2002 Warmwater Fisheries Survey of Pierre Lake, Stevens County, Washington

by

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Abstract

Pierre Lake (Stevens County) was surveyed by a 3-person investigation team June 11-14, 2002. Fish were sampled by boat electrofishing, gill netting, and fyke netting. Eight fish species were collected. Green sunfish *Lepomis cyanellus* (n=1,453) and largemouth bass *Micropterus salmoides* (n=816) were the most abundant species sampled during collection activities. Largemouth bass and green sunfish contributed the highest (48%), and second-highest (36%) proportion of the biomass, respectively. Brown bullhead *Ameiurus nebulosus*, black crappie *Pomoxis nigromaculatus*, cutthroat trout *Oncorhynchus clarkii*, kokanee *O. nerka*, rainbow trout *O. mykiss*, and walleye *Stizostedion vitreum* were also collected. Although a small proportion of green sunfish in Pierre Lake have grown larger than is commonly seen in most northern waters, most are too small to provide much angling value. Slow growth, low condition, and missing year classes of black crappie, and low condition of smaller size largemouth bass may be a result of heavy interspecific competition with the relatively high density population of green sunfish. Largemouth bass up to 19 inches were observed in Pierre Lake, though most were smaller than 10 inches. Although populations of salmonid species appeared low, their numbers were most likely under represented because of sampling bias. Cutthroat trout observed during this survey were below the national average in terms of condition. Given its northern latitude, habitat characteristics, and history as a successful salmonid water, Pierre Lake may be best suited as a water managed for trout and kokanee and rehabilitation should be considered. If Pierre Lake continues to be managed as a mixed species water, future management considerations should include monitoring the response of fish populations to the recently imposed largemouth bass slot-limit, and conducting a creel survey to determine angler harvest and preferences.

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Introduction

Pierre Lake is located approximately 35 kilometers (km) north of Kettle Falls, Washington, in Stevens County. Pierre Lake has a surface area of approximately 44.5 hectares (ha) and has a maximum and mean depth of about 23 and 8.5 meters (m), respectively (Table 1). Pierre Lake has one main inlet, Pierre Creek, that flows into the northeast end of the lake (Figure 1). During low water years, Pierre Creek flows subterranean. It is unknown whether subsurface flow from Pierre Creek disperses into the surrounding soil or continues a downstream course to Pierre Lake (Tom Shuhda, USFS personal communication). Water exits Pierre Lake at the south end through Toulou Creek. During low water, Toulou Creek flows about 1 km downstream of Pierre Lake before becoming subterraneous (Washington Department of Fish and Wildlife [WDFW] 1956). During high water periods, Toulou Creek floods a meadow south of the lake and becomes what is known as Little Pierre Lake, which dries up later in the season.

Table 1. Physical parameters of Pierre Lake, Stevens County (DOE 2003).

Physical Parameters	Measurement
Surface Area (ha)	44.5
Shoreline Length (km)	4.6
Maximum Depth (m)	23.0
Mean Depth (m)	8.5
Volume (acre-ft)	3,000.0
Shoreline Development D_L	2.0

Pierre Lake is surrounded by land owned by the United States Forest Service (USFS), Washington Department of Natural Resources, and privately owned land developed as vacation cabins or year-round residential homes. Historically, Pierre Lake supported a single resort, yet currently, no resorts reside on the lake. Recreational access at Pierre Lake is available to the public at a USFS owned and maintained campground and boat launch located on the west side of the lake (Figure 1). Recreational activities include fishing, swimming, hiking, and camping. Pierre Lake is open year-round with ice fishing available in the winter. Under current statewide WDFW angling regulations, the following rules apply on Pierre Lake: a slot-limit on largemouth bass *Micropterus salmoides* allows anglers to retain five largemouth bass less than 305 mm (12 inches) or greater than 432 mm (17 inches), and no more than one over 432 mm; anglers may retain five walleye *Stizostedion vitreum* over 406 mm (16 inches) with no more than one over 559 mm (22 inches); a combination of five trout species (no minimum length), including rainbow trout *Oncorhynchus mykiss*, kokanee *O. nerka*, cutthroat trout *O. clarkii,* and/or eastern brook trout *Salvelinus fontinalis*, may also be retained in the creel. There is no minimum length or bag limit on black crappie *Pomoxis nigromaculatus*, green sunfish *Lepomis cyanellus*, or brown bullhead *Ameiurus nebulosus*.

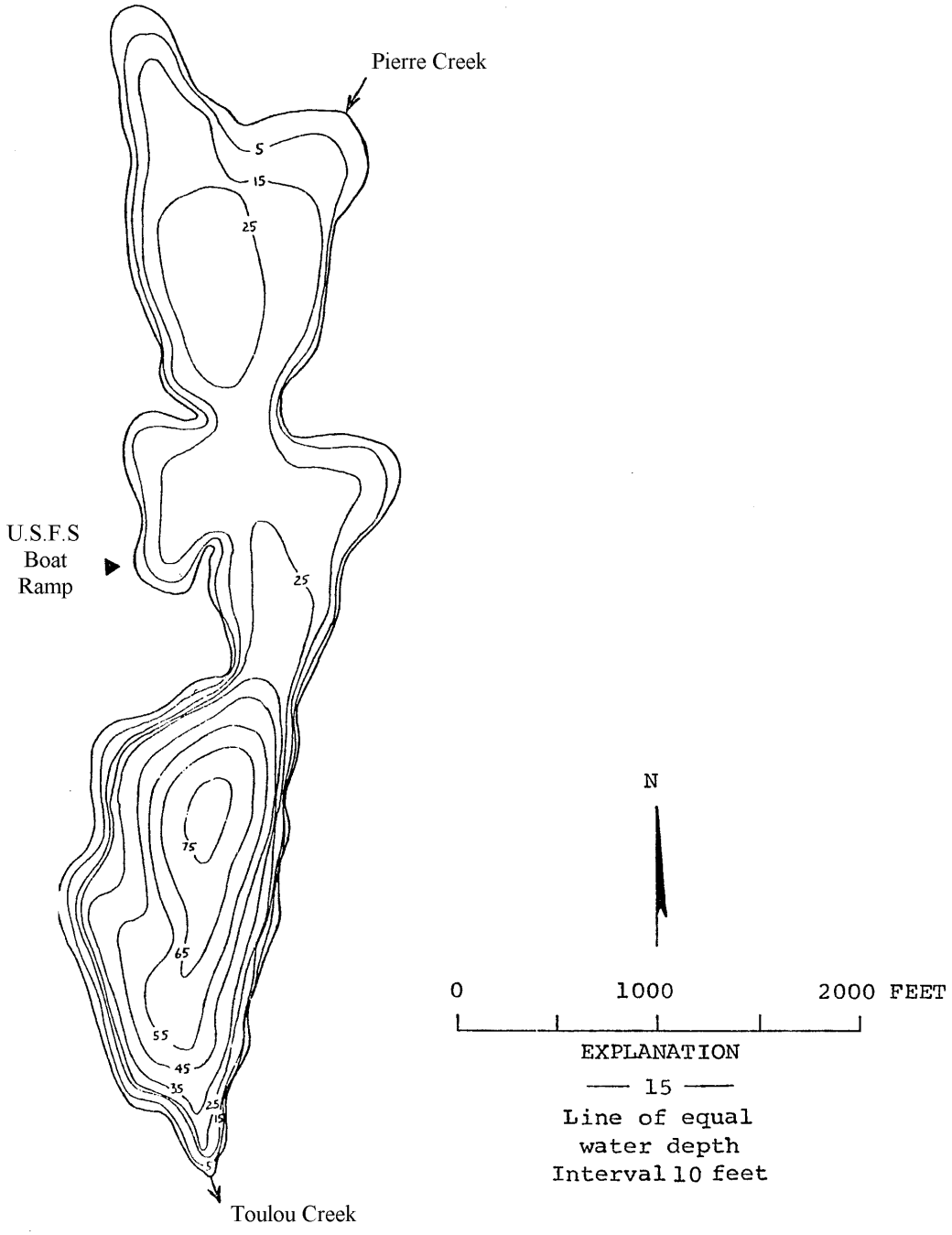

Figure 1. Bathymetric map of Pierre Lake (Stevens County). From Washington Department of Game Archive.

