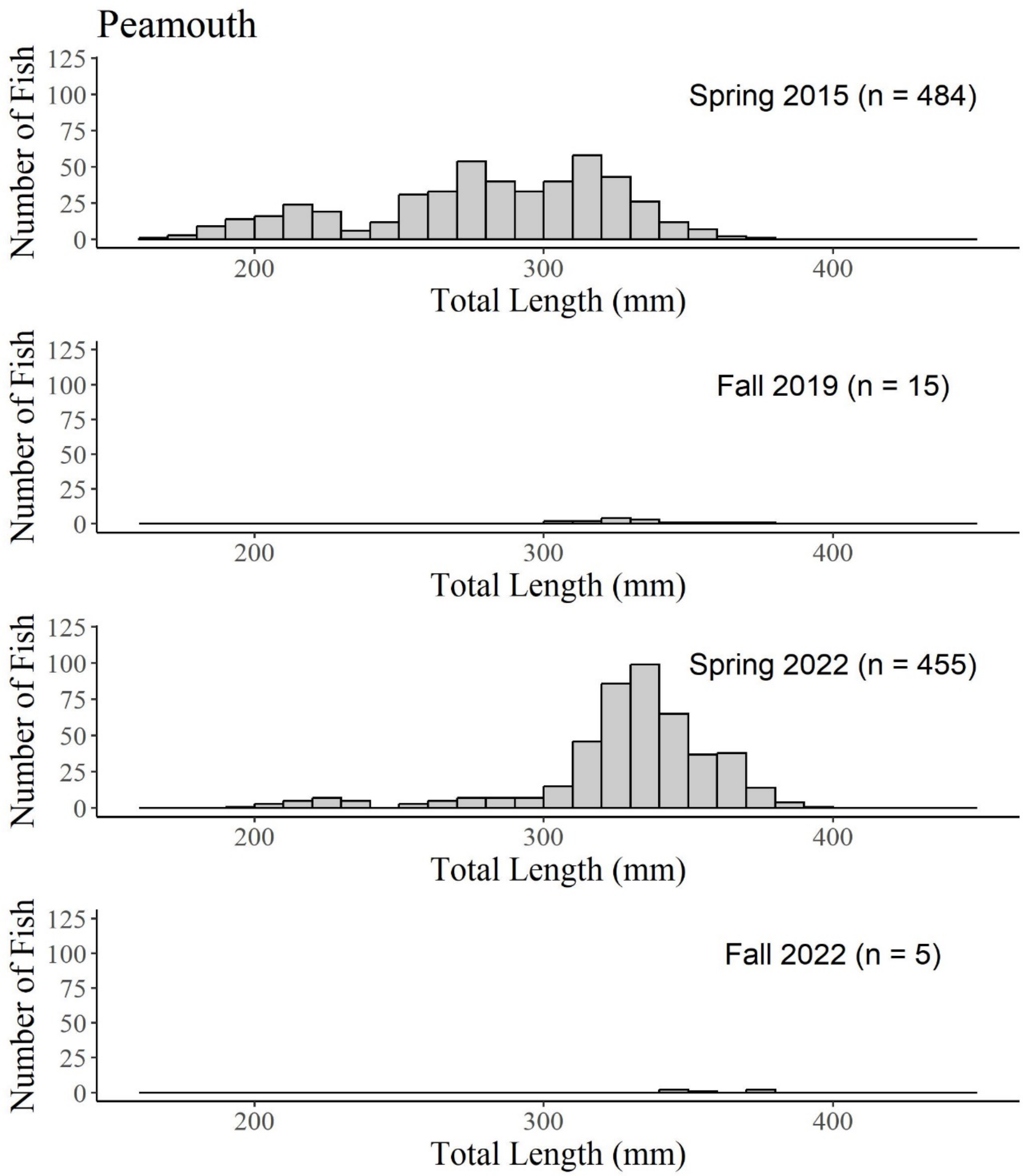

Figure 7. Length-frequency histogram (mm) of Peamouth sampled during the spring of 2015 (Bouwens and Jakubowski 2017), fall of 2019 (Ransom et al. 2021), fall of 2019, spring of 2022, and fall 2022 in the Lake Pend Oreille Nearshore Index Netting Survey.

