1999 Warmwater Fisheries Survey of Palmer Lake (Okanogan County), Washington

by

Randall S. Osborne, Marc R. Petersen, and Chad S. Jackson
Warmwater Enhancement Program
Washington Department of Fish and Wildlife
1550 Alder Street NW
Ephrata, Washington 98823

June 2003

Acknowledgments

We would like to thank John Pahutski, Teresa Nelson, and Heather Bartlett of the Washington Department of Fish and Wildlife (WDFW) for their assistance with data collection. We would also like to thank Joe Foster, Heather Bartlett, Michael Schmuck, and Jeff Korth (WDFW) for reviewing the original draft of this manuscript and Marc Divens, Larry Phillips, and Chris Donley (WDFW) who provided us with technical support. A sincere thanks also goes out to Dale Swedberg for allowing us to use the facilities at the Sinlahekin Wildlife Management Area and his son, Adam Swedberg, for assisting with data collection efforts. This survey was funded by the WDFW Warmwater Enhancement Program.

Abstract

Palmer Lake was surveyed June 21-25 and September 12-15, 1999, using a boat electrofisher, gill nets, and fyke nets. A total of 12 and 15 fish species were observed during the June and September sampling efforts, respectively. More fish were collected by boat electrofisher than gill nets or fyke nets. Electrofishing catch rates were highest for peamouth *Mylocheilus caurinus* (26.8 fish/hr) and black crappie *Pomoxis nigromaculatus* (60.3 fish/hr) during the June and September sampling periods, respectively. Smallmouth bass *Micropterus dolomieu* were the most abundant warmwater gamefish observed in both June (22%) and September (32%). Largescale sucker *Catostomus macrocheilus* produced the most biomass in the June (32.7%) and September (35.3%) samples. Proportional stock density (PSD) values indicate a relatively large proportion of the largemouth bass *M. salmoides* and smallmouth bass were of at least the preferred length category. Several smallmouth bass in the relative stock density (RSD) trophy category were observed. No black crappie, bluegill *Lepomis macrochirus*, or yellow perch *Perca flavescens* of greater than quality length were observed in our samples. Largemouth bass sampled in September ranged from 96 to 565 mm total length (TL), and appeared to be in good condition with few fish exhibiting relative weights less than 100. Smallmouth bass (ages 1-7) ranged from 93 to 590 mm (TL) but were below the statewide growth average except for age 5 fish. Relative weights of smallmouth bass were below the national average for most fish. Black crappie ranged in age from 1 to 6 years and growth was both above (ages 1, 4-6) and below (ages 2 and 3) the statewide average. Relative weights of black crappie were higher during September with few fish having relative weights less than 85. Bluegill sampled in September ranged from 80 to 180 mm (TL). Relative weights of most bluegill were above the national average and few fish had relative weights less than 100. Yellow perch (ages 1-5) ranged from 73 to 235 mm (TL). Growth of age 1, 2, and 3 yellow perch were above the statewide average, but below the statewide average for ages 4 and 5. Condition of yellow perch sampled in June and September were similar. Most fish were below the national average. No regulation changes are recommended at this time. We recommend stocking black crappie and bluegill to increase the prey base for smallmouth and largemouth bass, and to increase angling opportunities. We also recommend that periodic warmwater fish surveys should be conducted to monitor the size structure and condition of gamefish, including burbot, in Palmer Lake. In addition, future monitoring would likely forecast whether additional panfish stocking will be needed and/or whether adjustments in regulations should be made.

Table of Contents

List of Tables

List of Figures

Introduction and Background

Located in the Okanogan National Forest approximately five miles north of Loomis, Washington, Palmer Lake drains approximately 767 square kilometers (296 square miles) of north-central Washington's Sinlahekin Valley (Fig. 1). The lake has a surface area of 854 hectares (2,110 acres), a mean depth of 15.5 meters (m)(51 feet), maximum depth of approximately 27.7 m (91 feet), and volume of 107,610 acre-feet. Water is supplied to the south end of Palmer Lake via Sinlahekin Creek. Between the months of March and July, water levels of the lake are governed by the flows of the Similkameen River (Joe Foster, Washington Department of Fish and Wildlife (WDFW), pers. comm.). Water exits Palmer Lake at the north end through Palmer Creek. Palmer Creek flows northerly for several miles before joining the Similkameen River. During periods of high water, the Similkameen River flows into Palmer Creek, which reverses its flow, thus elevating the level of Palmer Lake.

Most of the land surrounding Palmer Lake is privately owned. Portions of the land, such as Palmer Lake Campground and Split Rock boat launch, are operated by the Washington Department of Natural Resources (DNR) and the United States Bureau of Land Management, respectively (Linda Shaw, DNR, pers. comm.). During the 1980s the Oroville-Tonasket Irrigation District (OTID) proposed to construct a water control structure on the outlet of Palmer Lake to provide a supplemental water supply to the district in case of inadequate water supplies from Lake Osoyoos and the Okanogan River (Tom Scott, OTID, pers. comm.). The OTID proposed to store 10,500 acre-feet of water and raise Palmer Lake to spring levels in years when water supplies in Lake Osoyoos were inadequate. However, public opposition prevented the action.

Palmer Lake is managed as a mixed-species fishery. Historical stocking records indicate that since 1972, WDFW has stocked the lake with rainbow trout *Oncorhynchus mykiss*, kokanee salmon *O. nerka*, eastern brook trout *Salvelinus fontinalis*, brown trout *Salmo trutta*, Lahontan cutthroat trout *O. clarki henshawi*, black crappie *Pomoxis nigromaculatus*. Smallmouth bass *Micropterus dolomieu* were introduced to the lake by WDFW in 1982, and while they have inhabited the lake for many years, the first documented stocking of largemouth bass *M. salmoides* occurred in 1984. Additional fish species found in Palmer Lake include burbot *Lota lota*, bluegill *Lepomis macrochirus*, northern pikeminnow *Ptychocheilus oregonensis*, lake whitefish *Coregonus clupeaformis*, peamouth *Mylocheilus caurinus*, largescale sucker *Catostomus macrocheilus*, and bridgelip sucker *C. columbianus*. Moreover, yellow perch *Perca flavescens* have become established in the lake through unauthorized introduction. Anglers have reported catching walleye *Stizostedion vitreum*, the origin of which are unknown, although numbers were likely few.

Palmer Lake provides a myriad of outdoor opportunities throughout the year. Anglers are allowed to fish the lake year-around. All bass species in Palmer Lake are protected by a slotlength limit regulation which allows anglers to harvest five bass less than 12 inches to include no more than one bass over 17 inches in length. Anglers may harvest five burbot of any size from Palmer Lake. In addition to conventional angling gear, anglers may fish for burbot using one set line with up to five hooks. Although there is no minimum size limit, anglers are allowed to harvest a combination of five trout (rainbow, Lahontan cutthroat, brook, brown) and salmon (kokanee) from Palmer Lake.

With the exception of those species mentioned previously, there is currently no minimum size or daily bag limit on the remaining fish species present in Palmer Lake. The public also uses the lake and its surrounding forest for hunting, camping, swimming, and hiking. In addition, wildlife enthusiasts occasionally utilize the lake for observing mountain goats *Oreamnos americanus* on near-by Grandview Mountain.

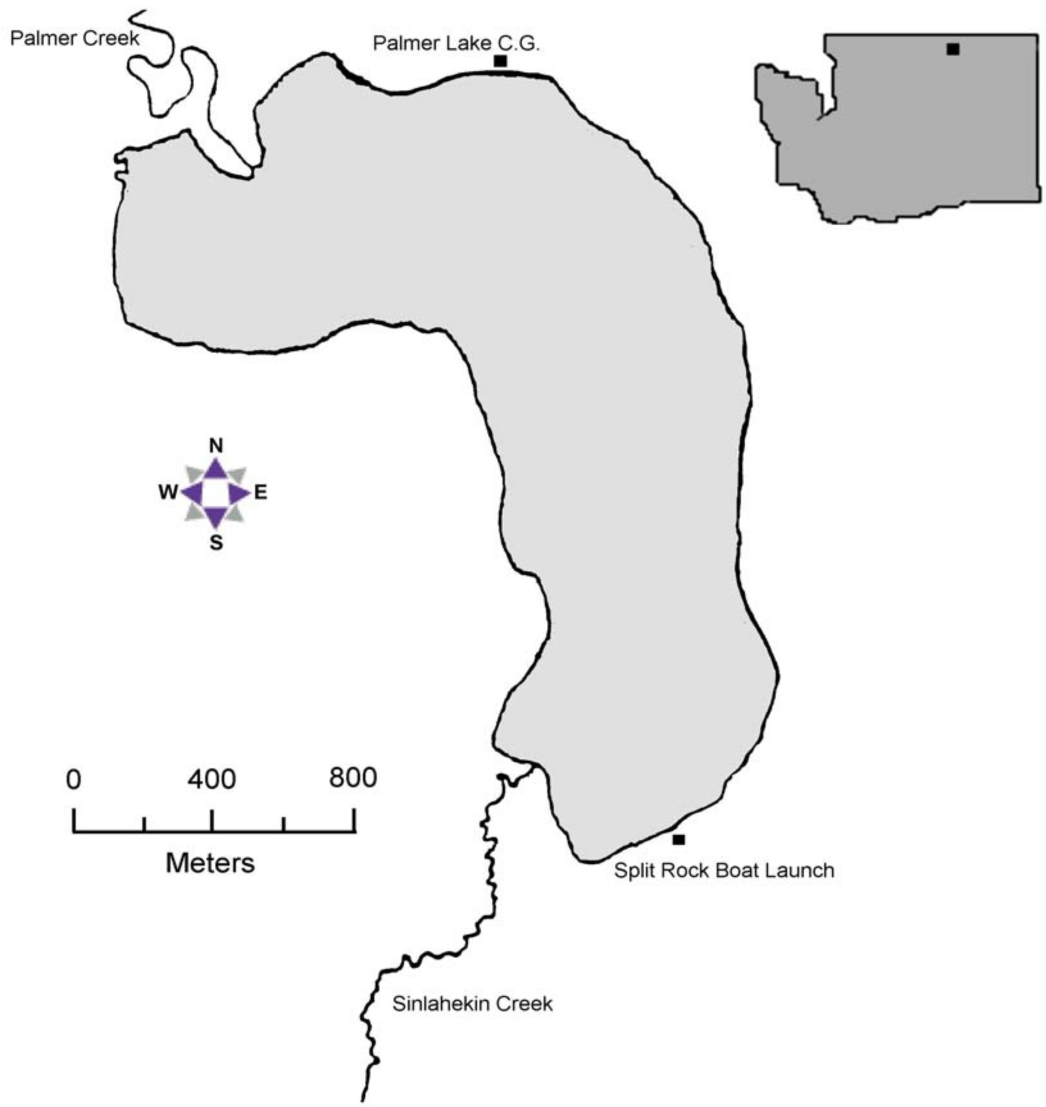

Figure 1. Map of Palmer Lake (Okanogan County).

