1998 Warmwater Fish Survey of Clear Lake, Spokane County, Washington

by

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Executive Summary

Clear Lake was surveyed by a three–person investigation team September 14-18, 1998, under the Warmwater Fish Enhancement Program. Water quality data collected at 2:45 p.m. on September 15, 1998, revealed thermal stratification. Dissolved oxygen is likely limiting the amount of available habitat for fish in Clear Lake during the summer months. Dissolved oxygen levels recorded below six meters were too low for even low-oxygen tolerant fish species. Fish were captured using boat electrofishing, gill netting, and fyke netting. Ten fish species were collected from Clear Lake. The Clear Lake warmwater fish community was dominated by an abundance of prey–size fish (e.g., brown bullhead, pumpkinseed sunfish and young largemouth bass) and numerous adult largemouth bass. Pumpkinseed sunfish were the most numerous fish collected although brown bullhead contributed equally to the biomass by weight. Adult largemouth bass CPUE, PSD (22±5) and RSD-P (11±4) values indicated a quality population compared to other surveys in nearby lakes. The black crappie population had a PSD 34±6 by electrofishing. However, of the 184 black crappie collected, none were of preferred length (≥ 250 mm). Management options presented included continuing with the current mixed–species management strategy *or* adopting Washington states recommended 12-17–inch slot–limit regulation for largemouth bass, and imposing a 10–inch minimum length limit and five fish bag limit restriction for black crappie.

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Introduction and Background

Clear Lake is an intermediate–sized lake (Table 1) located 3 kilometers (km) south of the town of Medical Lake in western Spokane County (Figure 1). The lake shore is heavily developed, mostly with single family residential homes. Although there are no major inlets or outlets on Clear Lake, water exchange may take place between local lakes during high water years. Access is available through a Washington Department of Fish and Wildlife (WDFW) owned boat launch located on the south end of the lake. Two privately owned resorts on the lake offer public services for a fee.

Table 1. Physical parameters of Clear Lake, Spokane County.

Physical Parameters	**Clear Lake (Spokane County)**
Surface Area (acres)	410.0
Surface Area (hectares)	165.9
Shoreline Length (m)	14,645.0
Maximum Depth (m)	33.5
Mean Depth (m)	7.9
Volume (m3)	13,568,192.0
Drainage Area (acres)	8,512.0
Shoreline Development D_L	3.2

Historically, Clear Lake has offered a wide range of fishing opportunities. The lake may have

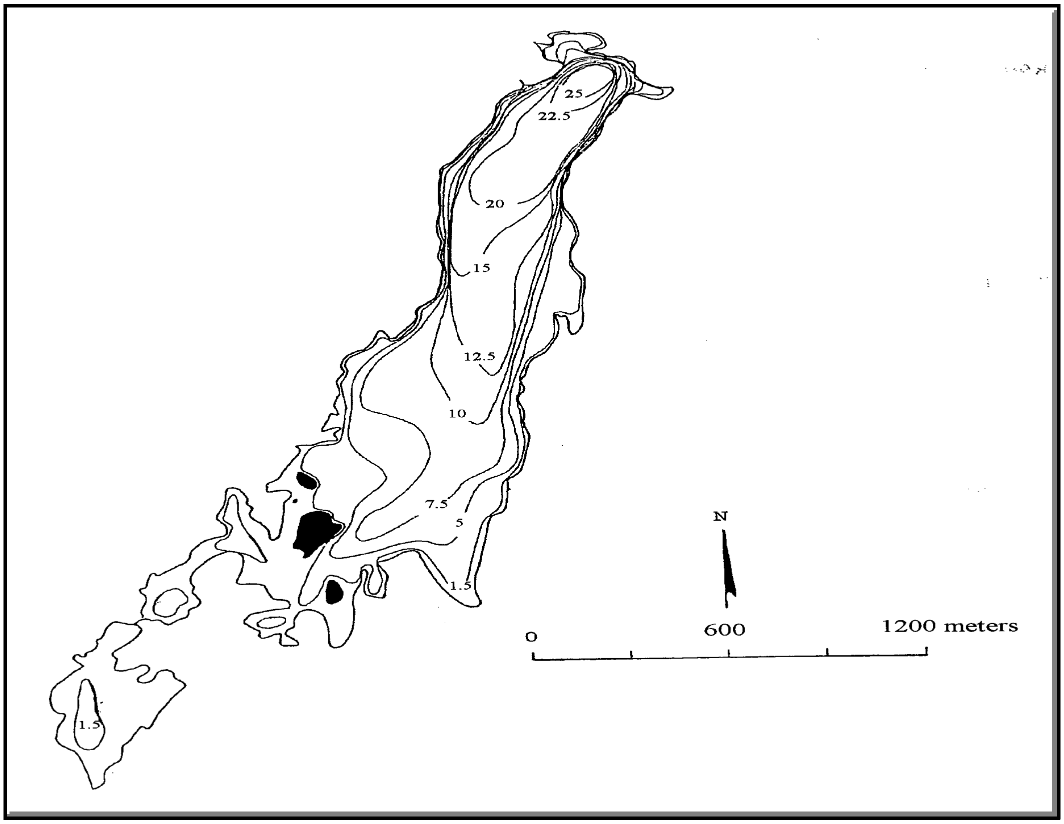

Figure 1. Bathymetry (meters) of Clear Lake (Spokane County).

been the first lake in Washington State to be planted with largemouth bass (*Micropterus salmoides*), which were later seen at markets in Spokane (unpublished data, WDFW, Region 1). During the late 1940s and ’50s, fingerling rainbow trout (*Oncorhynchus mykiss*) were stocked in the lake with varied success. Duff et al. (1977) described the lakes condition as somewhat of a disappointment during the 1970s due to the excessive number of goldfish (*Carassius auratus*). During 1996, two thousand lake trout (*Salvelinus namaycush*) were stocked in the lake. Since 1990 Clear Lake has been managed primarily as a put and take trout fishery. After the initial bass stocking in the early 1900s, little emphasis has been directed toward the management of warmwater fish in Clear Lake.