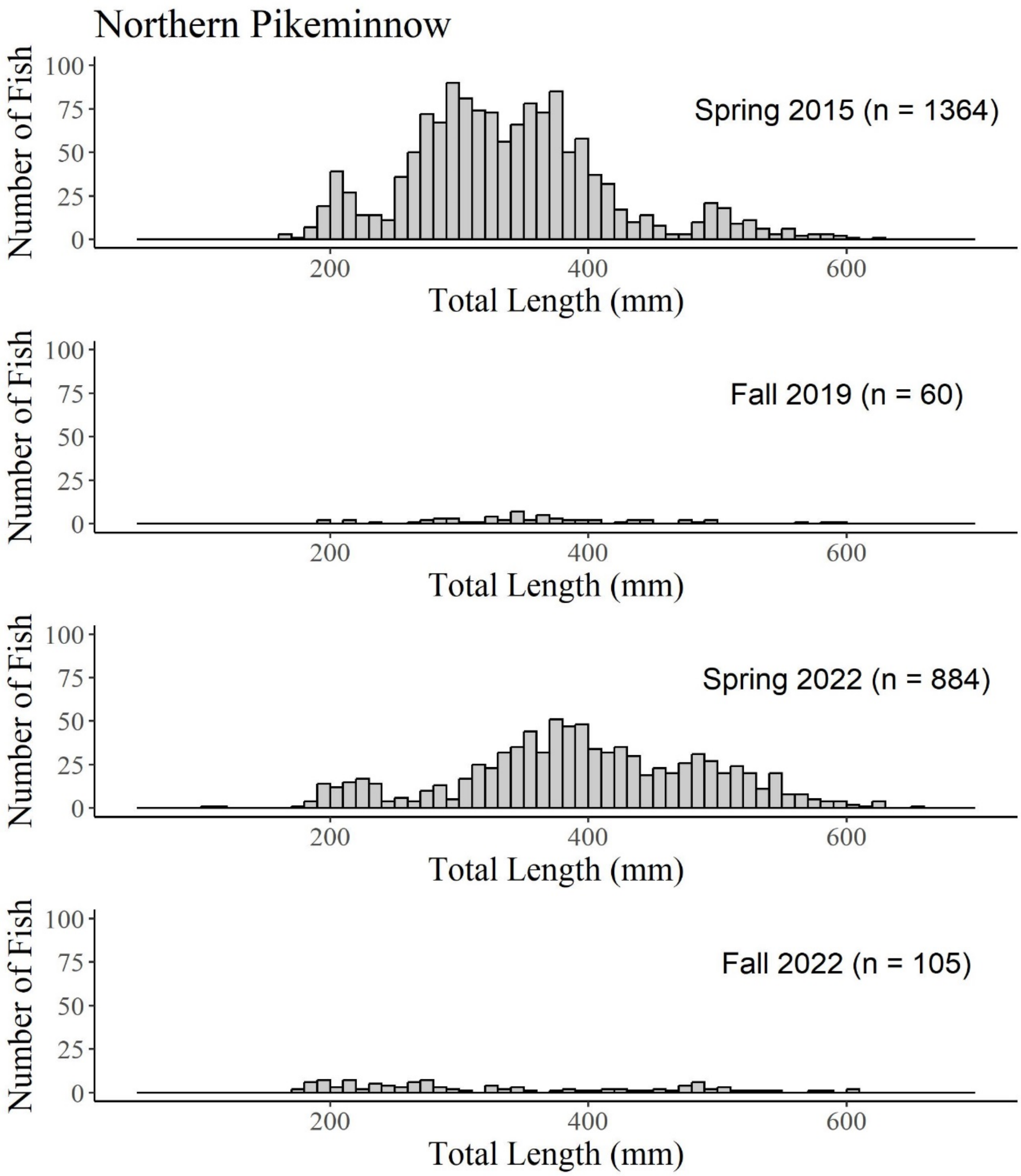

Figure 8. Length-frequency histogram (mm) of Northern Pikeminnow sampled during the spring of 2015 (Bouwens and Jakubowski 2017), fall of 2019 (Ransom et al. 2021), fall of 2019, spring of 2022, and fall 2022 in the Lake Pend Oreille Nearshore Index Netting Survey.