Table 1. Fish stocked in Palmer Lake since 1980. Species included rainbow trout (RB), smallmouth bass (SMB), eastern brook trout (EB), largemouth bass (LMB), kokanee (K), brown trout (BT), Lahontan cutthroat trout (LCT), and black crappie (BC). The size of fish stocked (excluding fry) were abbreviated as follows: f - fingerlings, a - adults, and sa - sub-adults.

Year	Species	Size	No. Stocked	Year	Species	Size	No. Stocked
1980	RB	f	38,788	1988	K	fry	102,630
1981	RB	f	73,232	1989	K	fry	40,000
1982	RB	f	37,400	1990	K	fry	100,000
	SMB	a	34	1991	K	fry	61,291
1983	SMB	a	75		RB	f	48,000
1984	EB	f	29,250	1992	K	fry	96,000
	SMB	a	64	1993	K	fry	100,000
	LMB	a	58	1994	K	fry	100,815
1985	K	fry	71,145	1995	K	fry	100,100
	BT	f	25,248		LCT	f	12,992
	LCT	fry	166,695	1996	K	fry	100,100
	RB	f	40,050		LMB	sa	219
	LMB	a/sa	383	1997	K	fry	100,000
1986	BT	u	12,400	1998	K	fry	115,416
	LCT	fry	218,290		LMB	a	1,057
	K	fry	115,700	1999	LMB	a	574
1987	K	fry	120,625		BC	fry	28,550
	LCT	fry	157,300	2000	K	fry	112,998
	RB	f	30,005				

Methods And Materials

Palmer Lake was surveyed by a three-person team June 21-25 and September 12-15, 1999. All fish were collected by boat electrofisher, gill nets, or fyke nets. The electrofishing unit consisted of a 5.5 meter (m)(18 ft.) 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 (four 1.2 m aluminum rings), 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 400 m sections determined from a map. The number of randomly selected sections surveyed were as follows: electrofishing - 15, gill nets - 8, and fyke nets - 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 70E angles from the lead. Gill nets and fyke nets were set overnight prior to electrofishing and were pulled the following morning (one net night each). All sampling was conducted during night-time hours when fish are most numerous along the shoreline thus maximizing the efficiency of each gear type.

All fish were identified to species, measured (mm) to total length (TL) from the anterior-most part of the head to the tip of the compressed caudal fin, and weighed to the nearest gram (g). Total length data was used to construct length-frequency histograms and to evaluate the size structure of the warmwater gamefish in the lake. In June, warmwater gamefish were assigned to a 10 mm size group based on total length, and scale samples were collected from the first five fish in each size group (Bonar et al. 2000). Scale samples were mounted on adhesive data cards and pressed onto acetate slides using a Carver® laboratory press (Fletcher et al. 1993).

Water chemistry data were collected at 1 m increments from the area of greatest depth (15 m during spring, and 13 m during fall). A Hydrolab® was used to collect information on dissolved oxygen (milligrams per liter)(mg/l), temperature (degrees Celsius)(EC), pH, conductivity (micro-siemens per centimeter)(FS/cm), and turbidity (nephelometric turbidity units)(NTU).

Species composition, by weight (kg) and number, was calculated from samples collected using a boat electrofisher, gill nets, and fyke nets. Fish less than 1 year old, young-of-the-year (YOY), were excluded from all analyses. Eliminating YOY fish prevented 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, fish/hour) of each sampling gear was determined for each warmwater fish species collected. Electrofishing CPUE was determined by dividing the number of fish captured by the amount of time that was spent electrofishing. Similarly, CPUEs were determined from gill and fyke samples by dividing the number of fish captured by the total time the nets were deployed.

A relative weight (W_r) index was used to evaluate the condition of fish in Palmer Lake. A W_r of 100 indicates that the fish is in a condition similar to the national average for that species and length (Anderson and Neumann 1996).

$$W_r = W/W_s \times 100$$

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). W_s was derived from a standard weight-length ($\log_{10}$) relationship which is defined for each species of interest in Anderson and Neumann (1996). Minimum lengths were used for each species since the variability can be significant for small fish (YOY). Relative weights less than 50 were also excluded due to inaccurate weight measurements.

Age and growth of warmwater gamefish in Palmer 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). Mean back-calculated lengths-at-age for all warmwater species were then compared to those of Eastern Washington and/or statewide averages (Fletcher et al. 1993).

The proportional stock density (PSD) of each warmwater gamefish species was determined following procedures outlined in Anderson and Neumann (1996). PSD uses two measurements, stock length and quality length, to provide useful information about the proportion of various fish sizes of a population. Stock length was defined as the minimum size of a fish which provides recreational value or the approximate length when fish reach maturity (Table 2). Quality length is defined as the minimum size of a fish that most anglers liked to catch and 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 vary by species and are based on percentages of world-record lengths. Stock length is 20-26 percent of world record length, whereas quality length is 36-41 percent of world record length.

Relative stock density (RSD) of each warmwater gamefish 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 2). Preferred length (RSD-P) is defined as the minimum size of fish anglers preferred to catch. Memorable length (RSD-M) is the minimum size fish anglers remembered catching and trophy length (RSD-T) is the minimum size of fish worthy of acknowledgment or a true trophy. Preferred, memorable, and trophy length fish are 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. RSD differs from PSD in that it is more sensitive to changes in year class strength. RSD is 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 PSD and RSD were selected from tables in Gustafson (1988).

Table 2. Minimum total length (mm) categories of warmwater fish used to calculate PSD and RSD values (Willis et al. 1993).

	Length Category				
Species	Stock	Quality	Preferred	Memorable	Trophy
Black crappie	130	200	250	300	380
White crappie *P. annularis*	130	200	250	300	380
Bluegill	80	150	200	250	300
Yellow perch	130	200	250	300	380
Largemouth bass	200	300	380	510	630
Smallmouth bass	180	280	350	430	510
Walleye	250	380	510	630	760
Channel catfish *Ictalurus punctatus*	280	410	610	710	910
Brown bullhead *I. nebulosus*	150	230	300	390	460
Yellow bullhead *I. natalis*	150	230	300	390	460

Results And Discussion

Species Composition

Twelve fish species were observed in June and fifteen fish species were observed in September (Table 3). Warmwater gamefish comprised 40.4 and 65.2% of the total fish captured in June and September, respectively. Peamouth were the most abundant species (29.9%) encountered in the June samples, whereas smallmouth bass were the most captured species (32.0%) in September. Although less abundant, largescale sucker represented 32.7 and 35.3% of the total biomass in the June and September samples, respectively. Burbot, while known to be a popular gamefish in Palmer Lake, were not observed during either survey. This may be due, in part, to the inability of our sampling gears to reach species inhabiting deep water.

Largemouth bass, pumpkinseed sunfish, and bluegill were encountered only in the fall. This may be due to the fact that water levels in the fall are at normal levels, whereas in the spring they are much higher. High water increases the amount of littoral habitat and decreases the proportion of shoreline sampled. Although sampled in low numbers (n = 5), rainbow trout were observed in June but not in September. We were uncertain why rainbow trout were observed only in June, perhaps due to prey abundance or location, but low numbers were expected. Rainbow trout (n = 48,000) were last stocked in Palmer Lake in 1991 as fingerlings (Table 1). Although some natural reproduction may occur, survival is likely low due to the prevalence of pelagic predators such as northern pikeminnow in the lake.

Higher numbers of kokanee were sampled in September (n = 100) than in June (n = 6) which was likely due to sampling date. Since kokanee are a pelagic species, we did not expect to sample high numbers. In September, most of the kokanee were collected near the mouth of Sinlahekin Creek where the fish were staging to spawn. Although some natural reproduction occurs in Sinlahekin Creek (Ken Williams, WDFW retired, pers. comm.), kokanee populations in Palmer Lake have been annually supplemented since 1985, with the exception of 1999 (Table 1). Kokanee fry were stocked in higher numbers (~ 100,000/year) than any other species in Palmer Lake. However, due to high mortality exhibited by fish stocked as fry and the abundant predators inhabiting the lake, kokanee populations in Palmer Lake are not likely self sustaining.

Northern pikeminnow and peamouth were two species observed in high numbers during both surveys. While pelagic as adults, the young of both species are found to rear in shallow, littoral habitat, and should provide prey for predator fish species within the lake. We observed several instances of adult northern pikeminnow strangled from attempting to engulf adult peamouth which had become entangled in our gill nets. This behavior suggests peamouth may be a preferred prey for adult northern pikeminnow in Palmer Lake. This may be a desirable relationship since northern pikeminnow are known to be a voracious predator and may consume more desired gamefish within the lake if peamouth were unavailable as forage.

Table 3. Species composition, by weight and number, of fish sampled at Palmer Lake, Washington during June and September 1999. Analyses do not include young-of-year.