In the early 1900s, Pierre Lake was very popular and was noted for its large rainbow trout. It is believed that early anglers obtained small fish from the Columbia River backwaters and used them for bait, thus introducing non-game species into the lake (WDFW 1956). The first recorded stocking of kokanee and rainbow trout in Pierre Lake was in 1933 and 1936, respectively (WDFW 2003). Since 1933, approximately 1.7 million kokanee, 2.1 million cutthroat trout, 11.5 thousand eastern brook trout, and 287 thousand rainbow trout have been stocked in Pierre Lake (Table 2). In recent years, WDFW has trended toward stocking Pierre Lake with slightly larger trout fry in the fall of each year to increase trout survival and reduce impacts of predation and competition (John Whalen, WDFW, personal communication). Largemouth bass were illegally introduced into Pierre Lake sometime prior to 1947. In August 1947, Pierre Lake was rehabilitated to eradicate tench *Tinca tinca*, northern pikeminnow *Ptychocheilus oregonensis*, suckers *Catostomus spp.*, and stunted largemouth bass (WDFW 1956). Following the 1947 rehabilitation, Pierre Lake was stocked with cutthroat trout and Whatcom-stock kokanee (Crawford 1979) which produced a consistent fishery for over three decades. In the late 1970s, black crappie were illegally introduced and by 1981 they had became overpopulated (Fletcher 1981), and the trout fishery began to deteriorate (WDFW 1981). In October 1981, 39 adult largemouth bass were stocked into Pierre Lake in an attempt to produce a self-sustaining population, with the objective of reducing black crappie density through predation. Fletcher (1981) suggested that if the stocked largemouth bass failed to achieve the desired result, lake rehabilitation should once again be considered. The largemouth bass stocked in 1981 did reproduce and produced a self-sustaining population; however, the warmwater fishery has remained less than desirable. Recent thoughts of lake rehabilitation have been postponed for concern of losing the naturally reproducing kokanee population (Curt Vail, WDFW, personal communication). Today, Pierre Lake is managed as a mixed-species fishery.

Table 2. Fish stocked into Pierre Lake by WDFW. With few exceptions, most fish were stocked as fry. Species included cutthroat trout (CT), eastern brook trout (EB), kokanee (KOK), largemouth bass (LMB), and rainbow trout (RB).

Year	Species	No.	Year	Species	No.	Year	Species	No.
1933	KOK	15,000	1953	CT	74,800	1982	RB	40,000
1934	KOK	33,160	1954	CT	75,000	1984	CT	20,150
1935	KOK	50,000	1955	CT	75,540	1985	CT	20,088
1936	KOK	32,500	1956	CT	90,000	1986	CT	20,010
	RB	4,500	1957	CT	80,290	1987	CT	17,010
1937	KOK	87,000	1958	CT	76,500	1988	CT	17,080
1938	KOK	103,630	1959	CT	75,100	1989	CT	20,125
1939	KOK	99,700	1960	CT	75,190	1990	CT	15,150
1940	KOK	76,900	1961	CT	75,000	1991	CT	15,000
1941	KOK	98,300	1962	CT	65,200	1993	CT	10,010
1942	KOK	201,183	1963	CT	75,230	1994	EB	8,510
	RB	1,443	1964	CT	74,100		RB	3,933
1943	KOK	207,598	1965	CT	75,100	1995	CT	9,510
	RB	8,800	1966	CT	75,900		RB	30,040
1944	RB	9,997	1967	CT	80,362	1996	EB	2,100
1945	KOK	274,800	1968	CT	75,400		RB	13,998
	RB	5,191	1969	CT	75,350	1997	CT	9,963
1946	KOK	138,320	1971	CT	39,990		RB	20,008
	RB	10,392	1973	CT	30,000	1998	CT	20,200
1947	CT	79,180	1974	CT	35,342		RB	15,048
1948	KOK	99,900	1975	CT	25,017	1999	CT	14,410
1949	CT	75,755	1976	CT	5,010	2000	CT	26,004
	KOK	94,800	1979	EB	1,060		RB	10,240
1950	CT	89,805		RB	25,060	2001	CT	29,998
	KOK	104,000	1980	RB	8,075	2002	CT	45,600
1951	CT	60,700	1981	RB	20,020		RB	30,032
1952	CT	49,200		LMB	39	2003	CT	28,715

Methods and Materials

Pierre Lake was surveyed by a 3-person team on June 11-14, 2002. All fish were collected using a boat electrofisher, gill nets, and fyke nets. The electrofishing unit consisted of a Smith-Root GPP electrofishing boat, using a DC current of 120 cycles/sec at 3 to 4 amps power. Experimental gill nets (45.7 m x 2.4 m) consisted of variable size [13, 19, 25, and 51 millimeter (mm) stretched] monofilament mesh. Fyke nets were constructed of a main trap (4.7 m long and 1.2 m in diameter with five aluminum hoops), a single 30.3 m lead, and two 15.2 m wings. All netting material was constructed of 6.35 mm nylon mesh.

Sampling locations were selected by dividing the shoreline into 12 sections of approximately 400 meters each. The number of randomly selected sampling locations were as follows: electrofishing - 12, gill netting - 8, and fyke netting - 8. Electrofishing occurred in shallow water (depth range: 0.2 - 1.5 m), adjacent to the shoreline at a rate of approximately 18.3 m/minute for 600 second intervals (Bonar et al. 2000). Gill nets were set perpendicular to the shoreline with the small-mesh end attached on or near the shore, and the large-mesh end anchored offshore. Fyke nets were set perpendicular to the shoreline with the wings extended at 70^{o} angles from the lead. Gill nets and fyke nets were set overnight prior to electrofishing and were pulled the following morning (1 net night each). This methodology was used to maintain a standardized 3:2:2 ratio of electrofishing to gill netting to fyke netting (three 10-minute electrofishing sections:2 net-nights of gill netting:2 net-nights of fyke netting) which was consistent with statewide Warmwater Program protocol (Bonar et al. 2000). All sampling was conducted during night-time hours when fish are most numerous along the shoreline, thus maximizing the efficiency of each gear type. Sampling at night can be more effective because some fish species seek shelter during the day and move freely at night (Helfman 1983).

All fish were identified to species, measured in millimeters to total length (TL), and weighed to the nearest gram (g). Total length data were used to construct length-frequency histograms and to evaluate the size structure of the warmwater game fish. Scales were collected from largemouth bass, green sunfish, black crappie, and walleye to analyze age and growth. The above species were assigned to a 10 mm size group based on total length, and scale samples were collected from five fish in each size group (Bonar et al. 2000). Scale samples were mounted on adhesive data cards, pressed onto acetate slides using a Carver® laboratory press, and aged according to Jerald (1983) and Fletcher et al. (1993).

Water chemistry data were collected from the area of greatest depth on June 14, 2002 (1300 hours). A Hydrolab® probe and digital recorder were used to collect information on dissolved oxygen (milligrams per liter [mg/l]), temperature (degrees Celsius [EC]), pH, and conductivity (micro-siemens per centimeter [FS/cm]). Water clarity was measured using a Secchi disc.

Species composition, by weight (kg) and number, was determined from fish captured. Fish less than one year old, i.e., young-of-the-year, were excluded from all analyses. Including young-of-the-year fish in the calculation of species composition can give a false impression of year class strength due to the abundance of small fish, which can suffer extensive mortality during the first winter (Chew 1974). In addition, eliminating young-of-the-year fish prevents distortions in analyses that may have occurred due to sampling location, method, and specific timing of hatches (Fletcher et al. 1993).