Three species of trout have been stocked in Clear Lake over the past three years. Rainbow trout and brown trout (*Salmo trutta*) were stocked in 1995, 1996, and 1997, and lake trout were stocked in 1997. Stocking density and length varied from year to year. For example, rainbow trout were stocked at a density of 37 fish/acre in 1995 and 132 fish/acre in 1997. Lake trout, of approximately 3.2 kilograms (kg), were stocked at a rate of less than 1 fish per/acre.

Clear Lake was identified by regional fisheries biologists as a lake to be surveyed under the Warmwater Fish Enhancement Program. To evaluate the established warmwater fish populations in Clear Lake, personnel from the Washington Department of Fish and Wildlife Warmwater Enhancement Program conducted a fisheries survey during September 1998. This report is intended to assist regional fisheries biologists identify management options that could improve the quality of warmwater fish angling in Clear Lake.

A 1994 Washington Department of Ecology (DOE) aquatic plant survey identified 12 species of aquatic plants in Clear Lake (Table 2). The dominant plant species was northern water milfoil (*Myriophyllum sibiricum*). Northern water milfoil was present throughout most of the litoral zone of the lake and was so dense in the southern end of the lake that boat access was limited (Jennifer Parsons, DOE, personal communications). Although some species with a lower distribution value may have changed since 1994, the abundance of northern aquatic water milfoil appeared to be the dominant species during our 1998 warmwater fish survey.

Table 2. Aquatic vegetation data collected by the Department of Ecology on August 4, 1994, from Clear Lake (Spokane County).

Species	Distribution Value	Comments
Coontail; hornwart *Ceratophyllus demersum*	2	
Common Elodea *Elodea canadensis*	2	
Nutall's waterweed *Elodea nuttallii*	2	
Northern water milfoil *Myriophyllum sibiricum*	4	thick patches throughout the littoral zone
Illinois pondweed *Potamogeton illinoensis*	2	
Sago pondweed *Potamogeton pectinatus*	3	
Slender pondweed *Potamogeton pusillus*	2	
Richardson's pondweed *Potamogeton richardsonii*	3	some thick patches
Eel-grass pondweed *Potamogeton zosterifomis*	2	
Water-buttercup *Ranunculus aquatilis*	1	near boat launch only
Ditch-grass *Ruppia maritima*	2	some flowering
Unknown	2	aquatic moss, at 6m deep

Distribution value definitions

1 few plants in only a few locations
2 few plants, but with a wide patchy distribution
3 plants growing in large patches, codominant with other plants
4 plants in nearly monospecific patches, dominant

Methods

Clear Lake was surveyed by a three–person investigation team September 14-18, 1998. Fish were captured using boat electrofishing, gill netting, and fyke netting. The electrofishing unit consisted of a 5.5 m Smith-Root 5.0 GPP "shock boat" using a DC current of 120 cycles / sec $^{-1}$ at 5 to 6 amps power. Experimental gill nets (45.7 m long x 2.4 m deep) were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable size (1.3, 1.9, 2.5, and 5.1 cm stretched mesh) monofilament. Fyke nets were constructed of a main trap (4.7 m long and 1.2 m in diameter), a lead net (30.5 m long x 1.2 m), and two wings (7.6 m long x 1.2 m deep).

Sampling locations were selected by dividing the shoreline into 43 consecutively numbered sections of approximately 500 meters each. Fifteen sections were randomly selected for sampling by boat electrofishing, eight by gill netting, and eight by fyke netting. Each section was selected using a random number generator (Casio fx-991D scientific calculator). While electrofishing, the boat was maneuvered through the shallows (depth range = 0.2 - 1.5 m), adjacent to the shoreline. Gill nets were set perpendicular to the shoreline with the small mesh end attached onshore and the large mesh end anchored offshore. Fyke nets were set perpendicular to the shore with the lead net anchored onshore and the wing nets set at 45–degree angles to the trap. Length of the lead from shore and depths at which the fyke nets were set varied with water depth and the slope of the shoreline.

Sampling was conducted during evening hours to maximize the size and number of fish captured. Electrofishing is more effective at night because some fish species seek shelter during the day and move freely at night (Helfman 1983). Nighttime electrofishing was conducted in roughly 35% of the possible established sampling sites. Two gill nets and two fyke nets were set overnight at random locations around the lake. Sampling was conducted so as to achieve a standardized 1:1:1 ratio of electrofishing to gill netting to fyke netting (1:1:1-1800 seconds of boat electrofishing:24 hours of gill netting:24 hours of fyke netting). This methodology is employed to reduce bias between gear types (Fletcher et al. 1993). Total electrofishing time was 9000 seconds ("pedal–down" time), or roughly five standard units. Gill netting and fyke netting time totaled eight nights for each gear type, or four standard units.

Each fish captured was identified to species, measured to total length (mm TL) and weighed (g). Scales were collected for age and growth analysis. Scale samples (up to five per 10 mm length class) were mounted, pressed, and aged according to Jearld (1983) and Fletcher et al. (1993). Rainbow trout, brown trout, lake trout, brown bullhead catfish (*Ameiurus nebulosus*) and tench (*Tinca tinca*) were not aged.

Water quality data was collected during the afternoon from the deepest location in the lake on August 31, 1998. Information was gathered on dissolved oxygen, temperature, specific conductance, total dissolved solids, pH, and salinity using a Hydrolab® probe and digital recorder. Water clarity was measured using a Secchi disc.