	Species Composition					
	Weight		Number		Size Range(mm)	
Fish Species	kg	%	No.	%	Min.	Max.
June						
Black crappie	1.3	0.52	10	1.31	87	362
Bridgelip sucker	0.8	0.33	2	0.26	232	415
Chiselmouth *Acrocheilus alutaceus*	0.2	0.08	1	0.13	272	272
Carp *Cyprinus carpio*	29.8	12.14	24	3.15	425	576
Kokanee	1.9	0.77	6	0.79	310	356
Largescale sucker	80.3	32.71	103	13.52	72	525
Mountain whitefish *Prosopium williamsoni*	0.8	0.33	4	0.52	261	288
Northern pikeminnow	52.8	21.51	81	10.63	177	680
Peamouth chub	41.8	17.03	228	29.92	108	298
Rainbow trout	1.9	0.77	5	0.66	292	390
Smallmouth bass	29.1	11.84	171	22.44	93	590
Yellow perch	4.8	1.96	127	16.67	75	235
September						
Black crappie	9.2	2.39	305	14.15	67	220
Bluegill	4.4	1.16	126	5.85	80	180
Bridgelip sucker	1.1	0.30	6	0.28	177	331
Chiselmouth	0.0	0.01	1	0.05	151	151
Sculpin	0.0	0.00	1	0.05	90	90
Carp	13.7	3.57	26	1.21	75	507
Kokanee	28.4	7.39	100	4.64	99	377
Largemouth bass	16.1	4.19	13	0.60	96	565
Largescale sucker	135.3	35.24	196	9.10	132	542
Mountain whitefish	6.4	1.68	29	1.35	200	395
Northern pikeminnow	58.1	15.15	159	7.38	110	596
Peamouth chub	43.4	11.30	227	10.53	207	303
Pumpkinseed sunfish *L. gibbosus*	0.0	0.01	2	0.09	102	109
Smallmouth bass	59.0	15.38	686	31.83	105	525
Yellow perch	8.5	2.22	278	12.90	73	222

Catch per Unit Effort (CPUE)

When using either active (electrofisher) or passive (gill or fyke nets) sampling techniques, CPUE can be used as an index to monitor size structure and relative abundance of fish species in a lake or reservoir (Hubert 1996). CPUE results from this survey provide baseline information which will allow fishery managers to monitor the effectiveness of management efforts in the future.

We captured more fish with an electrofisher than we did using gill nets or fyke nets during both sampling periods. During June, the highest overall catch rate from each sampling gear was for peamouth, whereas the smallmouth bass catch rate by electrofisher, and gill net and fyke net catch rates for yellow perch, were highest for warmwater gamefish (Table 4). During September, catch rates for warmwater gamefish were highest for yellow perch collected by electrofisher, black crappie collected with gill nets, and bluegill collected with fyke nets.

Sizes of fish captured with an electrofisher were similar in most cases to the sizes of fish captured during gill net sampling (refer to length-frequency histograms under species sections). In September, we captured more smallmouth bass 370-440 mm using gill nets than we did with an electrofisher. Fyke nets tended to capture smaller sizes of some species (e.g., black crappie and largemouth bass) and larger sizes of other species (e.g., smallmouth bass) compared to an electrofisher and gill nets. Gill nets captured larger yellow perch than the electrofisher and fyke nets. Adult yellow perch inhabit pelagic water and are, under most circumstances, sampled more effectively using gill nets.

Table 4. Mean catch per unit effort and 80% confidence intervals (CI), by gear type, of fish (excluding YOY) sampled at Palmer Lake, Washington, in June and September 1999.

	Gear Type								
	Electrofisher			Gill Nets			Fyke Nets		
Species	No. Hour	CI (+/-)	No. Sites	No. per Night	CI (+/-)	Net Nights	No. per Night	CI (+/-)	Net Nights
June									
Black crappie	1.20	1.11	15	0.00	–	8	0.25	0.21	8
Bridgelip sucker	0.00	–	15	0.13	0.16	8	0.13	0.16	8
Chiselmouth	0.00	–	15	0.13	0.16	8	0.00	–	8
Carp	6.80	3.51	15	0.50	0.24	8	0.38	0.34	8
Kokanee	1.20	1.54	15	0.38	0.23	8	0.00	–	8
Largescale sucker	20.40	4.85	15	4.75	2.81	8	1.75	1.41	8
Mountain whitefish	0.00	–	15	0.38	0.23	8	0.13	0.16	8
Northern pikeminnow	10.00	3.41	15	4.38	1.84	8	3.00	2.13	8
Peamouth chub	26.80	9.52	15	14.75	7.55	8	5.38	4.76	8
Rainbow trout	0.40	0.51	15	0.50	0.48	8	0.00	–	8
Smallmouth bass	16.80	4.76	15	1.00	0.64	8	0.75	0.53	8
Yellow perch	9.60	3.81	15	2.88	1.72	8	0.88	0.66	8
September									
Black crappie	60.31	34.00	15	4.00	2.51	8	0.25	0.32	8
Bluegill	46.71	33.46	15	0.25	0.21	8	0.88	0.78	8
Bridgelip sucker	2.37	1.24	15	0.00	–	8	0.00	–	8
Chiselmouth	0.00	–	15	0.00	–	8	0.13	0.16	8
Sculpin, unknown	0.40	0.51	15	0.00	–	8	0.00	–	8
Carp	4.76	2.25	15	0.38	0.23	8	0.00	–	8
Kokanee	23.59	23.82	15	3.88	2.26	8	0.00	–	8
Largemouth bass	3.59	3.07	15	0.38	0.34	8	0.00	–	8
Largescale sucker	40.91	7.89	15	9.38	3.48	8	2.25	1.47	8
Mountain whitefish	7.97	3.79	15	0.63	0.42	8	0.00	–	8
Northern pikeminnow	15.53	5.95	15	14.00	4.46	8	1.00	0.59	8
Peamouth chub	15.19	7.19	15	23.50	8.72	8	0.13	0.16	8
Pumpkinseed sunfish	0.80	0.70	15	0.00	–	8	0.00	–	8
Smallmouth bass	32.76	15.72	15	2.88	1.54	8	0.00	–	8
Yellow perch	63.26	32.07	15	1.38	0.90	8	0.50	0.64	8

Stock Density Indices

PSDs for smallmouth bass were 48 ± 10 and 63 ± 22 for samples collected in June using an electrofisher and gill nets, respectively (Table 5). Of the number of stock length smallmouth bass collected by an electrofisher (n = 42) , 21 ± 8 percent were of preferred size. Sixty-three (± 22) percent of the stock length smallmouth bass (n = 8) collected using gill nets were of preferred size. The PSDs for yellow perch collected in June using an electrofisher and gill nets were 17 ± 10 and 39 ± 13, respectively. None of the yellow perch sampled by any gear type were larger than quality length.

In September, PSDs for smallmouth bass collected by electrofisher (n = 82) and gill nets (n = 23) were 20 ± 7 and 87 ± 9, respectively (Table 5). Of those collected with gill nets, 83% were at least preferred size fish. Similarly, the PSDs for largemouth bass collected electrofishing (n = 9) was 67 ± 20. A minimum of 56% and 44% of these largemouth bass were of preferred and memorable size, respectively. The PSD for black crappie (n = 151), bluegill (n = 117), and yellow perch (n = 159) collected in September by an electrofisher were 1 ± 1, 8 ± 3, and 1 ± 1, respectively. Of those, none were larger than quality size.

Overall, many of the largemouth and smallmouth bass sampled were of at least preferred length. Moreover, relatively few stock length panfish were sampled. A low number of those stock length panfish are recruiting to quality size or larger. This may indicate that: (1) panfish were being cropped by predators, thereby reducing their overall abundance; (2) anglers were harvesting these fish as they reach stock or quality sizes; and/or (3) reproduction was limited because of low numbers of mature panfish. Anderson and Neuman (1996) suggest a sample size of 55 stock length fish is required for a valid PSD estimate. Certain species were collected in inadequate sample sizes; therefore, PSD values should be viewed with caution.

Table 5. Proportional (PSD) and relative (RSD, P = preferred, M = memorable, T = trophy) stock densities, by gear type, including 80% confidence intervals, of fish collected from Palmer Lake, Washington. Fish were sampled in June and September, 1999.

Species	#Stock Length	PSD	RSD-P	RSD-M	RSD-T
		June			
		Electrofisher			
Black crappie	3	33 ± 34	33 ± 35	33 ± 35	0
Smallmouth bass	42	48 ± 10	21 ± 8	2 ± 3	0
Yellow perch	24	17 ± 10	0	0	0
		Gill Nets			
Smallmouth bass	8	63 ± 22	63 ± 22	0	0
Yellow perch	23	39 ± 13	0	0	0
		Fyke Nets			
Black crappie	2	50 ± 45	50 ± 45	50 ± 45	0
Smallmouth bass	6	83 ± 19	83 ± 19	67 ± 25	50 ± 26
Yellow perch	7	43 ± 24	0	0	0
		September			
		Electrofisher			
Black crappie	151	1 ± 1	0	0	0
Bluegill	117	8 ± 3	0	0	0
Largemouth bass	9	67 ± 20	56 ± 21	44 ± 21	0
Pumpkinseed sunfish	2	0	0	0	0
Smallmouth bass	82	20 ± 7	9 ± 4	4 ± 3	0
Yellow perch	159	1 ± 1	0	0	0
		Gill Nets			
Black crappie	32	0	0	0	0
Bluegill	2	0	0	0	0
Largemouth bass	3	33 ± 35	33 ± 35	0	0
Smallmouth bass	23	87 ± 9	83 ± 10	13 ± 9	4 ± 5
Yellow perch	11	27 ± 17	0	0	0
		Fyke Nets			
Black crappie	2	0	0	0	0
Bluegill	7	0	0	0	0
Yellow perch	4	50 ± 32	0	0	0

Water Chemistry

Due to equipment failure, water chemistry samples were collected on July 9, 1999, 14 days following the June sampling period. Water chemistry parameters for Palmer Lake during both sampling periods were within acceptable ranges for supporting good health and vigorous growth of warmwater fish species (Table 6). Thermal stratification of Palmer Lake was observed during both sampling periods. Stratification occurred between 5 and 6 m of depth during July, and between 7 and 8 m of depth during September. Water temperatures ranged from 8.6 to 20.9EC in July and from 9.2 to 21.7EC in September. In July, dissolved oxygen ranged from 1.6 to 8.6 mg/l and dissolved oxygen concentration did not drop below 5.0 mg/l until a depth of 11 m. In September, dissolved oxygen ranged from 0.3 to 5.9 mg/l and although water deeper than 9 m was close to becoming anoxic, the majority of the water column supported dissolved oxygen concentrations greater than 4.0 mg/l. The pH levels of Palmer Lake were within the range (6.5-9) desirable for warmwater fish as reported by Swingle (1969).