Catch per unit effort (CPUE) of each sampling gear was determined for each warmwater fish species collected. The CPUE of electrofishing was determined by dividing the number of fish captured by the total amount of time that was electrofished. Similarly, CPUE of gill netting and fyke netting was determined by dividing the number of fish captured by the total time the nets were deployed. Standardized CPUE allows for comparisons of catch rates between different lakes or sampling dates on the same water.

Relative weight (W_r) was used to evaluate the condition of fish in Pierre Lake. As presented by Anderson and Neumann (1996), a W_r of 100 generally indicates that the fish is in a condition similar to the national average for that species and length. The index is defined as $W_r = W/W_s \times 100$, where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same total length (mm). Standard weight (W_s) was derived from a standard weight-length ($\log_{10}$) relationship which was defined for each species of interest (Anderson and Neumann 1996, Bister et al. 2000, Hyatt and Hubert 2000). Minimum lengths were used for each species as the variability can be significant for young-of-the-year fish. Relative weights less than 50 were also excluded from our analyses as we suspected unreliable weight measurements.

Age and growth of warmwater game fish in Pierre Lake were evaluated using procedures described by Fletcher et al. (1993). All samples were evaluated using both the direct proportion method (Fletcher et al.1993) and Lee's modification of the direct proportion method (Carlander 1982). Where applicable, mean back-calculated lengths-at-age for all warmwater game fish species were compared to those of statewide averages (Fletcher et al.1993).

The proportional stock density (PSD) of each warmwater game fish species was determined following procedures outlined in Anderson and Neumann (1996). Proportional stock density uses two measurements, stock length and quality length, to provide useful information about the proportion of various size fish in a population. Stock length is defined as the minimum size of a fish which provides recreational value or the approximate length when fish reach maturity (Table 3). Quality length is defined as the minimum size of a fish that most anglers like to catch or begin keeping. PSD is calculated using the number of quality size fish, divided by the number of stock size fish, multiplied by 100. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Stock length was 20-26 percent of world record length, whereas quality length was 36-41 percent of world record length.

Relative stock density (RSD) of each warmwater game fish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality lengths, the Gabelhouse model adds preferred, memorable, and trophy categories (Table 3). Preferred length (RSD-P) is defined as the minimum size of fish anglers would prefer to catch. Memorable length (RSD-M) refers to the minimum size fish anglers remember catching and trophy length (RSD-T) refers to the minimum size fish worthy of acknowledgment. Preferred, memorable, and trophy length fish were also based on percentages of world record lengths. Preferred length is 45-55 percent of world record length, memorable length is 59-64 percent of world record length, and trophy length is 74-80 percent of world record length. Relative stock density differs from PSD in that it is more sensitive to changes in year-class strength. Relative stock density is calculated as the number of fish within the specified length category, divided by the total number of stock length fish, multiplied by 100. Eighty-percent confidence intervals for PSDs and RSDs are provided as an estimate of statistical precision and were calculated using normal approximation (Conover 1980; Gustafson 1988).

Table 3. Minimum total length (mm) categories of warmwater fish species used to calculate PSD and RSD values (Anderson and Neumann 1996; Bister et al. 2000). Numbers in parenthesis represent percentages of world record lengths (Gabelhouse 1984).

	Standard Length Categories				
Species	**Stock (20-26%)**	**Quality (36-41%)**	**Preferred (45-55%)**	**Memorable (59-64%)**	**Trophy (74-80%)**
Black Crappie	130	200	250	300	380
Green Sunfish	80	150	200	250	300
Brown Bullhead	130	200	280	360	430
Largemouth Bass	200	300	380	510	630
Walleye	250	380	510	630	760

Results

Water Chemistry

Water chemistry data were collected on June 14, 2002 (1300 hours). Pierre Lake water temperatures ranged from 5.1EC at 22 m to 19.4EC at the surface (Table 4). Below 6 m, temperatures were below the preferred range for warmwater fish such as largemouth bass (Boyd 1990; Wydoski and Whitney 2003). Measured pH values ranged from 7.0 to 8.4 which is within the desired range (6.5-9) for warmwater fish species (Swingle 1969). Dissolved oxygen levels ranged from 9.4 mg/l at the surface to 0.2 mg/l at depths deeper than 20 m. Despite favorable water temperatures, low dissolved oxygen levels restricted all fish species to the upper 6-8 m of the lake. Although rainbow trout can inhabit water with temperatures as high as 26EC if dissolved oxygen is sufficient, kokanee prefer water temperatures close to 10EC (Wydoski and Whitney 2003) and may be restricted to a narrow band of habitat in Pierre Lake occurring at 6-7 m. To more fully understand the dynamics of water chemistry in Pierre Lake, additional measurements should be made annually, and at more locations.

Table 4. Water chemistry data collected from Pierre Lake (Stevens County) on June 14, 2002 (1300 hours).

Date	Depth	Temp (ºC)	pH	DO (mg/l)	Conductivity	Secchi (m)
06/14/02	0	19.4	8.4	9.4	301.9	7.5
	2	16.5	8.4	9.3		
	4	13.9	8.3	9.8		
	6	10.6	8.3	9.6		
	8	7.8	7.6	3.9		
	10	6.0	7.0	0.8		
	12	5.5	7.2	0.5		
	14	5.3	7.2	0.4		
	16	5.2	7.2	0.3		
	18	5.2	7.2	0.3		
	20	5.1	7.2	0.2		
	22	5.1	7.1	0.2	359.0	

Species Composition

A total of eight fish species were collected during sampling efforts on Pierre Lake (Table 5). Warmwater game fish comprised approximately 95% of the total fish captured and over 91% of the total biomass. Green sunfish was the most abundant game fish species, comprising 60% of the sample by number. Largemouth bass contributed the single highest biomass (48%). A total of 58 kokanee, 39 cutthroat trout, and 2 rainbow trout were observed during this survey. However, the sampling techniques used in this survey probably do not effectively capture pelagic species, such as trout, thus those species are likely under represented in our samples.

Table 5. Species composition, by weight and number, of fish sampled at Pierre Lake (Stevens County) during June 2002. Analyses do not include young-of-the-year fish.

	Species Composition					
	Weight		Number		Size Range (mm TL)	
Species	kg	%	No.	%	Min.	Max.
Brown Bullhead	10.6	5.4	22	0.9	230	330
Black Crappie	2.0	1.0	20	0.8	146	274
Cutthroat Trout	7.6	3.9	39	1.6	238	310
Green Sunfish	71.0	36.2	1,453	60.3	33	198
Kokanee	7.1	3.6	58	2.4	214	271
Largemouth Bass	94.5	48.2	816	33.8	63	489
Rainbow Trout	2.0	1.0	2	0.1	419	452
Walleye	1.2	0.6	1	0.1	497	497

Catch Per Unit Effort (CPUE)

Electrofishing captured more fish (n=1,642) in Pierre Lake than gill nets (n=445) or fyke nets (n=324). Electrofishing catch rates were highest on green sunfish (401.7 fish/hr) and largemouth bass (103.8 fish/hr)(Table 6) which was expected given the relative abundance of those species (Table 5). Green sunfish (33.5 fish/net-night), kokanee (7.3 fish/net-night), and cutthroat trout (4.9 fish/net-night) comprised the highest proportion of fish sampled by gill netting. Like electrofishing and gill netting catch rates, fyke netting catch rates were also highest on green sunfish (38.6 fish/net-night). Because of broad confidence intervals, interpretation of CPUE data were limited for most other species.