Data Analysis

Percentages of the total biomass and number of fish collected for each species provides useful information regarding the balance and productivity of the community (Swingle 1950; Bennet 1962; Fletcher et al. 1993). Species composition by weight (kg) and number was calculated from data collected using boat electrofishing (12 sections), gill netting (8 sections), and fyke netting (8 sections) so as to maintain the standard 1:1:1 ratio. Fish determined to be less than one year old were excluded from the calculations for species composition. Fry numbers can fluctuate dramatically according to sampling location, sampling methodology, and time of hatches (Fletcher et al. 1993). 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).

Catch per unit effort (CPUE) by sampling method was determined for each fish species collected (number of fish/hour electrofishing, number of fish/gill net night, and number of fish/fyke net night). The CPUE for each fish species was calculated using only stock length fish and larger. Stock length fish, which varies by species, is the length of a particular fish species that offers a threshold recreational value to an angler (Anderson 1976). Randomly chosen sample sections can contribute to high variability among samples, therefore, 80% confidence intervals (CI) were calculated for each mean CPUE by species and sampling method. Each CI was calculated as the mean $\pm t(\propto, N\text{-}1) \times SE$, where t=Student's t for $\propto$ confidence level with N-1 degrees of freedom (two tailed) and SE=standard error of the mean. When standardized sampling is used, CPUE is a useful index to compare lakes within the State of Washington and monitor changes in relative abundance over time.

Length frequency histograms (percent frequency captured by different sampling methods) were used to evaluate the size structure of all warmwater fish species collected. For reasons similar to those listed above, only fish greater than one year old were included in the length frequency histograms.

Proportional stock density (PSD), calculated as the number of fish$\geq$quality length/number of fish$\geq$stock length$\times$100, was determined for each warmwater fish collected that have established stock lengths (Anderson and Neuman 1996). PSD can provide information about the proportion of various size fish in a population and can be a useful tool when sample size is adequate (Willis et al. 1993; Divens et al. 1998). Stock and quality lengths are based on percentages of world record catch size and vary depending on fish species (Table 3). Stock length (20-26% of the world record) refers to the minimum size of fish with recreational value, and quality length (36-41% of the world record) refers to the minimum size fish anglers would like to catch. In addition to stock and quality length, Gabelhouse (1984b) introduced relative stock density (RSD) which includes preferred, memorable, and trophy lengths. Preferred length (45-55% of world record length) refers to the length fish anglers would prefer to catch. Memorable length (59-64% of the world record length) refers to the minimum length fish most anglers remember catching, whereas trophy length (74-80% of world record length) refers to the minimum length fish worthy of acknowledgment. Bister et al. (*in press*) developed and proposed additional length categories for 83 additional species including brown bullhead catfish. RSD, calculated as the number of fish≥specific length/number of fish≥stock length×100, was also calculated for each game fish species. Like PSD, RSD can also provide useful information regarding population dynamics and is more sensitive to changes in year class strength. For example, relative stock density preferred (RSD-P) is the percentage of stock length fish preferred length and longer, RSD-M is the percentage of stock length fish memorable length and longer, and RSD-T is the percentage of stock length fish trophy size and longer. 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. PSD/RSD Length categories for fish species collected during Clear Lake survey. Measurements are total length (mm) for each category (Anderson and Neumann 1996). 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)**
Largemouth bass	200	300	380	510	630
Brown bullhead	130	200	280	360	430
Black crappie	130	200	250	300	380
Pumpkinseed sunfish	80	150	200	250	300
Walleye	250	380	510	630	760
Rainbow trout	250	400	500	650	800
Lake trout	300	500	650	800	1000

Age and growth of warmwater fishes sampled were evaluated using the direct proportion method (Fletcher et al. 1993) and Lee's modification of the direct proportional method (Carlander 1982). Using the direct proportional method, total length at annulus formation, L_n, was back–calculated as L_n=(A×TL)/S, were *A* is the radius of the fish scale at age *n*, TL is the total length of the fish captured, and *S* is the total radius of the scale at capture. Using Lee's modification, L_n was back–calculated as L_n=a+A×(TL-a)/S, where *a* is the species–specific standard intercept from a scale radius–fish length regression. Mean back–calculated lengths at age *n* for each species were presented in tabular form for easy comparison of growth between year classes, as well as between the lake average and what has been found in other areas around the state of Washington (Fletcher et al. 1993) for the same species. Fletcher et al. (1993) calculated state averages using data collected from select warmwater fish populations throughout the state. These growth rates are referred to as the state average in the results section. Although not a true state average, this is likely representative of fish growth for lakes sampled within the state.

The relative weight (W_r) index was used to evaluate the condition of fish in Clear Lake. W_r is calculated as W_r=W/W_s×100, where *W* is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same length (Murphy and Willis 1991). W_s is calculated from the standard log10weight-log10length relationship defined for the species of interest. Relative weights are useful for comparing the condition of different size groups within a single population to determine if all sizes are getting adequate nutrition (ODFW 1997). A W_r value of 100 generally indicates that a fish is in good condition when compared to the national average for that species (Anderson and Gutreuter 1983). Anderson and Neumann (1996) list the parameters for the W_r equations of many warmwater fish species, including the minimum length recommendations for their application. W_r values from this survey were compared to the national average (W_r=100) for each species.

Results

Species Composition

Ten fish species were collected from Clear Lake. Pumpkinseed sunfish (*Lepomis gibbosus*) were the most numerous fish collected although brown bullhead contributed equally to the biomass by weight (Table 4). Several species were represented in the sample by low numbers. Salmonid species (i.e., rainbow trout, brown trout, and lake trout) were represented in the sample by only seven individuals collectively. The low number of trout (all species) collected during the sampling period may indicate that their contribution was underestimated due to limitations of our sampling methods.