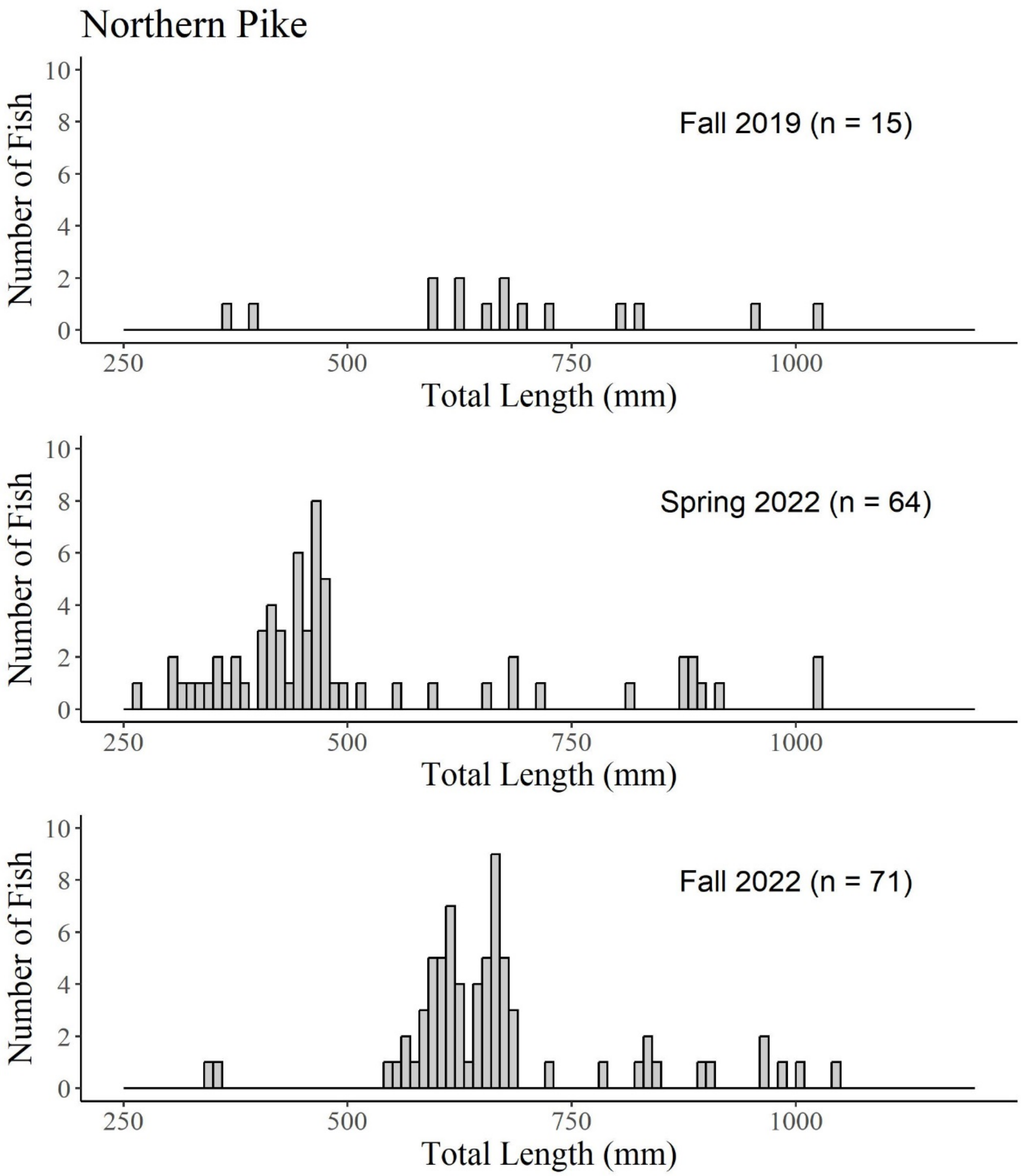

Figure 9. Length-frequency histogram (mm) of Northern Pike sampled during the fall of 2019 (Ransom et al. 2021), spring of 2022, and fall 2022 in the Lake Pend Oreille Nearshore Index Netting Survey. No Northern Pike were sampled during the spring of 2015.

Size structure remained relatively stable between years and seasons for WCT, with a slight increase in length for WCT in the fall of 2022 (Figure 6). Northern Pikeminnow exhibited a slight decrease in the relative proportion of smaller fish through time (Figure 8), whereas Peamouth exhibited a large reduction of fish less than 300 mm TL and length distribution condensed into a singular mode for the spring of 2022 (Figure 7). Northern Pike were first detected in 2019 and an inadequate quantity were captured to determine size structure. However, size structure was distinct between the spring and fall seasons of 2022, with the fall sample being predominately comprised of fish between 500 to 750 mm TL whereas the spring sample primarily ranged between 250 to 500 mm TL (Figure 9).