Table 6. Mean catch per unit effort (CPUE) by sampling method, including 80 percent confidence intervals, for stock length fish collected from Pierre Lake (Stevens County) in June 2002.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
Species	No./hour	No.	No./Net Night	No.	No./Night	No.
Brown Bullhead	1.5 ± 1.0	12	2.0 ± 0.9	8	0.4 ± 0.3	8
Black Crappie	0.0	12	1.8 ± 0.9	8	0.8 ± 1.0	8
Cutthroat Trout	0.0	12	4.9 ± 1.1	8	0.0	8
Green Sunfish	401.7 ± 74.6	12	33.5 ± 12.8	8	38.6 ± 13.2	8
Largemouth Bass	103.8 ± 24.3	12	2.1 ± 1.0	8	0.0	8
Kokanee	0.0	12	7.3 ± 5.7	8	0.0	8
Rainbow Trout	0.0	12	0.3 ± 0.2	8	0.0	8
Walleye	0.0	12	0.1 ± 0.1	8	0.0	8

Stock Density Indices

Electrofishing sample sizes of stock length largemouth bass and green sunfish were high (Table 7). Gill netting and fyke netting sample sizes of stock length fish were high for green sunfish, but were inadequate to provide useful information for other species (Bonar et al. 2000). Largemouth bass were represented in all RSD categories except RSD-T (Trophy) and their stock density indices were reflective of a population managed for panfish (Anderson and Neumann 1996). Green sunfish PSDs were relatively low and may be indicative of a high density population. Although it is common for green sunfish populations to become stunted in colder waters, such as Pierre Lake, they do provide forage to other warmwater piscivores (Wydoski and Whitney 2003).

Table 7. Traditional stock density indices, including 80% confidence intervals, of fish collected from Pierre Lake (Stevens County) in June 2002, by sampling method.

Species	# Stock Length L	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Green Sunfish	805	13 ± 2	0	0	0
Largemouth Bass	208	20 ± 4	3 ± 2	2 ± 3	0
		Gill Netting			
Black Crappie	14	21 ± 14	14 ± 12	0	0
Green Sunfish	268	25 ± 3	0	0	0
Largemouth Bass	17	18 ± 12	0	0	0
		Fyke Netting			
Black Crappie	6	17 ± 19	17 ± 19	0	0
Green Sunfish	309	34 ± 3	0	0	0

Largemouth Bass

Largemouth bass sampled from Pierre Lake ranged in length from 63 to 489 mm total length (Table 5; Figure 2) and ranged in age from 2 to 12 years (Table 8). Growth of Pierre Lake largemouth bass was below the statewide average at all ages observed. Because of the shorter growing season, largemouth bass in Pierre Lake may experience slower growth than bass found in more southern latitudes. Missing from our samples were young-of-the-year and age 1 largemouth bass which are typically observed in higher numbers than older age fish. This may be an artifact of sample timing or may indicate unstable year-class strength. The condition of most largemouth bass less than 250 mm TL was less than the national average, but appeared to improve as size increased (Figure 3).

Table 8. Back-calculated mean length at age (mm) of largemouth bass collected at Pierre Lake (Stevens County) during June 2002. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean Total Length (mm) at Age											
Year Class	**No.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2001	0	--											
		--											
2000	15	49	112										
		60	112										
1999	4	36	83	131									
		51	91	131									
1998	29	47	90	123	160								
		61	99	127	160								
1997	40	42	105	154	188	218							
		58	115	160	190	218							
1996	22	52	114	176	223	259	301						
		69	126	184	228	262	301						
1995	14	50	115	174	229	267	307	340					
		67	128	184	235	271	309	340					
1994	5	53	120	165	214	252	280	318	359				
		70	133	176	222	258	284	320	359				
1993	2	41	96	140	186	235	262	306	330	340			
		58	110	152	195	241	267	308	330	340			
1992	3	55	124	177	213	260	295	349	380	412	435		
		73	139	189	223	268	301	353	383	413	435		
1991	1	67	124	165	196	231	266	300	320	344	375	394	
		84	137	177	206	240	273	305	324	347	376	394	
1990	1	44	134	228	280	306	365	391	419	452	469	480	489
		63	149	238	288	313	370	395	422	454	470	480	489
Overall Mean		49	111	163	210	254	297	334	361	387	426	437	489
Weighted Mean		62	115	160	198	243	301	336	362	389	430	437	489
WA State Mean		60	146	222	261	289	319	368	396	440	485	472	496

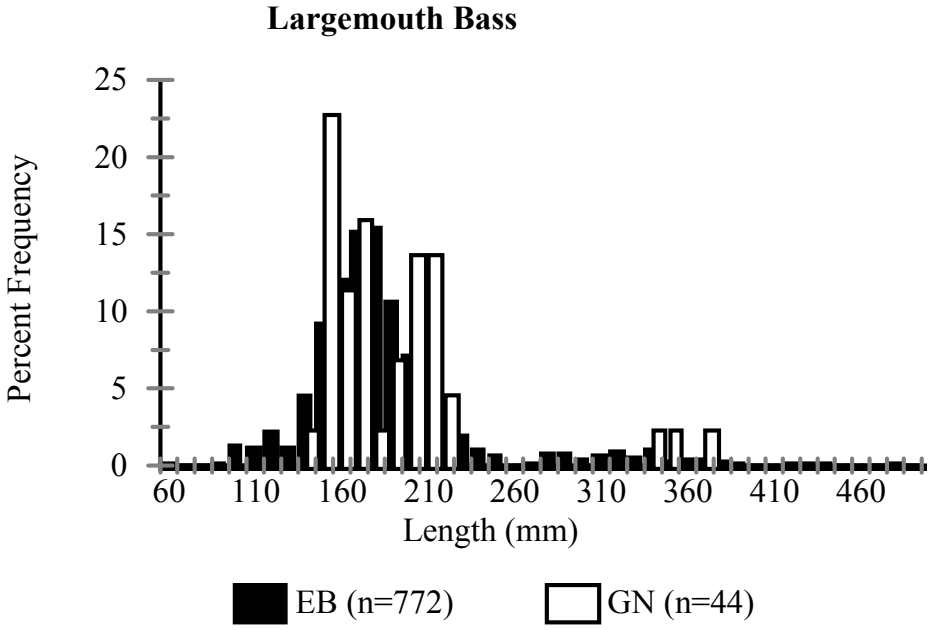

Figure 2. Length frequency distribution of largemouth bass, excluding young-of-the-year, sampled by electrofishing (EB) and gill netting (GN) at Pierre Lake (Stevens County) during June 2002.

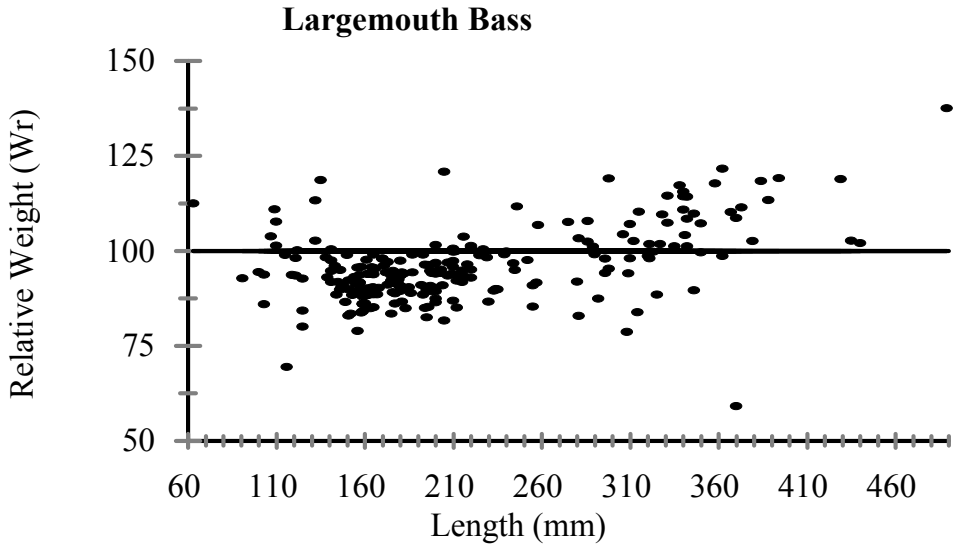

Figure 3. Relative weights of largemouth bass (n=240), excluding young-of-the-year, sampled at Pierre Lake (Stevens County) during June 2002, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Green Sunfish

Pierre Lake green sunfish ranged in length from 33 to 198 mm total length (Table 5; Figure 4) and ranged in age from 2 to 5 years (Table 9). No Washington state average for green sunfish is available for comparison. However, green sunfish growth rates were lower than those reported by Wydoski and Whitney (2003) for populations in other states including Ohio, Oklahoma, and Iowa, but were higher than those reported for Montana. Like largemouth bass, young-of-the-year and age 1 green sunfish were missing from our samples which may be an artifact of sample timing or may indicate unstable year-class strength. Overall, Pierre Lake green sunfish were in good condition with most having relative weights above the national average (Figure 5).