Table 4. Species composition (young–of–the–year excluded) by weight (kg) and number of fish captured at Clear Lake (Spokane County) in September 1998.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Type of Fish	**(kg)**	**(%w)**	**(#)**	**(%n)**	**Min**	**Max**
Pumpkinseed sunfish	68.004	24.19	2007	63.41	43	170
Brown bullhead	67.471	24.00	584	18.45	95	370
Largemouth bass	54.502	19.39	277	8.75	47	499
Tench	46.889	16.68	90	2.84	250	444
Black crappie	13.156	4.68	173	5.47	48	239
Goldfish	12.909	4.59	21	0.66	245	391
Walleye	8.230	2.93	4	0.13	505	660
Brown trout	5.141	1.83	6	0.19	254	524
Lake trout	4.787	1.70	2	0.06	610	690
Sculpin	0.015	0.01	1	0.03	94	94

CPUE

Electrofishing catches were higher than both fyke nets and gill nets for all fish except brown bullhead. Catch rates for brown bullhead were 61 fish/net–night using gill nets and 36 fish/electrofishing hour (Table 5). Although gill nets caught more brown bullhead, fyke nets were more effective on large fish. Electrofishing proved more effective at catching numerous largemouth bass, black crappie (*Pomoxis nigromaculatus*), and pumpkinseed sunfish. While interpretation of CPUE values may be limited at this time, CPUE will serve as a baseline to monitor effectiveness of different management strategies once high and low CPUE values are evaluated on a statewide level.

Table 5. Mean catch per unit effort by sampling method, including 80% confidence intervals, for fish collected from Clear Lake (Spokane County) in September 1998.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
Species	(# /hour)	Sites	#/Net Night	Nights	#/Net Night	Nights
Brown bullhead	36.8 ± 17.9	15	61.8 ± 14.2	8	12.4 ± 7.5	8
Black crappie	37.9 ± 9.6	15	11.4 ± 5.3	8	0	8
Brown trout	0	15	.1 ± .2	8	0	8
Goldfish	9.6 ± 3.9	15	.8 ± .3	8	.1 ± .2	8
Largemouth bass	40.8 ± 7.9	15	2.9 ± 1.1	8	0	8
Lake trout	0	15	.3 ± .3	8	0	8
Pumpkinseed sunfish	773.9 ± 174.4	15	28.6 ± 6.8	8	4.1 ± 3.9	8
Rainbow trout	0	15	.4 ± .5	8	0	8
Tench	17.2 ± 5.9	15	6.5 ± 3.3	8	1.0 ± 1.1	8
Walleye	0	15	.5 ± .2	8	0	8

Stock Density Indices

The PSD for black crappie was 34(±6) electrofishing and 21(±5) gill netting (Table 6). Of the 184 black crappie collected, none were of preferred length or larger. This may be due to the slow growth rates of black crappie in the state of Washington and/or intensive angling pressure. Largemouth bass collected electrofishing had a PSD value of 22 (±5), and a RSD-P of 11 (±4). Too few walleye were collected to evaluate PSD. Species such as walleye (Stizostedion vitreum) and lake trout, which have high PSD, RAD-P, and RAD-M, should be viewed with caution given the low catch rate and small sample size. Overall, a large number of stock length fish of all species were collected, although few preferred size fish were caught.

Table 6. Traditional stock density indices, including 80% confidence intervals, of fish collected from Clear Lake (Spokane County) September 1998, by sampling method.

	#Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Brown bullhead	92	17 ±5	0	0	0
Black crappie	95	34 ±6	0	0	0
Largemouth bass	102	22 ±5	11 ±4	0	0
Pumpkinseed sunfish	1937	3 ±0	0	0	0

Table 6. Traditional stock density indices, including 80% confidence intervals, of fish collected from Clear Lake (Spokane County) September 1998, by sampling method (continued).

	#Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Gill Netting			
Brown bullhead	494	6 ±1	0	0	0
Black crappie	91	21 ±5	0	0	0
Largemouth bass	23	48 ±13	0	0	0
Lake trout	2	100 ±0	50 ±45	0	0
Pumpkinseed sunfish	229	0	0	0	0
Rainbow trout	3	0	0	0	0
Walleye	4	100 ±0	75 ±28	25 ±28	0
		Fyke Netting			
Brown bullhead	99	10 ±4	0	0	0
Pumpkinseed sunfish	33	0	0	0	0

Water Quality

Water quality data collected at 2:45 p.m. on September 15, 1998, revealed thermal stratification. A thermocline (or metalimnion) was located from 6 to10 m from the surface (Table 7). The thermocline had a temperature that changed from 20.48°C at 6m to 9.86°C at 11 m. Dissolved oxygen levels varied widely in the lake. In the epilimnion, which is from 6m to the surface, dissolved oxygen levels were within the desirable range for all warmwater fish species (Boyd 1990). However, the dissolved oxygen levels below 6 m were well below acceptable levels for all species of warmwater fish (Table 7).

Table 7. Water quality data from Clear Lake (Spokane County) collected midday September 15, 1998.

Depth (m)	Temp (C)	D O	Conductivity	Total Dissolved Solids	pH	Salinity
0	22.07	9.06	713.0	.4562	9.04	.37
5	20.72	7.70	711.3	.4559	9.02	.37
10	10.58	.12	701.2	.4480	8.00	.36
15	7.67	.05	706.5	.4520	7.83	.36
20	6.94	.01	715.3	.4578	7.68	.37
25	6.84	.00	716.1	.4579	7.67	.37
30	6.48	.00	733.8	.4694	7.59	.38

* Secchi Disk Reading 2.5 meters

Desirable pH levels for warmwater fish are between 6.5 and 9 (Swingle 1969). The pH level was acceptable from the surface to the bottom for all species of fish found in the lake, although it was slightly above desirable range in the epilimnion (Table 7).

Dissolved oxygen is likely limiting the amount of available habitat for fish in Clear Lake during the warmer summer months. Warmwater fish species are more tolerant of low dissolved oxygen levels, although even the most tolerant species cannot survive at levels below 1mg/l (Swingle

1969). Coolwater fish species such as rainbow trout, which are less tolerant of low oxygen levels, cannot survive levels below 2.5mg/l (Wheaton 1977). Although the stratification and dissolved oxygen levels are limiting the amount of habitat available for fish during late summer, additional water profiles collected during the fall, winter, and summer are needed to accurately assess any permanent limitations on fish.