Table 6. Water chemistry data collected from Palmer Lake, Washington in July and September 1999.

Location	Depth (m)	Temp (EC)	pH	Dissolved O_2	Conductivity
		July			
Main Body	Surface	20.90	8.39	8.60	163.4
	1	18.35	8.37	8.20	162.7
	2	17.89	8.37	8.04	161.7
	3	17.76	8.37	8.22	161.7
	4	17.09	8.30	8.14	161.2
	5	16.29	8.14	7.87	159.2
	6	13.57	8.14	8.16	106.5
	7	12.11	7.96	6.54	181.3
	8	10.74	7.94	5.57	203.6
	9	10.13	7.93	5.31	212.5
	10	9.80	7.92	5.16	219.5
	11	9.53	7.91	4.63	223.7
	12	9.17	7.89	4.06	229.7
	13	8.99	7.86	3.43	232.7
	14	8.66	7.82	1.89	238.0
	15	8.61	7.82	1.57	239.3
		September			
Main Body	Surface	21.70	8.63	5.55	196.1
	1	19.26	8.72	5.78	194.5
	2	18.32	8.73	5.94	194.2
	3	17.81	8.62	5.47	194.6
	4	17.72	8.56	5.33	195.1
	5	17.54	8.47	5.18	195.4
	6	17.49	8.40	4.89	196.1
	7	17.35	8.36	4.76	196.3
	8	14.88	7.46	2.50	202.8
	9	13.24	7.30	1.58	200.8
	10	11.53	7.26	1.31	210.7
	11	10.73	7.25	1.14	215.3
	12	9.90	7.26	1.00	224.0
	13	9.64	7.23	0.78	229.3

Largemouth Bass

No largemouth bass were sampled at Palmer Lake in June which may have been a function of water level (see species composition). Fish scale samples were only collected during the June survey, therefore age and growth of largemouth bass were not investigated. Largemouth bass (n = 13) ranged from 96 to 565 mm (Table 3, Fig. 2). Largemouth bass appeared to be in good condition. Very few had relative weights less than 100 (Fig. 3).

In Washington, largemouth bass spawning typically peaks in mid to late June in water one to four feet deep (Wydoski and Whitney 1979). Since water elevation in Palmer Lake is ultimately governed by flows of the Similkameen River during spring run-off, lake levels are often receding during June. In years exhibiting normal run-off, water levels can fluctuate approximately fifteen feet in late spring and early summer (OTID unpublished). Only one YOY largemouth bass was observed in our samples indicating that recruitment is likely limited due to water fluctuations in the spring. In addition, largemouth bass in Palmer Lake may spawn later due to cooler water temperatures than fish found in more southern latitudes which may result in low overwinter survival.

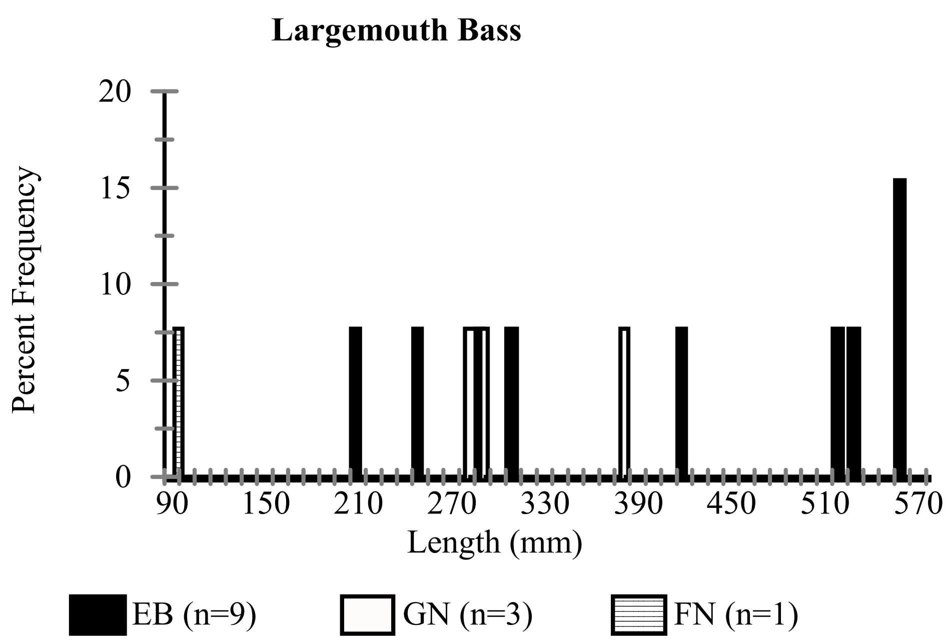

Figure 2. Length frequency distribution of largemouth bass sampled at Palmer Lake, Washington, during September 1999 using an electrofisher (EB), gill nets (GN), and fyke nets (FN). No largemouth bass were collected during the June 1999 sampling.

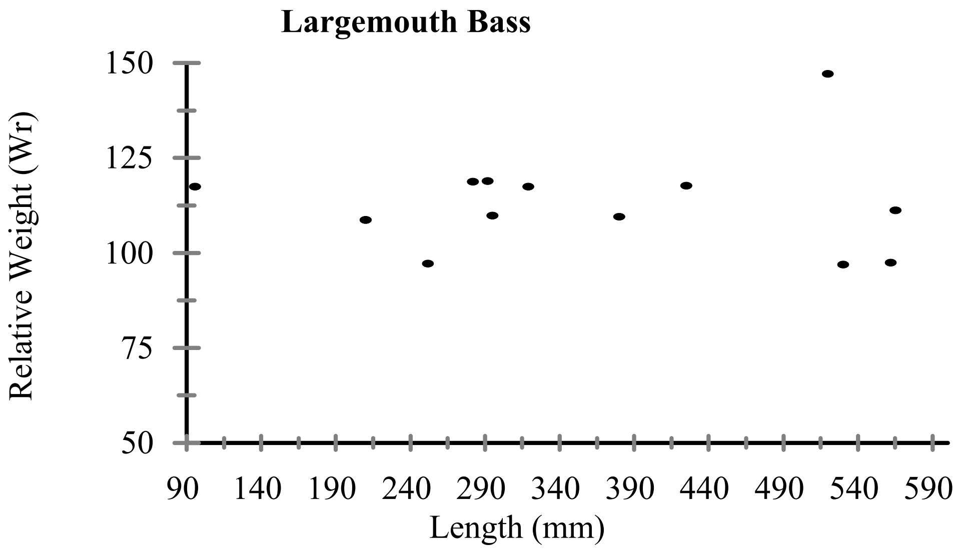

Figure 3. Relative weights of largemouth bass (n = 13) sampled at Palmer Lake, Washington during September 1999 compared to the national average, W_r=100 (Anderson and Neumann 1996).

Smallmouth Bass

Smallmouth bass were the most abundant warmwater gamefish sampled, comprising 22% of the June, and 32% of the September samples. Smallmouth bass sampled in June ranged in age from 1 to 7 years with age 1 being the most abundant (Table 7). Except for age 6 fish, growth of smallmouth bass remained below the statewide average. Total lengths of smallmouth bass sampled at Palmer Lake ranged from 93 to 590 mm in June (n = 171, Table 3, Fig. 4) and from 105 to 525 mm in September (n = 686, Table 3, Fig. 5). Relative weights of smallmouth bass greater than 200 mm sampled in both June (Fig. 6) and September (Fig. 7) were below the national average. While growth and relative weights of smallmouth bass in Palmer Lake were below average, they may be typical for fish inhabiting lakes found in more northern locations where the growing seasons are shorter and temperatures cooler.

A total of 29 YOY smallmouth bass were observed in June, whereas 35 were observed in September. Smallmouth bass are better adapted to spawning in deeper water than largemouth bass, thus water level fluctuations in Palmer Lake are less likely to affect survival of smallmouth bass.

Stocking of smallmouth bass in Palmer Lake, which began in 1982, has been successful thus far in attaining population growth and a resulting fishery. While largemouth bass have struggled to maintain their own population, Palmer Lake has provided a niche for smallmouth bass. Approximately five years following smallmouth bass introduction, the Palmer Lake smallmouth bass fishery was considered a best-kept secret. While more widely recognized today, Palmer Lake's smallmouth bass fishery provides an angling opportunity for trophy-size bass.