Table 9. Back-calculated mean length at age (mm) of green sunfish collected at Pierre Lake (Stevens County) during June 2002. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean Total Length (mm) at Age				
Year class	**No.**	**1**	**2**	**3**	**4**	**5**
2001	0	--				
		--				
2000	9	22	70			
		29	71			
1999	14	21	59	99		
		29	63	100		
1998	47	25	71	108	138	
		34	76	110	138	
1997	4	23	68	111	137	162
		32	74	115	139	162
Overall mean		23	67	106	138	162
Weighted Mean		32	73	108	138	162
WA State Mean		NA	NA	NA	NA	NA

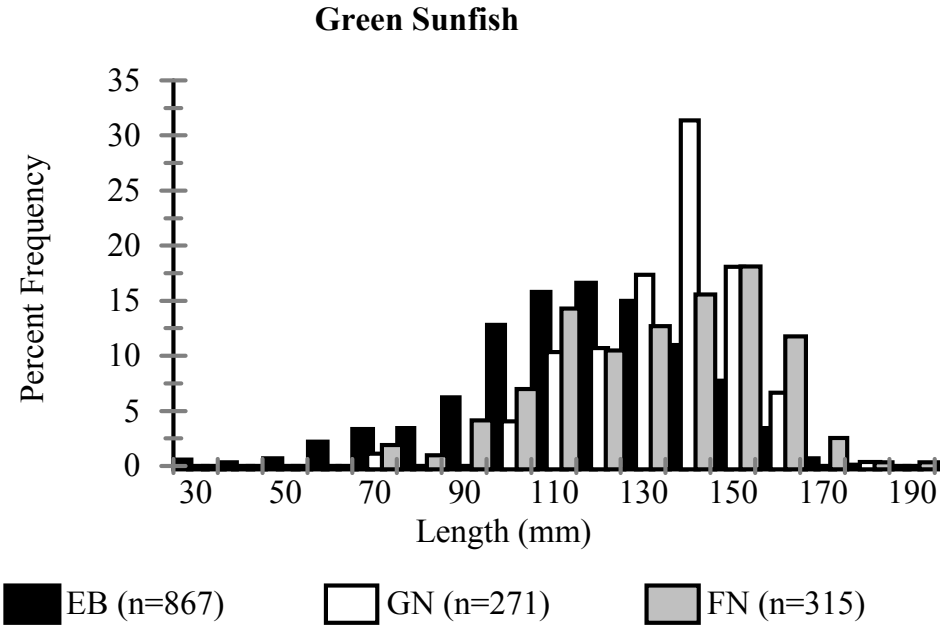

Figure 4. Length frequency distribution of green sunfish, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Pierre Lake (Stevens County) during June 2002.

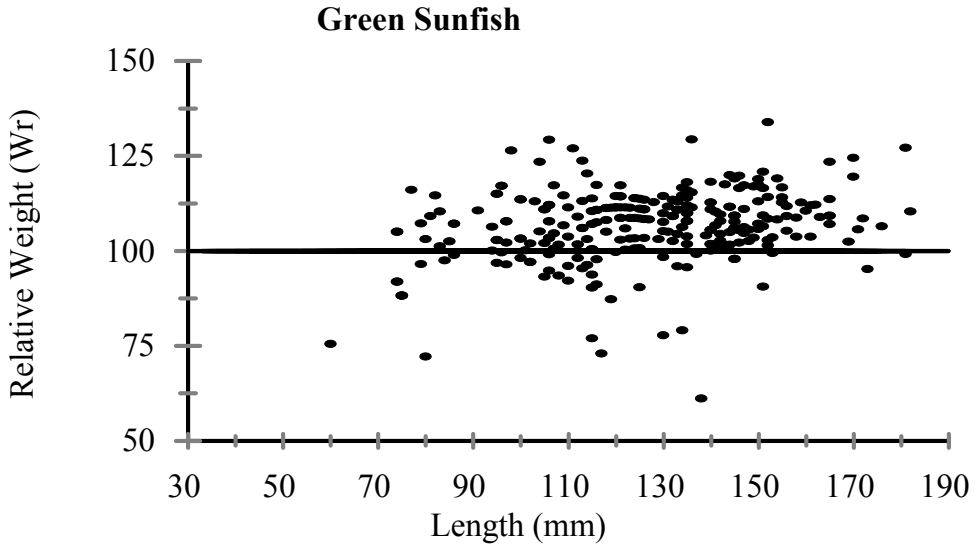

Figure 5. Relative weights of green sunfish (n=281), excluding young-of-the-year, sampled at Pierre Lake (Stevens County) during June 2002, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Black Crappie

Black crappie sampled from Pierre Lake ranged in length from 146 to 274 mm total length (Table 5; Figure 6). The age of Pierre Lake black crappie ranged from 4 to 8 years (Table 10). Black crappie from the 1995, 1996, 1999, 2000, and 2001 year classes were not observed in our samples which may indicate year-class failures for those years. Growth of Pierre Lake black crappie was lower than the statewide average at all ages observed. Because of the colder climate and shorter growing season, black crappie in Pierre Lake may experience slower growth than crappie found in more southern latitudes. The condition of most black crappie were near or below the national average (Figure 7).

Table 10. Back-calculated mean length at age (mm) of black crappie collected at Pierre Lake (Stevens County) during June 2002. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean Total Length (mm) at Age							
Year class	**No.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2001	0	--							
		--							
2000	0	--	--						
		--	--						
1999	0	--	--	--					
		--	--	--					
1998	12	22	57	101	162				
		53	80	114	162				
1997	5	19	48	84	131	181			
		50	74	103	140	181			
1996	0	--	--	--	--	--	--		
		--	--	--	--	--	--		
1995	0	--	--	--	--	--	--	--	
		--	--	--	--	--	--	--	
1994	3	23	63	104	161	211	236	251	263
		55	90	125	175	218	240	253	263
Overall mean		21	56	96	151	196	236	251	263
Weighted Mean		52	80	113	159	195	240	253	263
WA State Mean		46	111	157	183	220	NA	NA	NA