Estimated ages of WCT in 2022 varied from 3 to 10 years, with most fish being ages 4 to 6. Length-at-age of WCT was variable (Table 2; Figure 10). Estimates for $L\infty$, K, and t_0 for the von Bertalanffy growth function were 491 mm, 0.25, and -1.01, respectively (Figure 10). When assessed for differences between seasons (i.e., spring and fall 2022), the global model (all parameters were controlled for season) was not significantly different than the base model (no parameters controlled for season; $p = 0.14$), thus data for both seasons were combined to assess differences between years. When assessed for differences between years (i.e., 2019 and 2022), the global model (all parameters were controlled for year) was not significantly different than the base model (no parameters controlled for year; $p = 0.64$). Similar results were observed using AICc scores.

Table 2. Mean total length (TL) and standard deviation (SD) by age class for Westslope Cutthroat Trout sampled during the spring and falls seasons for the Lake Pend Oreille Nearshore Index Netting Survey.

	Age	n	Mean TL (mm)	SD of TL (mm)
Spring	3	1	205	-
	4	6	354	42
	5	20	366	37
	6	17	406	42
	7	2	470	44
	8	7	441	50
	9	1	442	-
Fall*	3	9	313	31
	4	18	363	56
	5	11	385	53
	6	5	390	53
	7	4	431	27
	8	2	451	17
	9	1	407	-
	10	1	456	-