Table 7. Back-calculated length at age (mm) of smallmouth bass sampled at Palmer Lake, Washington, during June 1999. Shaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Unshaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean length (mm) at age						
Year Class	# Fish	1	2	3	4	5	6	7
1998	27	92.4						
		98.5						
1997	6	59.8	156.1					
		83.5	161.4					
1996	14	51.7	125.8	187.1				
		77.9	139.5	190.8				
1995	13	50.6	114.2	193.6	260.8			
		79.5	135.6	205.4	264.8			
1994	8	48.5	114.2	193.9	255.6	306.2		
		78.4	137.3	208.7	263.9	309.2		
1993	7	79.7	143.0	225.3	291.9	347.0	387.0	
		108.0	166.1	241.4	302.5	353.0	389.5	
1992	3	50.9	102.9	164.0	246.7	314.1	359.6	384.3
		81.6	129.0	184.9	260.5	322.3	363.9	386.5
Overall mean		68.4	125.6	194.6	265.1	323.4	378.8	384.3
		88.6	143.8	205.7	272.6	328.4	381.8	386.5
Statewide Average		70.4	146.3	211.8	268	334	356.1	392.7

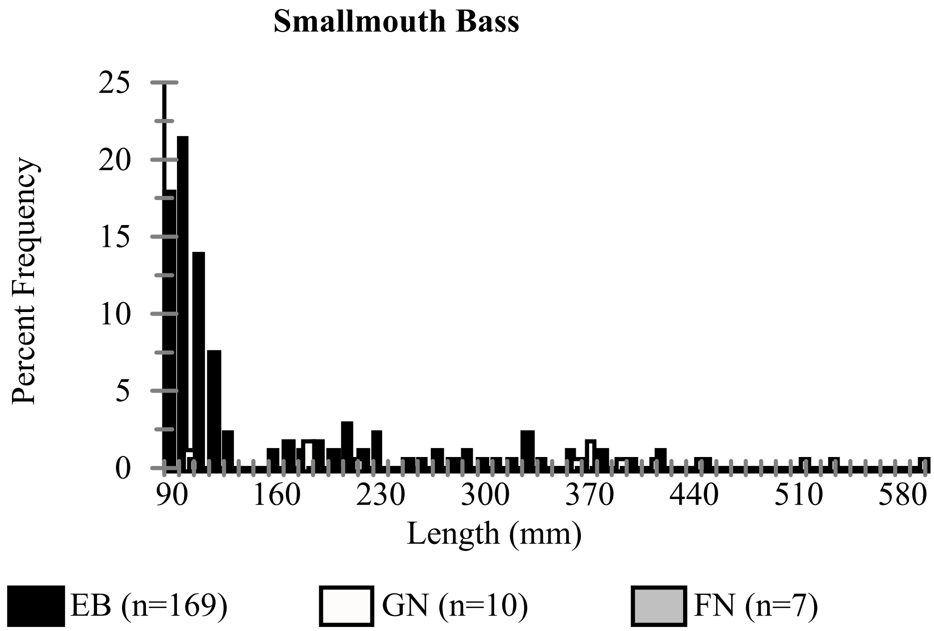

Figure 4. Length frequency distribution of smallmouth bass sampled at Palmer Lake, Washington during June 1999. Smallmouth bass were collected using an electrofisher (EB), gill nets (GN), and fyke nets (FN).

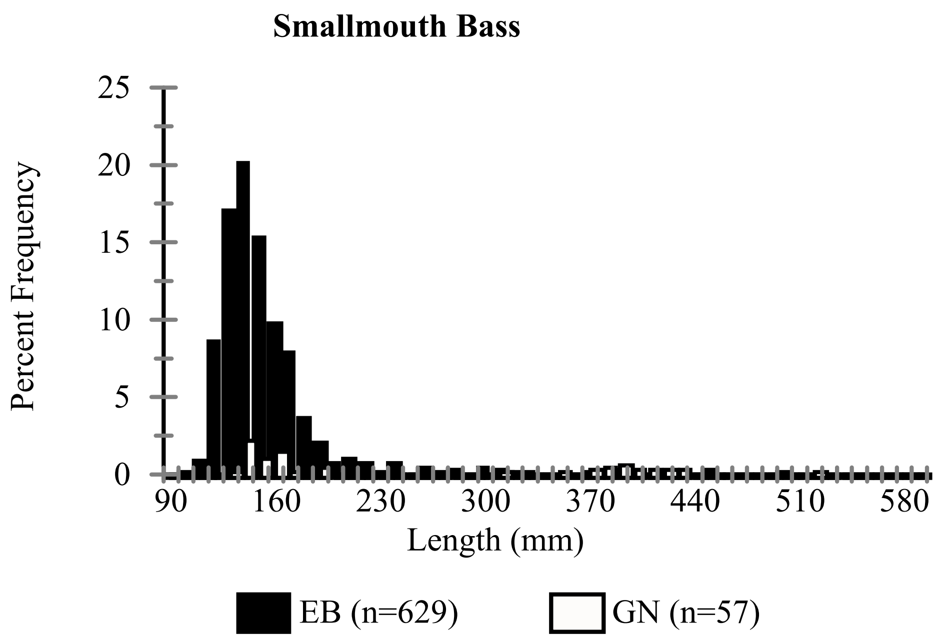

Figure 5. Length frequency distribution of smallmouth bass sampled at Palmer Lake, Washington during September 1999. Smallmouth bass were collected using an electrofisher (EB) and gill nets (GN).

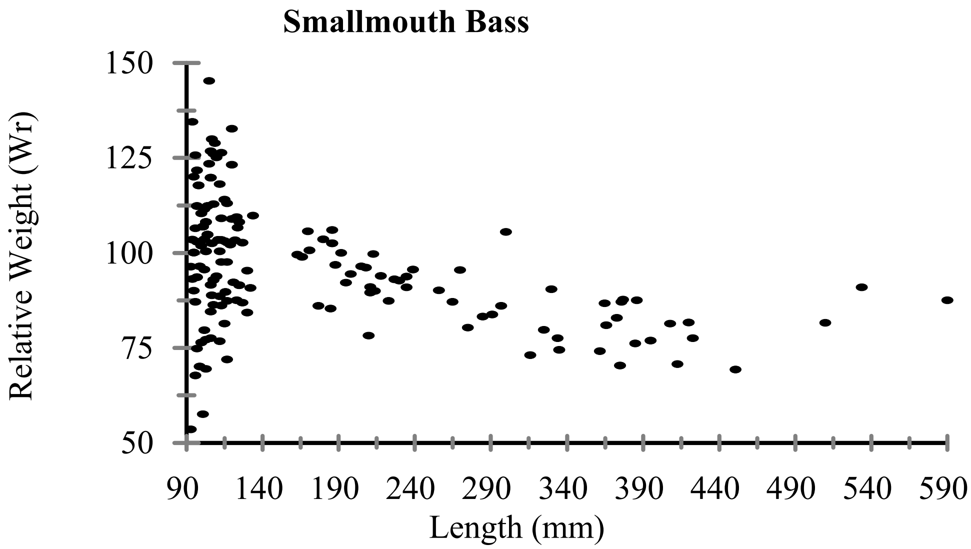

Figure 6. Relative weights of smallmouth bass (n = 165) sampled at Palmer Lake, Washington during June 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

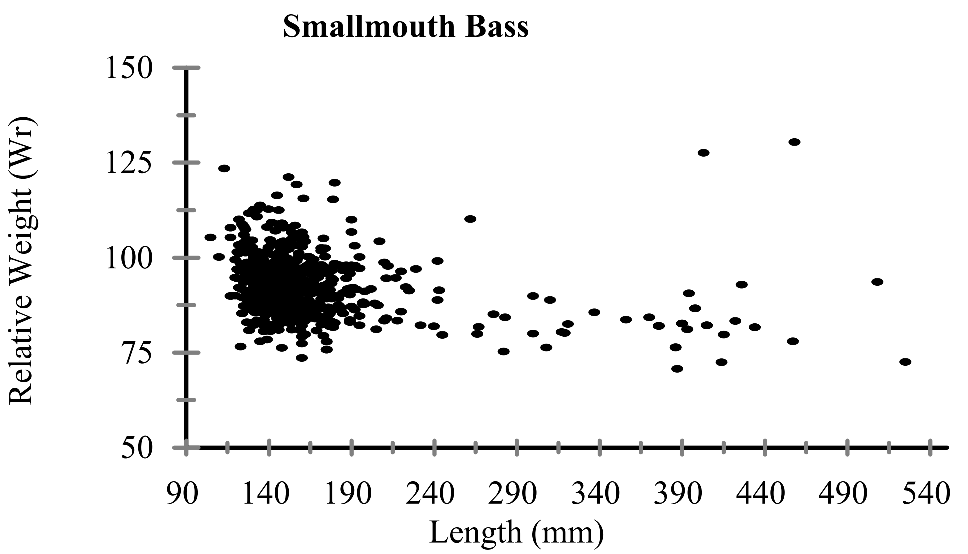

Figure 7. Relative weights of smallmouth bass (n = 685) sampled at Palmer Lake, Washington during September 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

Black Crappie

Black crappie collected in June ranged in age from 1 to 6 years with age 1 being the most abundant (Table 8). Except for age 2 and age 3 fish, growth of black crappie remained well above the statewide average. Total lengths of black crappie sampled at Palmer Lake ranged from 87 to 362 mm in June (n = 10, Table 3, Fig. 8) and from 67 to 220 mm in September (n = 305, Table 3, Fig. 9). Relative weights of black crappie sampled in June (Fig. 10) were lower than those sampled in September (Fig. 11). Relative weights of most black crappie sampled in June were below the national average, whereas most black crappie sampled in September were above the national average (Figs. 10 and 11).

The sample size of black crappie in June was low (n = 10), thus making it difficult to analyze indices such as PSD, RSD, W_r, and length frequency. We found the PSD of black crappie in September to be 1 $\pm$ 1 indicating few or no quality size fish or larger in our samples. Black crappie were found in above average condition in September, which indicates food competition is not likely a factor. We believe a low density of black crappie exists in Palmer Lake which may be caused by angler exploitation, predation, and/or low numbers of mature fish in the population. Although we found reasonable numbers of stock length fish in September (n = 151), those fish that are of spawning size are less fecund and produce fewer offspring than the larger fish. As a result, natural production of black crappie in Palmer Lake may be low. In addition, a total of 31 YOY black crappie were observed in September. However, it is uncertain whether those fish were a result of natural reproduction or those that were stocked as fry in 1999 (Table 1).