Black Crappie

Clear Lake black crappie ranged in size from 48 to 239 mm TL (age 1 to 4) and displayed stable year–class strength. No black crappie >4 years old were collected (Table 8). The growth of fish collected was consistent with what is typically found in Washington (Fletcher et al. 1993), and other lakes in Spokane County. For example the average length of black crappie at four years old collected from Liberty Lake, Spokane County, was 183mm TL, and the average length of 11 black crappie at four years of age collected from Newman Lake, Spokane County, was 197mm (1998, WDFW, unpublished). The relative weight of black crappie <200mm TL was higher than the national standard (Figure 2), fish > 200mm TL had relative weights lower than the national standard. The dominant size class of black crappie in the sample was between 120 and 160mm TL (Figure 3). Only five young–of–the–year black crappie were collected which may be an indication of low spawning success.

Table 8. Age and growth of black crappie sampled from Clear Lake (Spokane County) September 1998. Unshaded values are mean back–calculated length at age using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using Lee's modification (Carlander 1982).

		Mean total length (mm) at age			
Year Class	**# Fish**	**1**	**2**	**3**	**4**
1997	24	42			
		67			
1996	19	35	114		
		63	127		
1995	8	36	104	168	
		66	122	176	
1994	8	32	108	169	206
		62	127	178	210
Direct Proportion Overall mean		36	109	169	206
Lee's Weighted Mean		65	126	177	210
Direct Proportion State Average		46	111	157	183

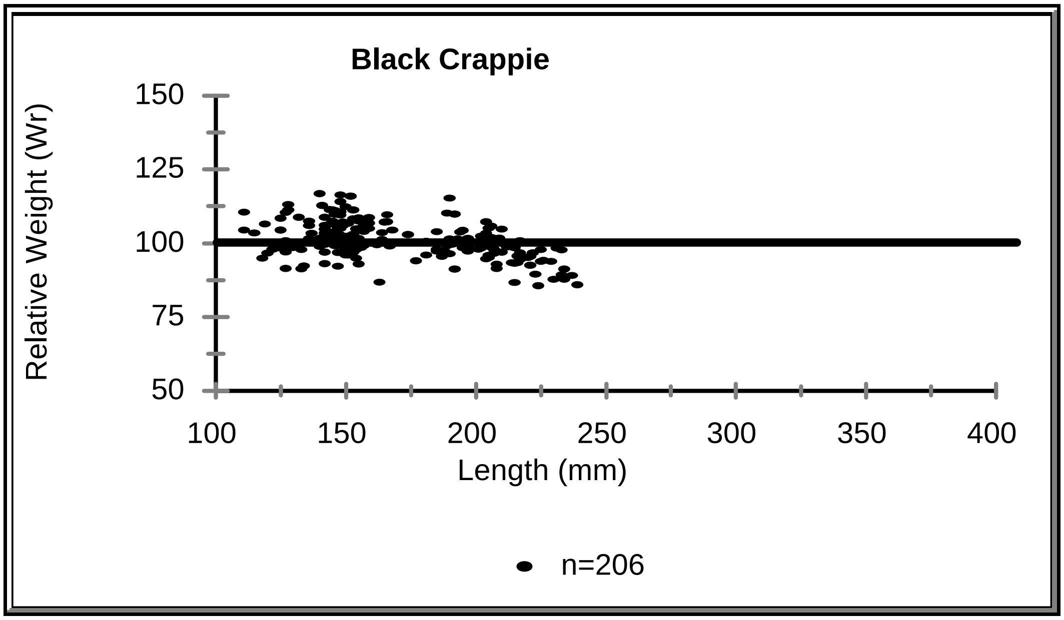

Figure 2. Relationship between total length and relative weight (Wr) of black crappie, excluding young–of–the–year, compared to the national standard (horizontal line 100), collected at Clear Lake (Spokane County) during September 1998.

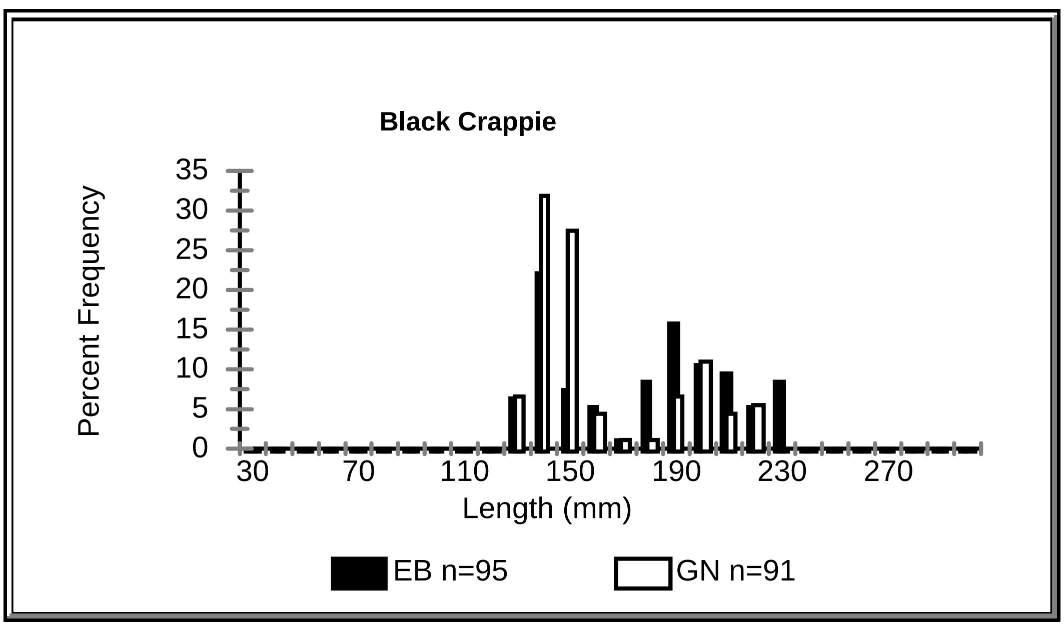

Figure 3. Length distribution of black crappie, excluding young–of–the–year, captured while electrofishing (EB),and gill netting (GN), at Clear Lake (Spokane County) during September 1998.