*Only 32 nets were set in the fall of 2022

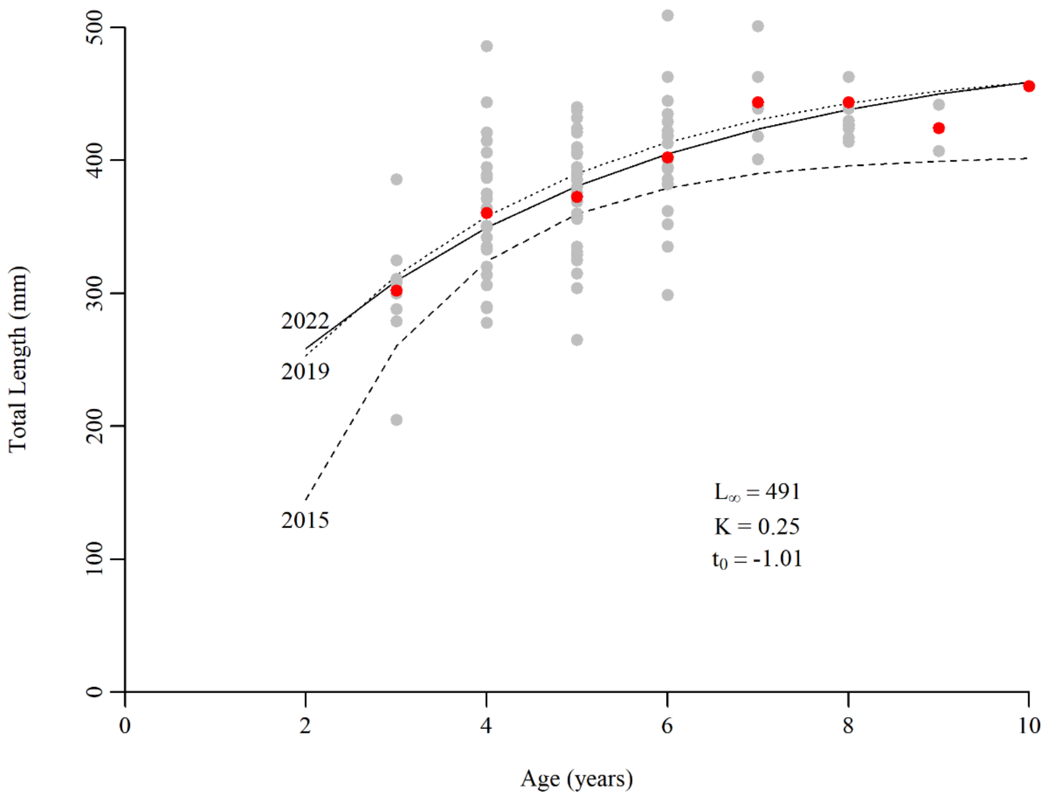

Figure 10. Estimates of mean length-at-age (red circles), observed length-at-age of individuals (gray circles), and parameters listed with trendline (black line) for the von Bertalanffy growth function for Westslope Cutthroat Trout sampled during the 2022 Lake Pend Oreille Nearshore Index Netting Survey. The trendline for the 2015 and 2019 von Bertalanffy growth functions (dashed and dotted black lines, respectively) are included for comparison.

Only age-five and older WCT appeared to be fully recruited to the sampling gear, so a weighted catch-curve regression was fitted to WCT ages 5 to 10 (Figure 11). The estimated total annual mortality rate (A) was 46.50% (95% CI = 24.60–62.05) and instantaneous mortality rate (Z) was 0.626 (95% CI = 0.282 – 0.969). Results from the ANCOVA indicate these values were not significantly different from data collected during the 2019 and 2015 surveys (P = 0.84) for A = 49.08%, and Z = 0.675 (Table 3), suggesting survival has remained similar (Bouwens and Jakubowski 2017).

Table 3. Catch curve estimates (instantaneous mortality [*Z*], and total annual mortality [*A*]) with their corresponding 95% confidence intervals for Westslope Cutthroat Trout sampled during the 3 years of the Lake Pend Oreille Nearshore Index Netting Surveys.

Year	*Z* (95% C.I)	*A* (95% C.I)
2015	0.69 (0.15–1.23)	50% (14–70)
2019	0.68 (0.42–0.93)	49% (34–61)
2022	0.63 (0.28–0.97)	47% (25–62)