Table 8. Back-calculated length at age (mm) of black crappie sampled at Palmer Lake, Washington, during June 1999. Shaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Unshaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean length (mm) at age					
Year Class	# Fish	1	2	3	4	5	6
1998	5	67.4					
		76.2					
1997	0	0.0	0.0				
		0.0	0.0				
1996	1	33.8	85.9	123.7			
		61.0	101.0	130.0			
1995	2	38.6	74.4	109.5	155.2		
		65.7	94.2	122.0	158.3		
1994	0	0.0	0.0	0.0	0.0	0.0	
		0.0	0.0	0.0	0.0	0.0	
1993	1	52.4	15.8	210.9	271.8	295.0	338.8
		82.3	49.3	225.5	280.5	301.4	341.1
Overall mean		55.6	62.7	138.4	194.1	295.0	338.8
		72.9	84.7	149.9	199.1	301.4	341.1
Statewide Average		46.0	111.2	156.7	183.4	220.0	224.0

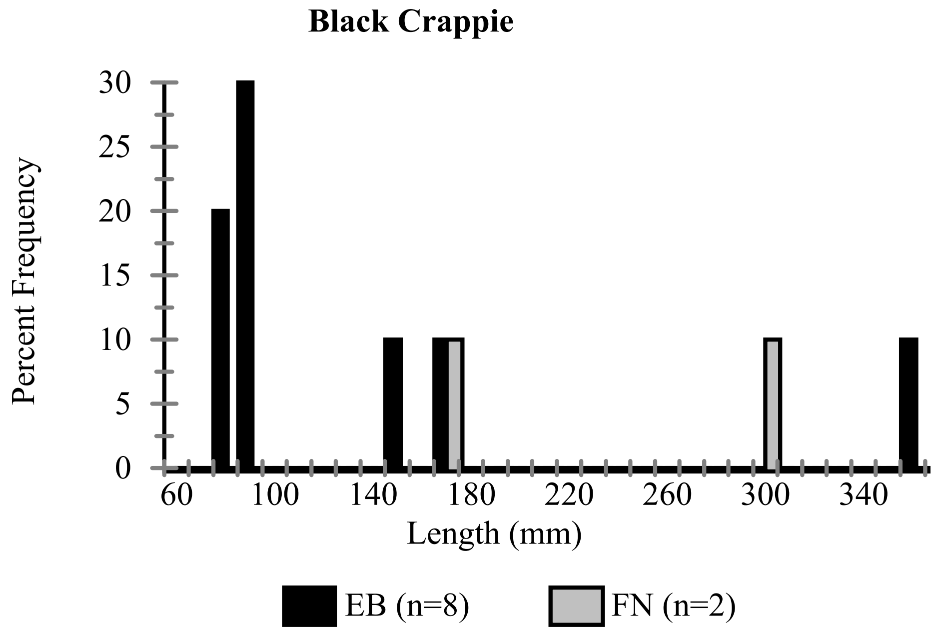

Figure 8. Length frequency distribution of black crappie sampled at Palmer Lake, Washington during June 1999. Black crappie were collected using an electrofisher (EB) and fyke nets (FN).

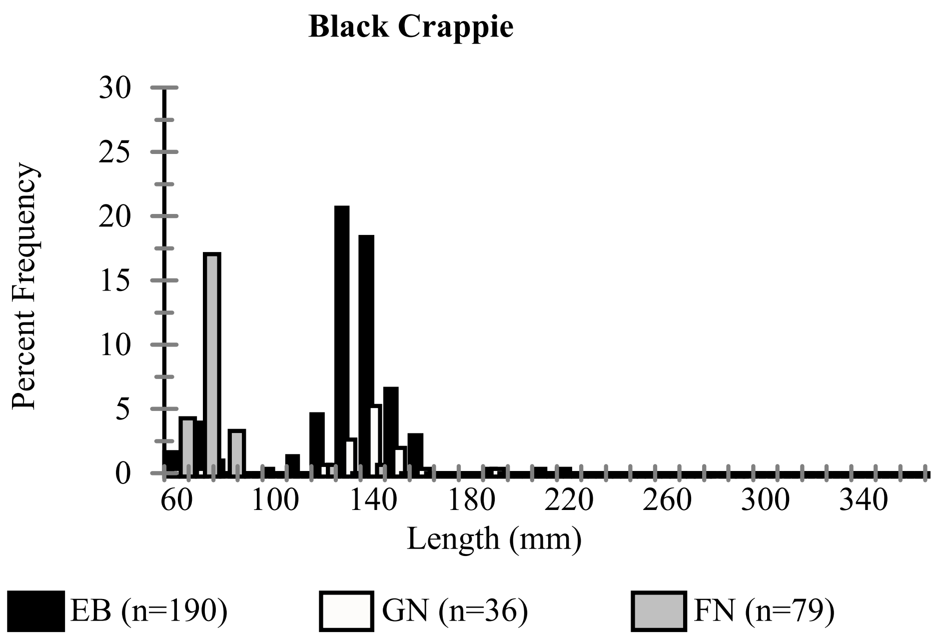

Figure 9. Length frequency distribution of black crappie sampled at Palmer Lake, Washington during September 1999. Black crappie were collected using an electrofisher (EB), gill nets (GN), and fyke nets (FN).

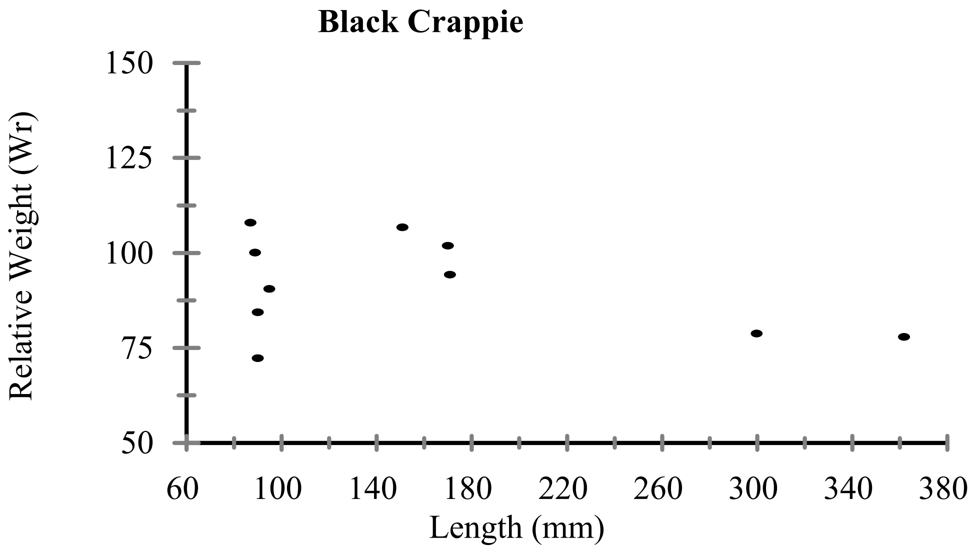

Figure 10. Relative weights of black crappie (n = 10) sampled at Palmer Lake, Washington during June 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

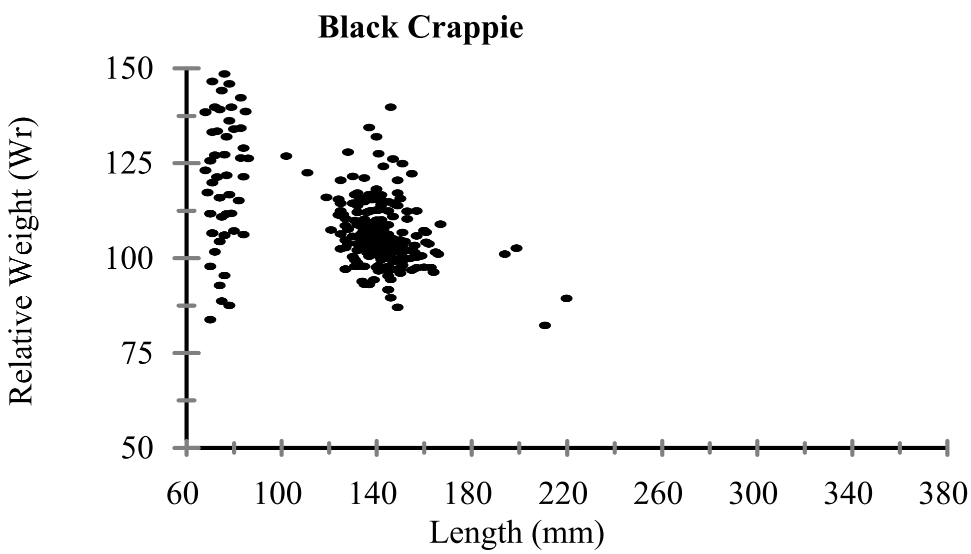

Figure 11. Relative weights of black crappie (n = 271) sampled at Palmer Lake, Washington during September 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

Bluegill

No bluegill were sampled at Palmer Lake in June which may be a function of water level (see species composition). Scale samples were collected in June only; therefore, age and growth information were not investigated. Historical stocking records indicate that bluegill have not been stocked in Palmer Lake since 1980. Although the ages of bluegill observed in Palmer Lake are unknown, their presence indicate that natural reproduction is occurring and the population is self-sustaining.

Bluegill collected at Palmer Lake in September (n = 126) ranged from 80 to 180 mm (Table 2, Fig. 11). Relative weights of bluegill sampled in September were above the national average. Most fish had relative weights greater than 100 (Fig. 12.). The PSD of bluegill in September was 8 $\pm$ 3 indicating few fish were reaching quality size or larger. Bluegill were found in above average condition which indicates density is lower than what could be sustained with the available food supply. As with black crappie, the low density of bluegill in Palmer Lake may be caused by angler exploitation, predation, or low production from few mature fish in the population.