Brown Bullhead

Clear Lake brown bullhead ranged in size from 95 to 370 mm TL. The average condition factor (*K*) of 10 brown bullhead (>260 mm TL) collected from Clear Lake was 1.37 ± .13. This average condition factor was higher than the condition factor calculated from a sample of 82 brown bullhead (>260 mm TL) collected from 29 lakes in eastern Washington, which had an average condition factor (K) of 1.22 ± .1 (Fletcher et al. 1993). Although brown bullhead were common and in good condition in Clear Lake, it is unknown what, if any, contribution they are making to the recreational fishery.

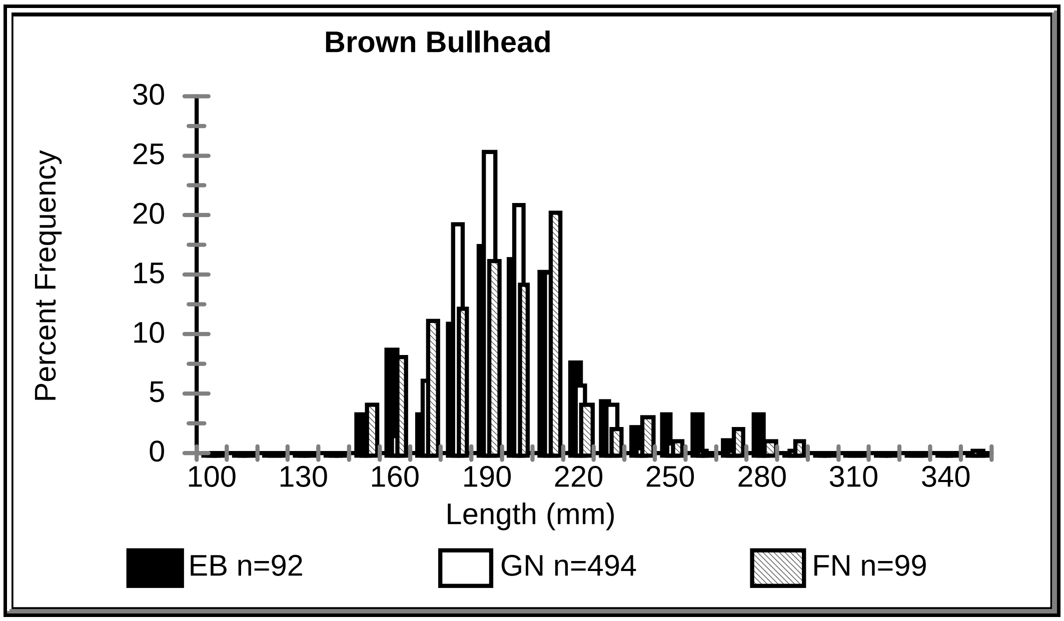

Figure 4. Length distribution of brown bullhead, excluding young–of–the–year, captured while electrofishing (EB), gillnetting (GN), and fyke netting (FN) at Clear Lake (Spokane County) during September 1998.

Largemouth Bass

Clear Lake largemouth bass ranged in size from 47 to 499 mm TL (age 1 to 7) and displayed variable year–class strength (Table 9). The 1997, 1996, and 1995 year classes were well represented in the sample. No fish were collected from the 1990 year class. Largemouth bass growth was generally lower than the growth of other largemouth bass in Washington (Fletcher et al. 1993) and nearby lakes in Spokane County. For example, the average length of six–year old largemouth bass collected from Liberty Lake (Spokane County) in 1998 were 407mm (1998, WDFW, unpublished). The average length of largemouth bass, at seven years of age, collected in 1998 at Newman Lake (Spokane County), were 439mm (1998, WDFW, unpublished). Even though growth rates for largemouth bass in Clear Lake are lower than the two above examples, the relative weight of quality length largemouth bass (≥300 mm) were above the national average (Figure 5). Larger fish (>300mm) were well represented in the sample (Figure 6).

Table 9. Age and growth of largemouth bass sampled from Clear Lake (Spokane County) September 1998. Unshaded values are mean back–calculated length at age using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using Lee's modification (Carlander 1982).

		Mean total length (mm) at age										
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1997	26	63										
		75										
1996	51	65	172									
		79	177									
1995	12	74	172	234								
		89	180	238								
1994	5	103	183	255	304							
		118	193	261	307							
1993	2	76	126	179	241	278						
		91	138	187	246	281						
1992	4	54	148	212	263	318	383					
		71	161	222	271	323	385					
1991	1	42	118	183	228	277	370	412				
		60	133	196	239	286	375	415				
1990	0	0	0	0	0	0	0	0	0			
		0	0	0	0	0	0	0	0			
1989	1	52	105	175	217	287	347	381	426	459		
		70	120	188	228	296	353	385	428	460		
1988	1	57	127	160	200	243	283	326	376	403	446	
		74	141	173	212	253	292	333	381	407	448	
1987	1	44	95	137	197	232	270	302	327	356	394	419
		62	111	151	208	242	278	308	333	360	396	421
Direct Proportion Overall mean		63	138	192	236	273	331	355	376	406	420	419
Lee's Weighted mean		81	174	227	266	293	355	360	381	409	422	421
Direct Proportion State Average		60	146	222	261	289	319	368	396	440	485	472