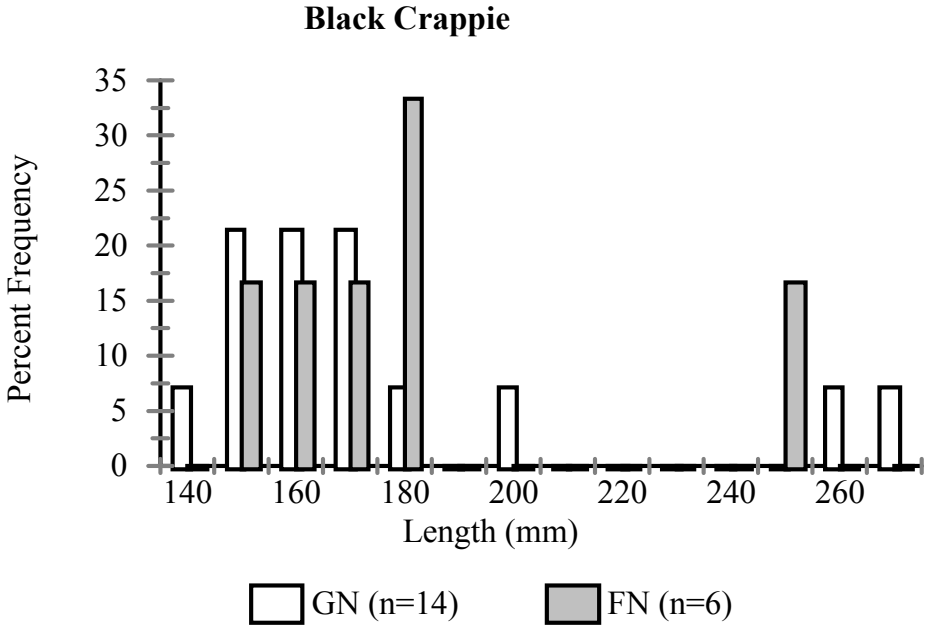

Figure 6. Length frequency distribution of black crappie, excluding young-of-the-year, sampled by gill netting (GN) and fyke netting (FN) at Pierre Lake (Stevens County) during June 2002.

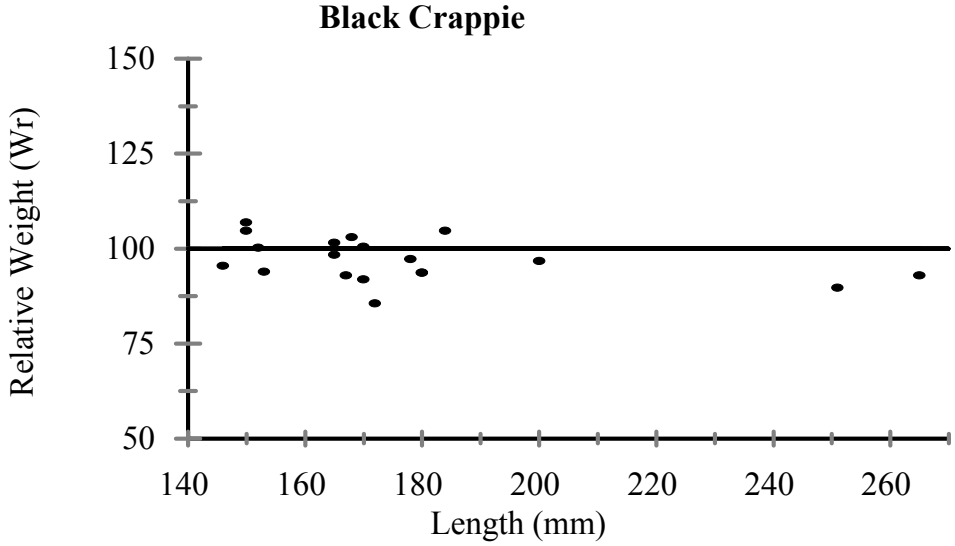

Figure 7. Relative weights of black crappie (n=20), excluding young-of-the-year, sampled at Pierre Lake (Stevens County) during June 2002, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Brown Bullhead

Brown bullhead sampled in Pierre Lake ranged in length from 230 to 330 mm total length (Table 5; Figure 8). Condition of all brown bullhead observed was above the national average (Figure 9). Age and growth were not analyzed for brown bullhead.

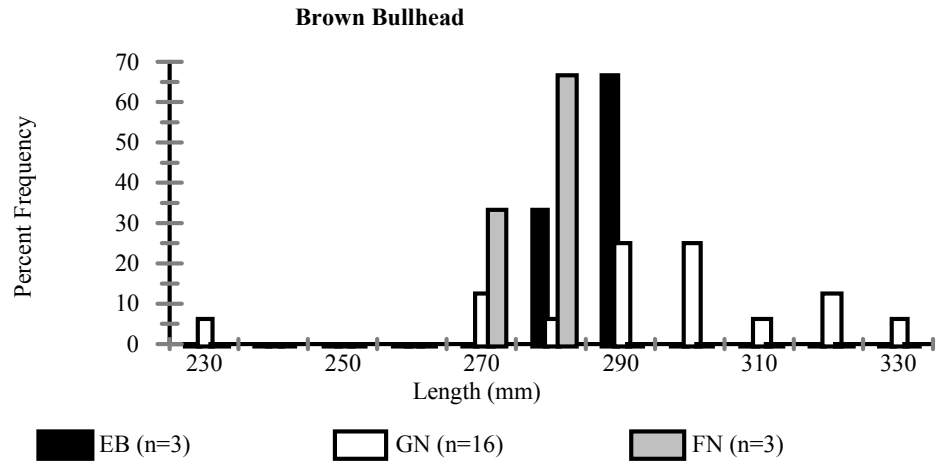

Figure 8. Length frequency distribution of brown bullhead sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Pierre Lake (Stevens County) during June 2002.

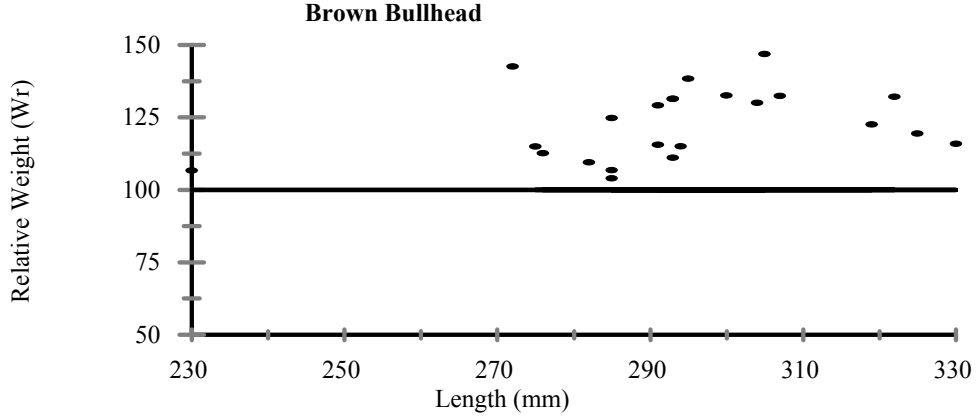

Figure 9. Relative weights of brown bullhead (n=22) sampled at Pierre Lake (Stevens County) during June 2002, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Walleye

One walleye was collected from Pierre Lake during the June 2002 sampling activities. This fish was 497 mm in length, weighed 1,184 g, and was 4 years of age. The WDFW has never stocked walleye into Pierre Lake, thus this fish was likely a result of an unauthorized introduction.

Cutthroat Trout

Cutthroat trout sampled from Pierre Lake ranged in length from 238 to 310 mm total length (Table 5; Figure 10). Cutthroat trout length frequency distribution reflects a stocked put-and-take population and does not indicate that natural reproduction is occurring (Figure 10). The condition of most cutthroat trout were below the national average (Figure 11) which may indicate interspecific forage competition. Age and growth were not analyzed for cutthroat trout.