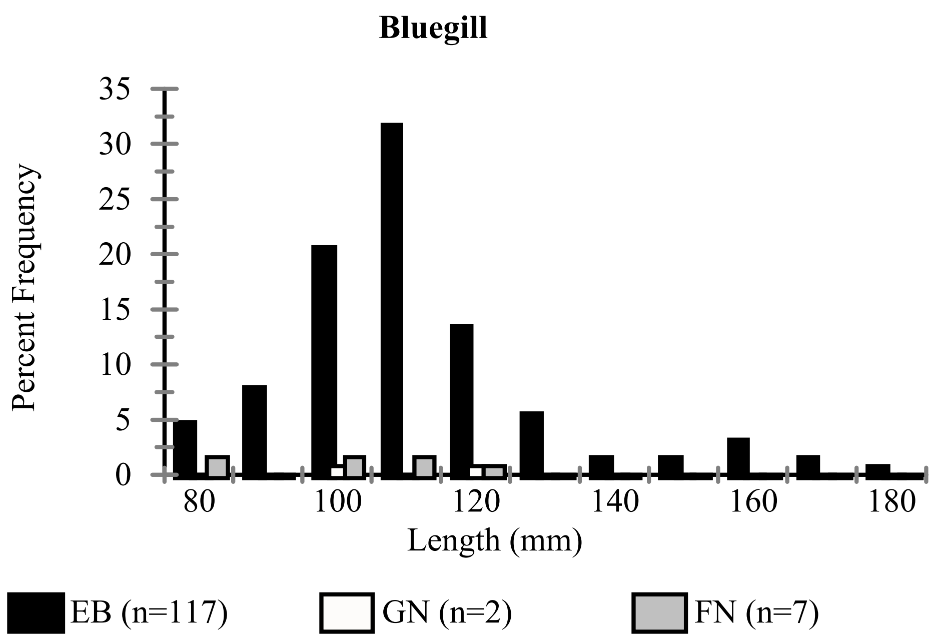

Figure 12. Length frequency distribution of bluegill sampled at Palmer Lake, Washington during September 1999. Black crappie were collected using an electrofisher (EB), gill nets (GN), and fyke nets (FN). No bluegill were collected during the June 1999 sampling.

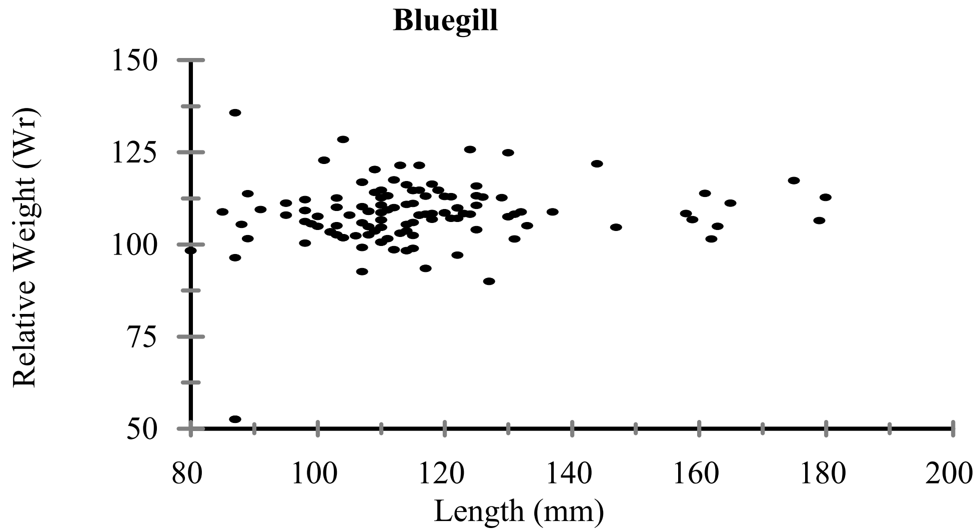

Figure 13. Relative weights of bluegill (n = 126) collected at Palmer Lake, Washington during September 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

Yellow Perch

Stocking records indicate that yellow perch have not been stocked in Palmer Lake since 1980 (Table 1). The presence of yellow perch in the lake is evidence that natural reproduction is occurring and that the population is self-sustaining. Yellow perch sampled in June ranged in age from 1 to 5 years with age 2 being the most abundant (Table 9). Growth of age 1, 2, and 3 fish were well above the statewide average, but were below the statewide average for ages 4 and 5. A total of 57 YOY yellow perch were observed in September. Total lengths of yellow perch sampled at Palmer Lake ranged from 75 to 235 mm in June (n = 127, Table 3, Fig.14) and from 73 to 222 mm in September (n = 278, Table 3, Fig.15). Relative weights of most yellow perch sampled in June (Fig. 16) and September (Fig. 17) were below the national average and appeared to decrease as length increased. This may be due, in part, to intraspecific competition for food.

A total of 127 yellow perch were observed in June. Fifty-four of those were of stock length. The stock density indices should be viewed with caution because of the low sample size of stock length yellow perch. As with black crappie and bluegill, the PSD of yellow perch captured by an electrofisher in September was low (1 $\pm$ 1). A total of 11 and 4 stock length yellow perch were collected by gill nets and fyke nets, respectively. Although the PSD of yellow perch captured by gill nets (27 + 17) and fyke nets (50 + 32) indicate the presence of quality size fish, their numbers are few. The absence of yellow perch larger than quality size may be a result of angler exploitation and/or predation by the large smallmouth bass, largemouth bass, and northern pikeminnow in the lake.

Table 9. Back-calculated length at age (mm) of yellow perch sampled at Palmer Lake, Washington, during June 1999. Shaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Unshaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982)

		Mean length (mm) at age				
Year Class	# Fish	1	2	3	4	5
1998	21	72.4				
		80.2				
1997	22	58.5	135.2			
		77.2	139.1			
1996	10	59.2	130.2	173.6		
		80.2	140.6	177.5		
1995	5	70.7	123.4	172.3	197.3	
		90.8	136.1	178.1	199.6	
1994	1	64.7	88.9	137.4	161.6	185.9
		84.8	105.3	146.4	166.9	187.4
Overall mean		64.7	131.1	171.0	191.4	185.9
		80.1	138.2	175.8	194.2	187.4
E. Washington Average		59.7	119.9	152.1	192.5	206.0

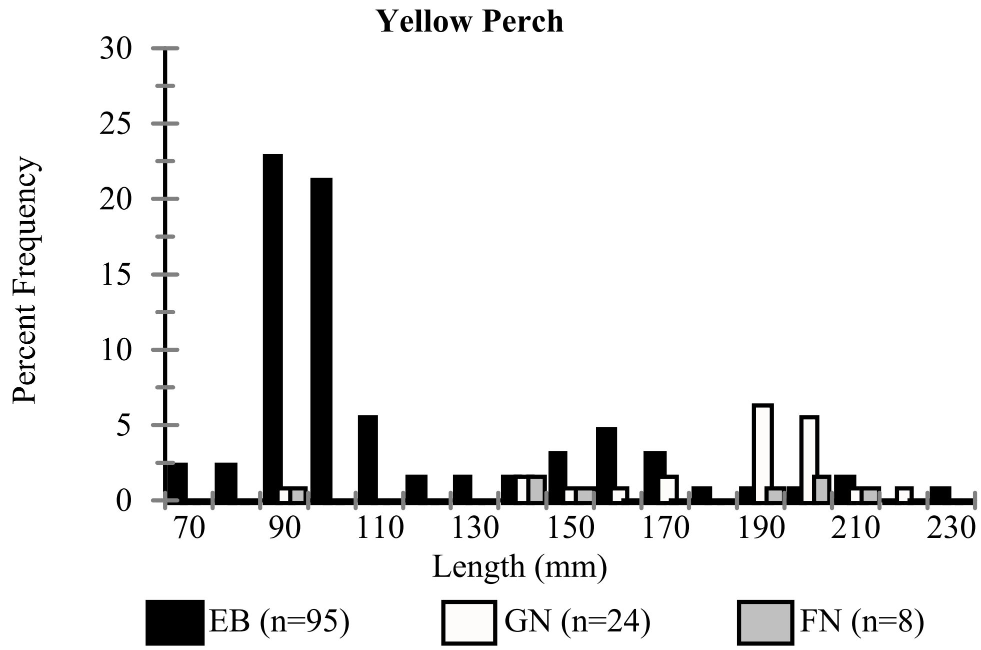

Figure 14. Length frequency distribution of yellow perch sampled at Palmer Lake, Washington during June 1999. Yellow perch were collected using an electrofisher (EB), gill nets (GN), and fyke nets (FN).

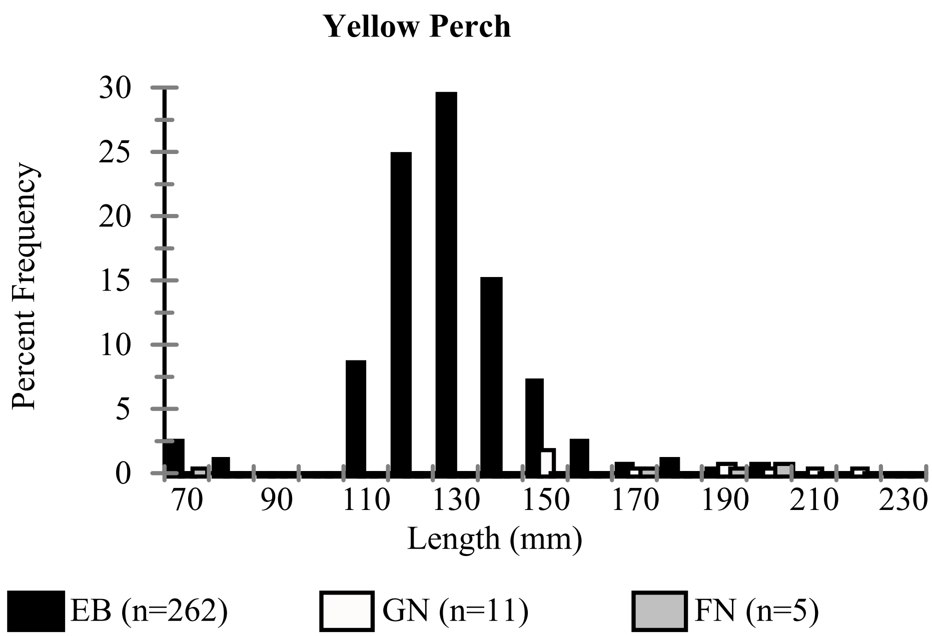

Figure 15. Length frequency distribution of yellow perch sampled at Palmer Lake, Washington during September 1999. Yellow perch were collected using an electrofisher (EB), gill nets (GN), and fyke nets (FN).