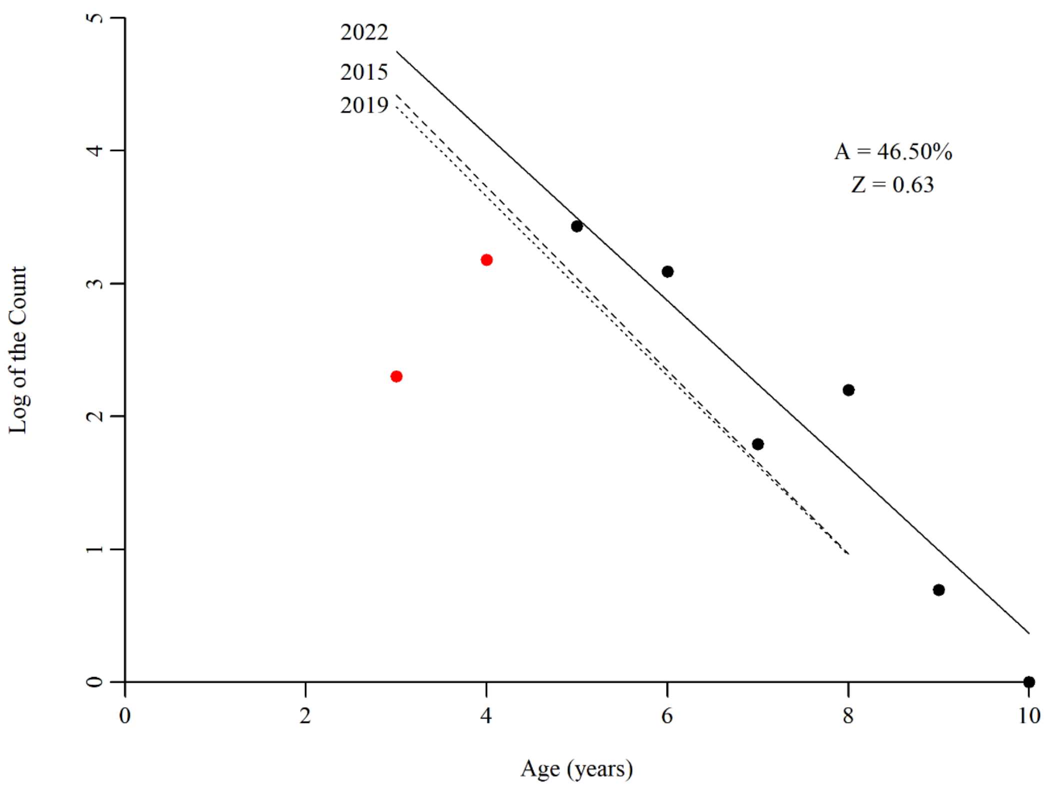

Figure 11. Catch curve used to estimate instantaneous (*Z*) and total annual mortality (*A*) for Westslope Cutthroat Trout (n = 105) ages 5 to 10 that were sampled during the LPO Nearshore Index Netting Survey in 2022. Red circles depict data not included in the analysis because fish at this age were not fully recruited to the sampling gear. Line of best fit from 2022 (solid line), 2019 (dotted line) and 2015 (dashed line) were included to help with visualization of mortality trends t_0.

DISCUSSION

The primary purpose of this survey was to monitor the WCT population in LPO over time. The similarity between years and seasons suggests a stable population with respect to relative abundance. Additionally, the relative abundance was similar to other monitored WCT populations in Idaho and Montana. Recent nearshore netting surveys in nearby Priest Lake, Idaho resulted in catch rates of 1.1 fish/net (Ryan et al. 2020). Westslope Cutthroat Trout have also been sampled using similar methods in Flathead Lake, Montana since the early 1980s (Hansen et al. 2014) and seasonal WCT catch rates in Flathead Lake varied from 0.5 fish/net to more than 3 fish/net. These populations highlight that the LPO WCT population is comparable to other Intermountain West populations.

Conducting the survey in the spring is appropriate for long-term trend monitoring of the WCT population due to the similar results between seasons. An additional benefit of our survey design was that it provided monitoring data for several other fish species of interest. Sampling during the fall resulted in decreased catch rates of most species, except WCT. Northern Pikeminnow and Peamouth are two native non-game fishes in the lake, and it is important to monitor these species through time to assess general ecological changes possibly related to the introduction and growth of non-native predator species, such as Northern Pike and Walleye (Vander Zanden and Vadeboncoeur 2002; Scarnecchia et al. 2014; Mumby et al. 2018). For example, Peamouth have been functionally extirpated from Noxon and Cabinet reservoirs, presumably caused by increased predation by Northern Pike, Walleye, Smallmouth Bass, and Largemouth Bass (Rehm et al. 2023). Catch rates may vary depending on fish behavior during certain times of the year; for example, Peamouth and Northern Pikeminnow were actively spawning in the nearshore zone during June of 2022 and were likely more vulnerable to our gear than during the fall survey in 2022. Since data collected for WCT during both time periods are similar, and Northern Pikeminnow and Peamouth catches were considerably higher in the spring season, then consistently sampling during the spring would allow for effective monitoring of both Northern Pikeminnow and Peamouth. This is consistent with our results from 2015 and 2019.