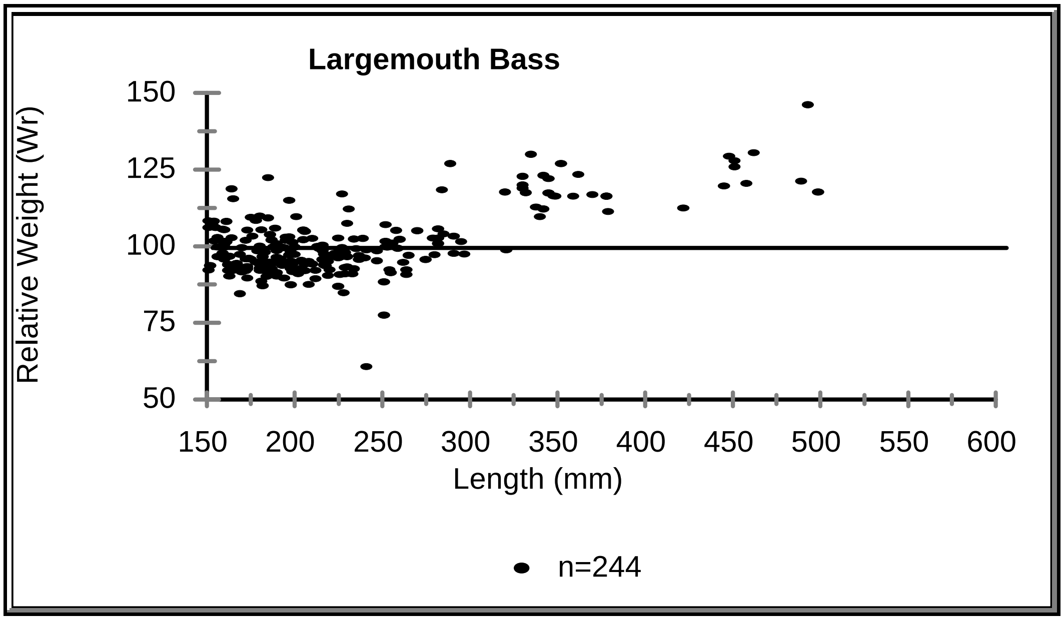

Figure 5. Relationship between total length and relative weight (Wr) of largemouth bass, excluding young–of–the–year, compared to the national standard (horizontal line 100), collected at Clear Lake (Spokane County) during September 1998.

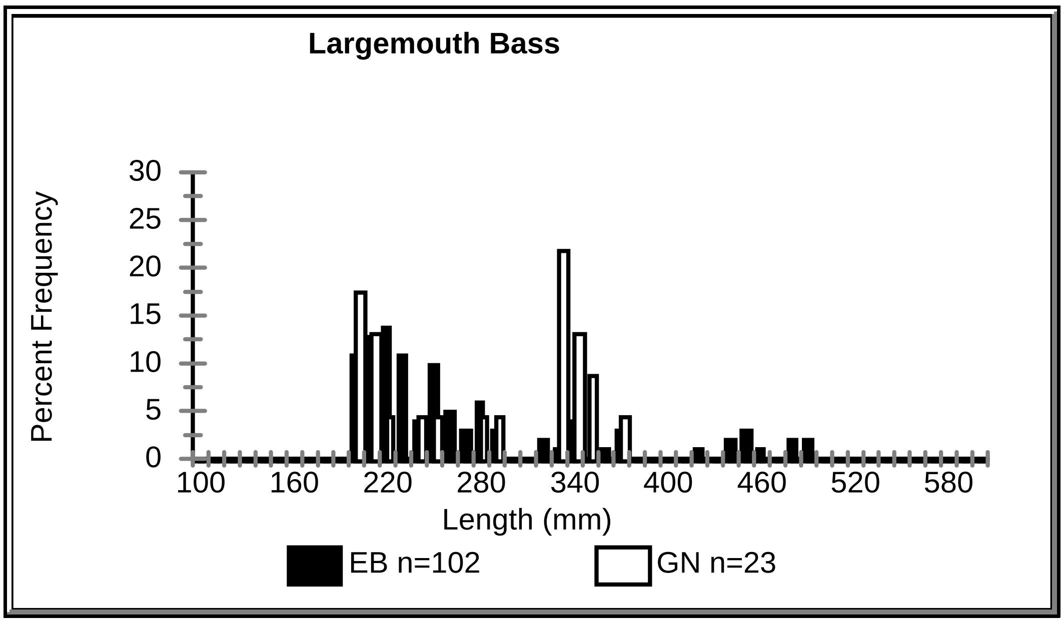

Figure 6. Length distribution of largemouth bass, excluding the young–of–the–year, captured while electrofishing (EB) and gillnetting (GN) at Clear Lake (Spokane County) during September 1998.

Pumpkinseed Sunfish

Clear Lake pumpkinseed sunfish ranged in size from 43 to 170mm TL (age 2 to 6) and displayed variable year–class strength (Table 10; Figure 8). Although the sample size was very large, the size range was narrow. The sampling technique may have reduced the chances of collecting zero and one year old fish. Relative weights are generally below 100 (Figure 7).

Table 10 . Age and growth of pumpkinseed sunfish sampled from Clear Lake (Spokane County) September 1998. Unshaded values are mean back–calculated length at age using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using Lee's modification (Carlander 1982).