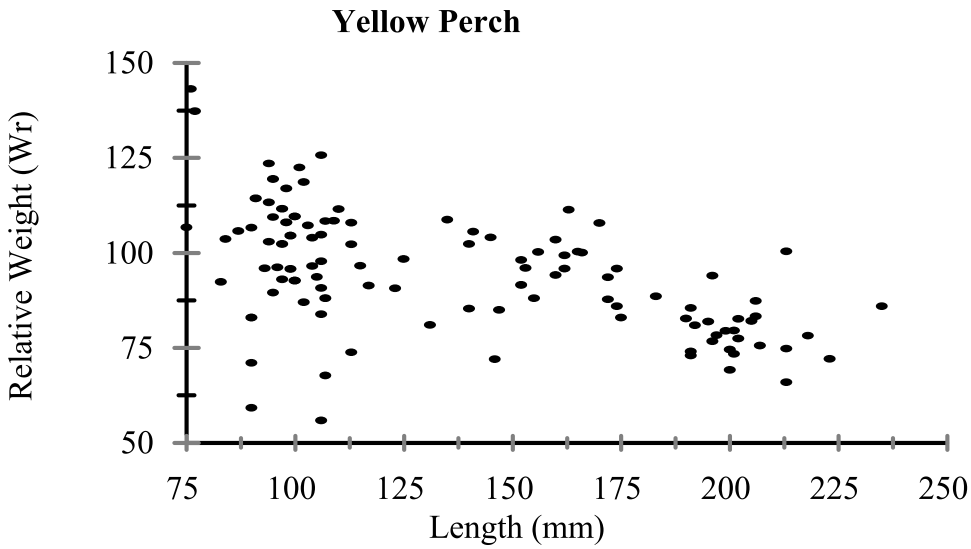

Figure 16. Relative weights of yellow perch (n = 123) sampled at Palmer Lake, Washington during June 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

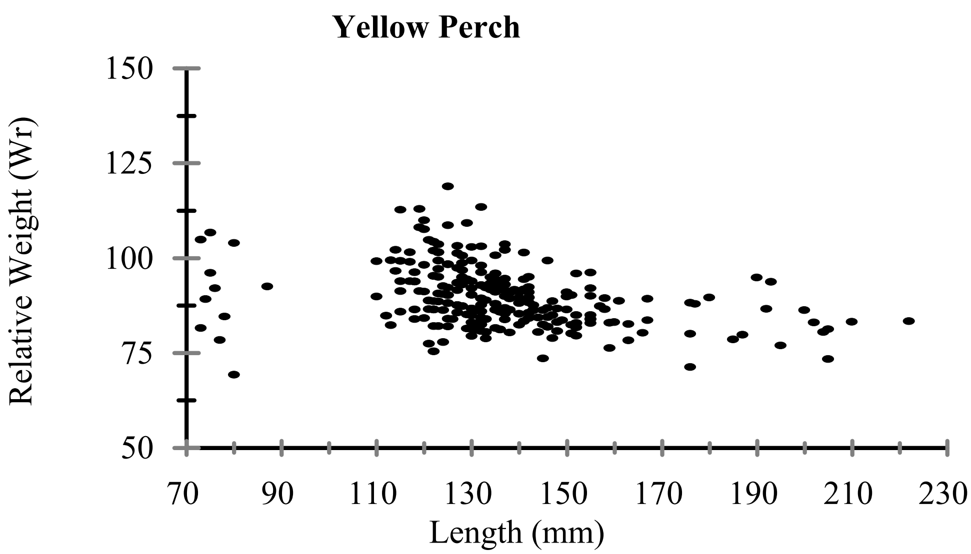

Figure 17. Relative weights of yellow perch (n = 278) sampled at Palmer Lake, Washington during September 1999, compared to the national average, W_r=100 (Anderson and Neumann 1996).

Conclusions and Management Options

We found 15 fish species in Palmer Lake. Smallmouth bass were the most abundant warmwater species observed in both sampling periods. Smallmouth bass were observed within each RSD category (Preferred, Memorable, and Trophy). Although the smallmouth bass population in Palmer Lake is self-sustaining and exhibits good size structure, the relative weights of most smallmouth bass greater than 200 mm in length were below the national average indicating their food supply may be limited. While fish species such as peamouth and northern pikeminnow were abundant and expected to be available as a food source, below average relative weights of smallmouth bass greater than 200 mm in length indicate these fish may not be available to, or preferred by, larger-size smallmouth bass in Palmer Lake. Black crappie and bluegill in Palmer Lake were in above average condition indicating these fish may be in densities lower than what could be sustained. In addition, low numbers of black crappie and bluegill achieved quality size or greater. Low panfish densities, combined with the absence of larger size panfish which may be preferred by larger-size smallmouth bass as forage, may be contributing to the below average relative weights of smallmouth bass.

Recommendation 1:

No regulation changes are recommended at this time. We recommend stocking of black crappie and bluegill to increase the prey base for smallmouth and largemouth bass and improve abundance of stock size fish and larger for warmwater angling opportunities.

Palmer Lake contains an estimated 384 acres of littoral habitat. We recommend stocking adult black crappie at a density of 20 fish/littoral acre (~ 7,680 adults). Mortality of black crappie stocked as adults would be lower than of those stocked as fry into a system with high densities of northern pikeminnow. In addition to the current population, several annual stockings of adult black crappie would likely be required to establish consecutive-year spawning.

We recommend stocking adult bluegill at a density of 30 fish/littoral acre (~11,500). As with black crappie, bluegill would experience higher survival rates when stocked as adults into a system with high densities of predators. Adult bluegill could be collected from Whitestone Lake, Okanogan County, which contains an extremely high density of adult bluegill. Stocking should be conducted in the spring during high water. This would allow stocked fish to utilize the increased amount of littoral habitat and should increased their survival.

Recommendation 2:

We recommend that periodic warmwater fish surveys should be conducted to monitor the size structure and condition of the smallmouth bass, largemouth bass, and panfish in Palmer Lake. In addition, future monitoring would likely forecast whether additional panfish stocking will be needed and/or adjustments in regulations should be made. Warmwater surveys should include long lines or another sampling technique which would be effective in capturing burbot so management biologist may include their population in a monitoring program.

Literature Cited

Anderson, R. O. and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in Murphy, B. R. and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Bonar, S. A., B. D. Bolding, and M. Divens. 2000. Standard fish sampling guidelines for Washington State pond and lake surveys. Report No. FPT 00-28, Washington Department of Fish and Wildlife, Olympia, Washington. 24 pp.

Carlander, K. D. 1982. Standard intercepts for calculating length from scale measurements for some centrarchid and percid fishes. Transactions of the American Fisheries Society 111:332-336.

Fletcher, D., S. A. Bonar, B. D. Bolding, A. Bradbury, and S. Zeylmaker. 1993. Analyzing warmwater fish populations in Washington State. Warmwater fish survey manual. Washington Department of Fish and Wildlife, Olympia, Washington. 164 pp.

Gablehouse, D. W., Jr. 1984. A length categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Gustafson, K. A. 1988. Approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8:139-141.

Hubert, W. A. 1996. Passive capture techniques. Pages 157-192 in Murphy, B. R. and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Swingle, H. S. 1969. Methods for the analysis of waters, organic matter, and pond bottom soils used in fisheries research. Auburn University, Auburn, Alabama. 119 pp.

Willis, D. W., B. R. Murphy, and C. S. Guy. 1993. Stock density indices: development, use, and limitations. Review in Fisheries Science 1:203-222.

Glossary

Catch Per Unit Effort (CPUE): Is defined as the number of fish captured by a sampling method (i.e., electrofisher, gill nets, or fyke nets) divided by the amount of time sampled.

Confidence Interval (CI): Is defined as an estimated range of values which is likely to include an unknown population parameter with a percentage or degree of confidence.

Memorable Size: Is defined as fish anglers remember catching, and also identified as 59-64 percent of the world record length. Memorable length varies by species.

Preferred Size: Is defined as the size fish anglers preferred to catch when given a choice, and also identified as 45-55 percent of world record length. Preferred length varies by species.

Proportional Stock Density (PSD): Is defined as the number of quality length fish and larger, divided by the number of stock sized fish and larger, multiplied by 100.

Quality Length: Is defined as the length at which anglers begin keeping fish. Also identified as 36-41 percent of world record length. Quality length varies by species.

Relative Stock Density (RSD): Is defined as the number of fish of a specified length category (quality, preferred, memorable, or trophy) and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Stock Density of Preferred Fish (RSD-P): Is defined as the number of fish in the preferred size category and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Stock Density of Memorable Fish (RSD-M): Is defined as the number of fish in the memorable size category and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Stock Density of Trophy Fish (RSD-T): Is defined as the number of fish in the trophy size category and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Weight (W_r): The comparison of the weight of a fish at a given size to the national average weight (W_r = 100) of fish of the same species and size.

Standard Weight (W_s): Is defined as a standard or average weight of a fish species at a given length determined by a national length-weight regression.

Stock Length: Is defined by the following: 1) approximate length of fish species at maturity; 2) the minimum length effectively sampled by traditional sampling gears; 3) minimum length of fish that provide recreational value; and 4) 20-26 percent of world record length. Stock length varies by species.

Total Length (TL): Is defined as the length measurement from the anterior most part of the fish to the tip of the longest caudal (tail) fin ray (compressed).

Trophy Size: Considered a trophy, and also identified as 74-80 percent of world record length. Trophy length varies by species.