Although there was no difference in von Bertalanffy growth parameters between seasons and years for WCT, high variation was observed for length-at-age. Some of the variation in length-at-age may be caused by differing growth conditions among juvenile WCT due to environmental conditions in rearing streams. For example, the lower portions of Spring Creek and Mosquito Creek are low gradient streams with fine substrate, whereas Char Creek is a relatively high gradient stream with coarse substrate. These differences in stream structure may foster different macroinvertebrate communities leading to differences in forage availability and subsequently reflect differences in growth. Additionally, lower portions of Mosquito Creek and Spring Creek exhibit higher water temperature conditions which may influence growth differences observed between rearing streams. Similarly, residence time in rearing tributaries may have influenced growth rates for WCT within a particular cohort. Westslope Cutthroat Trout age in 2009 varied from one to four years, whereas WCT age in 2014 varied from one to two years in

Johnson Creek below a fish barrier (Ransom et al. 2022). Furthermore, fish that emigrated in the spring may have experienced faster growth than fish of the same cohort that waited until the fall to enter the lake. Once fish have emigrated from the rearing streams into Lake Pend Oreille, growth most likely stabilizes at a much higher rate than in the streams. Interestingly, a similar pattern showing large variability in length-at-age and potentially age-at-outmigration was also evident in WCT from Priest Lake (Ryan et al. 2020).

The relative stability of mortality through time (*A* = 47–50%; Table 3) and a comparable mortality rate to other cutthroat populations further indicates a stable population of WCT in the LPO system (Janowicz et al. 2018). For comparison, estimated mortality rate in nearby Priest Lake was 44% in 2014 and 70% in 2017 with the suggestion that the variability in observed mortality due to low catch of juvenile WCT (Watkins et al. 2018; Ryan et al. 2020). Our catch curve suggests WCT were not fully recruited to the sampling gear until age-5 (366 and 385 mm average TL in the spring and fall, respectively). Gear selectivity influences when fish become vulnerable to sampling (Hubert 1996), but does not fully explain the lack of smaller WCT in our sampling. Kokanee were one of the most commonly captured species, many of which were less than 280 mm in size, 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 rear in tributary streams from approximately one to three years before migrating to the lake based upon the large variation in lengths at ages two to four in our samples. Fish estimated to be recent migrants were represented by a group of smaller fish varying from approximately 200 to 300 mm TL and three to four years old, which corresponds roughly with the largest WCT measured in the tributaries that generally vary from approximately 150 to 200 mm TL and three to four years old (Ransom 2022). Despite the delayed recruitment to our sampling gear, our catch curve encompassed enough years to adequately represent mature WCT in LPO. 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 harvest 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), although there may be some minor mortality caused by catch-and-release fishing.

Overall, this evaluation indicated that relative abundance and population demographics for WCT were not significantly different between the spring and the fall seasons, whereas catch-rates were much higher for some native species. Due to these findings and apparent relative stability of the WCT population, we recommend conducting future surveys during the spring season on the established 3-year rotation. Additionally, given the similar relative abundance of WCT to other systems in the region and the stability of the relative abundance and population demographics over the past 7 years, conducting harvest modeling simulations to determine if the WCT population can sustain a limited harvest fishery may be warranted. It is also clear that this assessment will also be useful in monitoring other native nearshore species over time as predation from Northern Pike and Walleye increase.

RECOMMENDATIONS

1) Continue sampling in the spring using the existing survey design on a 3-year rotation (next due 2025) to continue identifying population trends.
2) Conduct harvest modeling simulations to assess the potential for the WCT population to support a limited harvest fishery in Lake Pend Oreille.

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