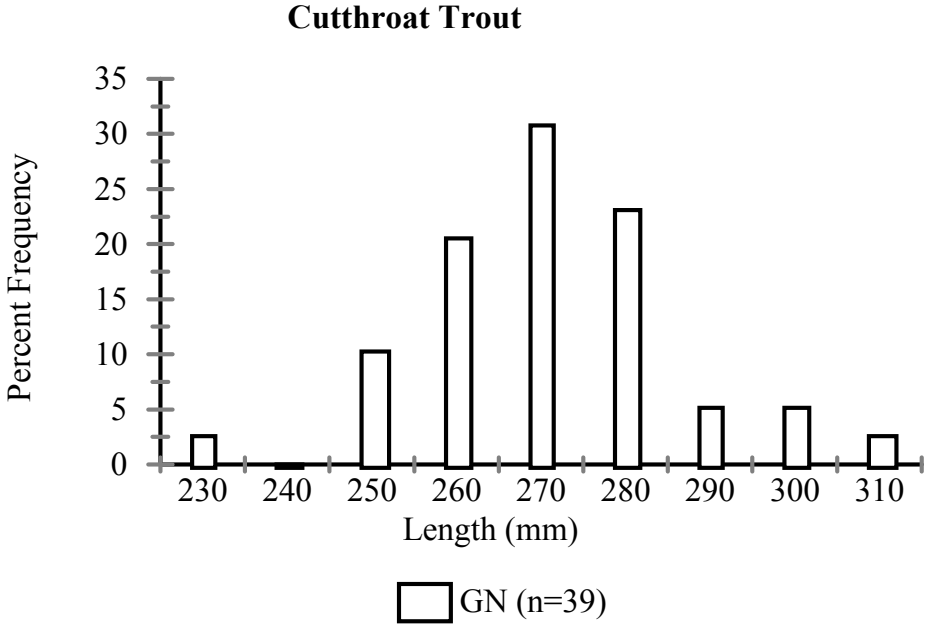

Figure 10. Length frequency distribution of cutthroat trout sampled by gill netting (GN) at Pierre Lake (Stevens County) during June 2002.

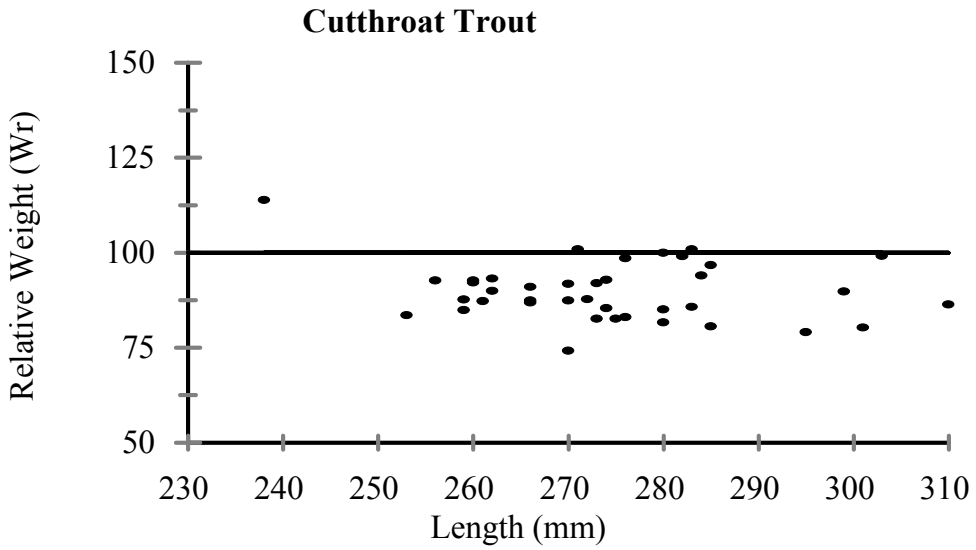

Figure 11. Relative weights of cutthroat trout (n=39) sampled at Pierre Lake (Stevens County) during June 2002, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Kokanee

Kokanee sampled from Pierre Lake ranged in length from 214 to 271 mm total length (Table 5; Figure 12). Because WDFW has not stocked kokanee in Pierre Lake since 1950, fish observed during the 2002 survey were most likely naturally reproduced. Washington Department of Fish and Wildlife personnel have observed kokanee spawning in Pierre Creek; however, the level of spawning success is unknown (Curt Vail, WDFW, personal communication). The condition of kokanee were below the national average (Figure 13) which may indicate interspecific forage competition. Kokanee less than 200 mm TL were not observed in our samples which may be a result of sample timing or gear bias rather than an indication of reproduction failure.

Lengths of kokanee (214-217 mm TL, n=58) sampled in Pierre Lake in June 2002 were similar to those sampled from Sullivan Lake, Pend Orielle County (118-339 mm TL, n=104) during May-July 2003 with the exception of low numbers of smaller and larger fish observed in Sullivan Lake (Eastern Washington University, unpublished data). Sullivan Lake and Pierre Lake kokanee were in similar condition, most having relative weights between 75 and 90 percent of the national average.

Kokanee sampled from Chain Lake, Pend Orielle County (176-399 mm TL, n=25) were both shorter and longer than those observed in Pierre Lake (Polacek et al., unpublished report). Kokanee between 177 and 310 mm (which encompasses the entire range of kokanee sampled in Pierre Lake) were not observed in Chain Lake. Although larger in size, Chain Lake kokanee were similar to those sampled in Pierre and Sullivan lakes in terms of condition. Most Chain Lake kokanee exhibited relative weights between 75 and 90 percent of the national average.

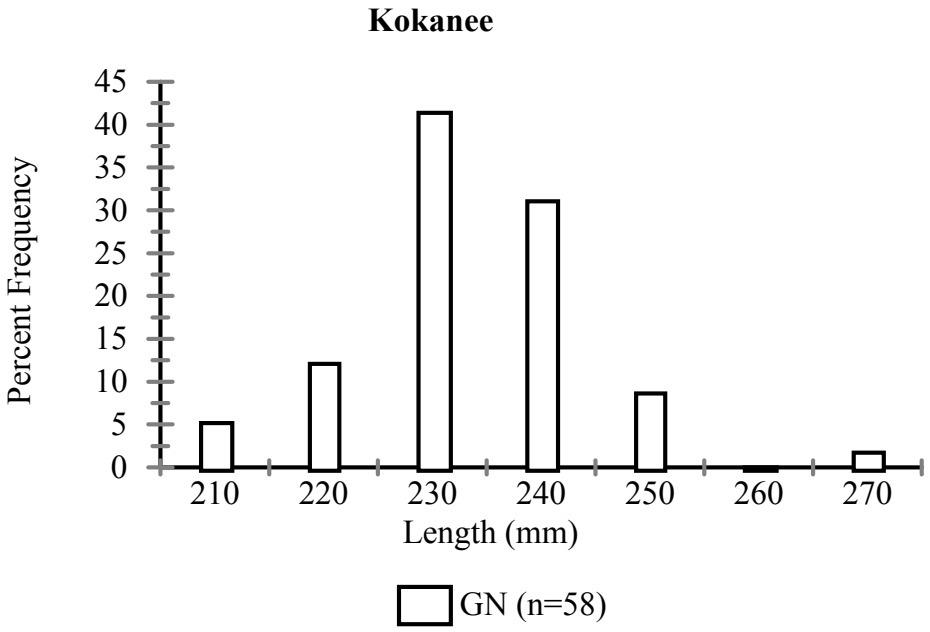

Figure 12. Length frequency distribution of kokanee sampled by gill netting (GN) at Pierre Lake (Stevens County) during June 2002.

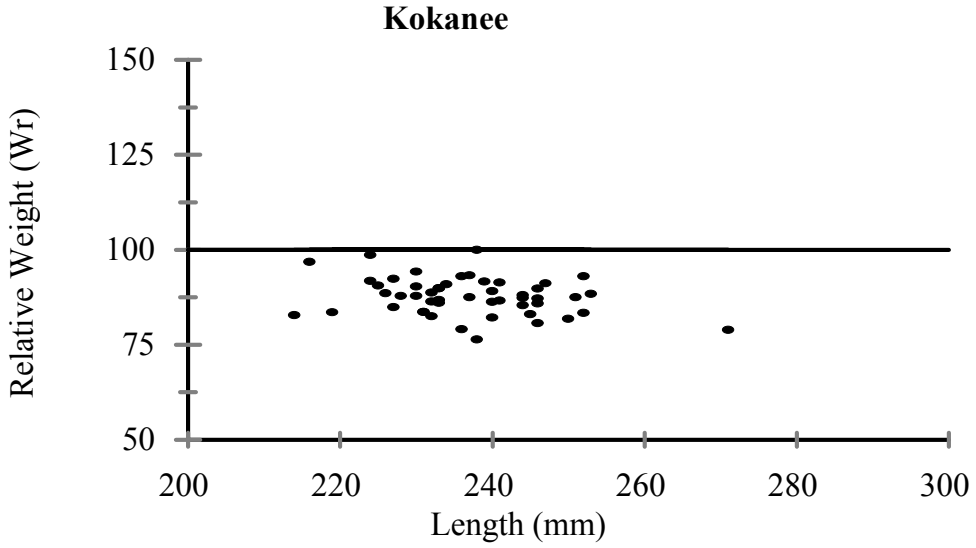

Figure 13. Relative weights of kokanee (n=50) sampled at Pierre Lake (Stevens County) during June 2002, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Rainbow Trout

Two rainbow trout were collected from Pierre Lake during the June 2002 sampling activities. One fish was 419 mm in length and weighed 904 g. The other fish was 452 mm in length and weighed 1,116 g. Both rainbow trout exhibited relative weights above the national average. Age and growth were not analyzed for rainbow trout.

Discussion

A total of eight different fish species were observed in Pierre Lake in June 2002. Green sunfish were the most abundant species present. Stock density indices suggest that the green sunfish population is in relatively high density. In general, green sunfish grow larger in Pierre Lake than in many northern waters (Wydoski and Whitney 2003). Green sunfish have little angling value until reaching about 130 mm TL (Wydoski and Whitney 2003). Although approximately one-third of the green sunfish observed in this survey were larger than 130 mm, most were small and likely provide little angling opportunity. In the early 1980s, black crappie were the dominant fish species in Pierre Lake. Since then, green sunfish have replaced black crappie as the dominant panfish species in the lake, although it is unknown when they became established in the lake. Black crappie in Pierre Lake are slow growing and are below the national average in terms of condition. Although crappie up to age 8 were observed in 2002, five year classes were absent. Slow growth, below average condition, and year-class failures during those years may all be attributed to green sunfish. Because green sunfish are aggressive feeders and can consume prey nearly half their body size (Wydoski and Whitney 2003), they most likely out-compete black crappie for available food, space and/or prey upon their young.

Largemouth bass were the second-most abundant fish species observed and contributed the single highest biomass of any species. Largemouth bass less than 250 mm TL exhibited below average condition which is likely due to interspecific competition with the highly abundant green sunfish. Conversely, the condition of largemouth bass larger than 250 mm was higher than that of smaller bass, which may indicate that larger bass are able to prey effectively upon forage species, rather than compete with them. Although largemouth bass up to 19 inches inhabit Pierre Lake, most are smaller than 10 inches. Considering the current status of the warmwater fish community, populations of all species would likely benefit by increased predation and/or angler harvest of the abundant green sunfish and smaller size largemouth bass.

Although trout density appeared low, the low catch rates are likely a result of sampling bias. Pelagic sampling and/or creel survey data, in addition to the warmwater survey protocols, would help quantify the contribution of trout to the fishery in Pierre Lake. The WDFW has not stocked kokanee in Pierre Lake since 1950, thus all that were observed were most likely from natural reproduction. Pierre Lake anglers are given the opportunity to catch cutthroat trout up to 13 inches, and rainbow trout up to 18 inches. Both rainbow trout observed in our samples were likely carry-overs from fish stocked in previous years.

Given its northern latitude, habitat characteristics, and history as a successful salmonid water, Pierre Lake may be best suited as a water managed for trout and kokanee. Historically, the lake was renowned for its trout and kokanee fishing, but since the early 1980s, Pierre Lake has been plagued with overpopulated panfish populations such as black crappie, and more recently, green sunfish. Pierre Lake supports a small number of quality size warmwater game fish; however,

most individuals are small and provide only limited angling value. The high density populations of green sunfish and small largemouth bass are likely utilizing a large proportion of the available food resources in the lake. Although few comparisons of relative weight was available for kokanee and rainbow trout, the condition of cutthroat trout in Pierre Lake were below the national average indicating that food may be limited. Additionally, Pierre Lake supports only limited shallow littoral habitat and, because of its northern latitude, offers a shorter growing season than most other Washington lowland lakes. Most of Pierre Lake is characterized by relatively steep shorelines and water depth in excess of 15 feet. Some species, such as largemouth bass and crappie, utilize deeper open-water habitat during certain parts of the year. However, habitat characteristics of Pierre Lake are probably more optimal for salmonid species rather than for warmwater fish (Wydoski and Whitney 2003) even though salmonids may be slightly restricted during summer because of low dissolved oxygen levels.

Management Considerations

Lake Rehabilitation

As in the past, if the management objective is to manage Pierre Lake as a trout water, rehabilitating the lake using rotenone should be an option considered. Because of the lake's connectivity to streams and wetlands, achieving lasting results would undoubtedly be a challenge. However, results lasting at least as long as other rehabilitated lowland trout waters could be expected. For example, the rehabilitation conducted in 1947 resulted in a viable trout and kokanee fishery for over three decades with few problems. Following the 1947 rehabilitation, kokanee were stocked in the lake for three consecutive years. From those stockings alone, kokanee produced a self-sustaining population which still exists today. It would be reasonable to believe that if the lake were rehabilitated again, successive stockings of kokanee would result in a self-sustaining population as in the past and stocked trout would provide a valuable fishery.

Slot-limit Regulation Monitoring

If Pierre Lake continues to be managed as a mixed-species fishery, management biologists should consider developing a long-term plan to monitor the statewide 12- to 17-inch slot-limit on largemouth bass implemented in May 2002. This survey was conducted approximately one month following this regulation change, and the indices of population structure from this survey are more than likely representative of the population under the previous regulation. Therefore, this survey may serve as a baseline for documenting changes in the Pierre Lake fish community under the new, more restrictive regulation. Objectives of the monitoring plan should focus on monitoring Pierre Lake every three to five years and documenting changes in population density and size structure of largemouth bass, and changes in the green sunfish and black crappie population structures possibly due to increased predation by largemouth bass. In addition, creel survey data should be collected regularly to evaluate angler compliance.

Creel Survey

Warmwater fisheries surveys can provide management biologists useful information on the state of a fish community; however, they provide only circumstantial evidence as to the effects of angler harvest. Creel surveys are an integral part of managing a fishery although adequate funding for such surveys is rarely available. Detailed and well planned creel surveys can provide more conclusive information. Creel surveys can provide information on fishing effort, angler catch per unit effort (e.g., number fish/hour fishing), and numbers of fish caught or harvested. Creel surveys can also be used to determine angler preferences with regard to management actions, regulations, as well as species and sizes of fish desired (Hahn et al. 1993). Additionally, creel survey data can also provide insights into the economic value provided by a fishery.

Biological information collected from the anglers creel can provide information not typically colleted during standard surveys. The preference of WDFW biologists is to return sampled fish back to the lake alive when conducting surveys. However, information collected from fish retained by anglers can be collected without additional harm to fish populations. For example, otoliths collected from dead fish are very accurate when determining fish age.

Creel survey objectives for Pierre Lake should include documenting fishery utilization throughout the year, angler catch per unit effort, and angler preferences. Otoliths should be collected from dead fish retained by anglers for more definitive aging of warmwater populations in the lake. Over time, creel information should aid management biologists in evaluating current regulations and their effect on fisheries management objectives.

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