		Mean total length (mm) at age					
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**
1997	0	0					
		0					
1996	9	20	72				
		40	78				
1995	3	25	81	126			
		46	92	129			
1994	17	16	51	78	106		
		38	66	87	110		
1993	2	14	37	71	108	143	
		37	56	85	117	146	
1992	2	14	60	90	107	122	
		36	75	100	114	127	
Direct Proportion Overall Mean		18	60	91	107	132	138
Lee's Weighted Mean		39	71	93	111	136	140
Direct Proportion State Average		24	72	102	123	139	

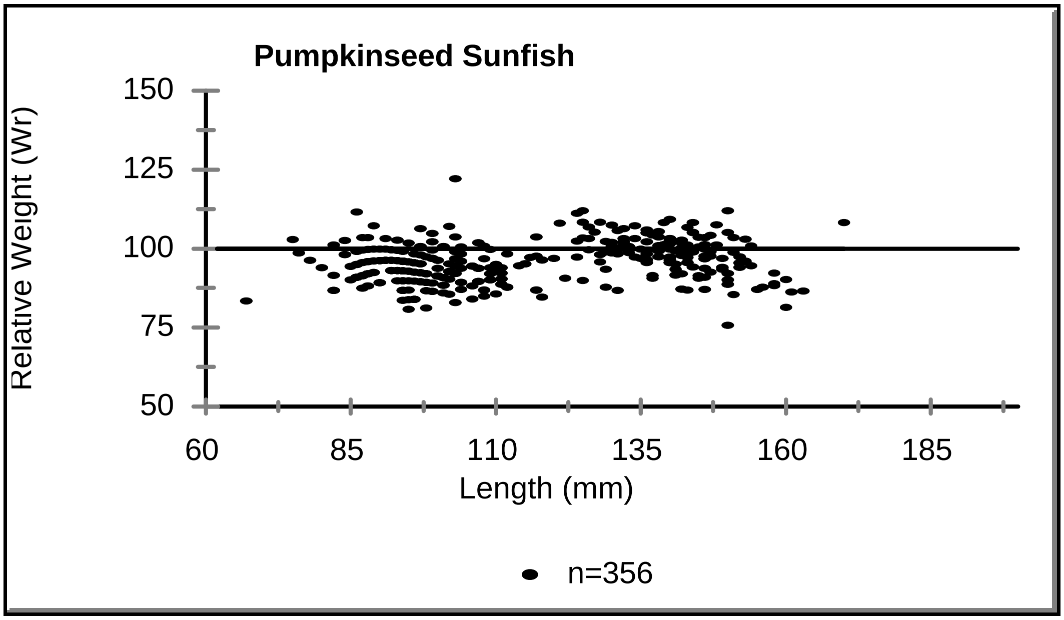

Figure 7. Relationship between total length and relative weight (Wr) of pumpkinseed sunfish, excluding young–of–the–year, compared to the national standard (horizontal line 100), collected at Clear Lake (Spokane County) during September, 1998.

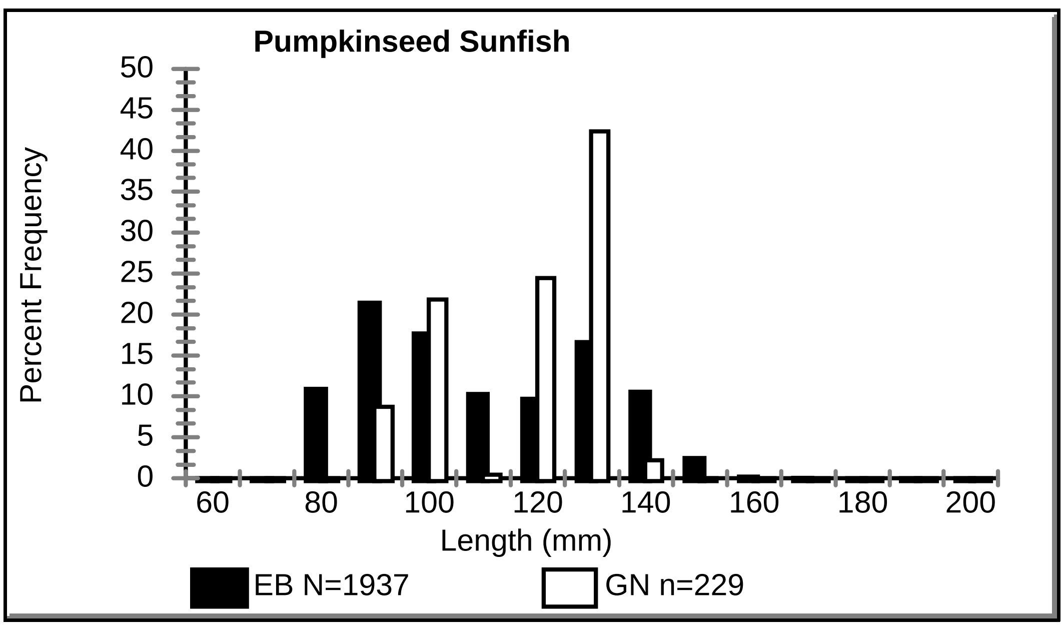

Figure 8. Length distribution of pumpkinseed sunfish, excluding young–of–the–year, captured while electrofishing (EB), and gill netting (GN),at Clear Lake (Spokane County) during September, 1998.

Walleye

Clear Lake walleye ranged in size from 505 to 660 mm. Although there is no evidence of natural reproduction, fish continue to show up in both stock assessments and angler creel. Only four fish were collected during the warmwater stock assessment during September 1998. The relative weight value of the fish sampled were below the national average (Figure 9). Growth rates of walleye collected from Clear Lake may not accurately represent walleye growth in the lake, the growth may be more representative of the lake of origin.

Table 11. Age and growth of walleye sampled from Clear Lake (Spokane County) September 1998. Unshaded values are mean back–calculated length at age using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using Lee's modification (Carlander 1982).

		Mean Total Length (mm) at Age							
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1991	2	110	205	266	336	411	454	487	
		154	239	293	355	423	461	491	
1990	1	105	206	292	365	419	513	563	592
		150	242	321	387	436	521	567	594
Direct Proportion Overall Mean		107	205	279	350	415	483	525	592
Lee's Weighted Mean		153	240	303	366	427	481	516	594

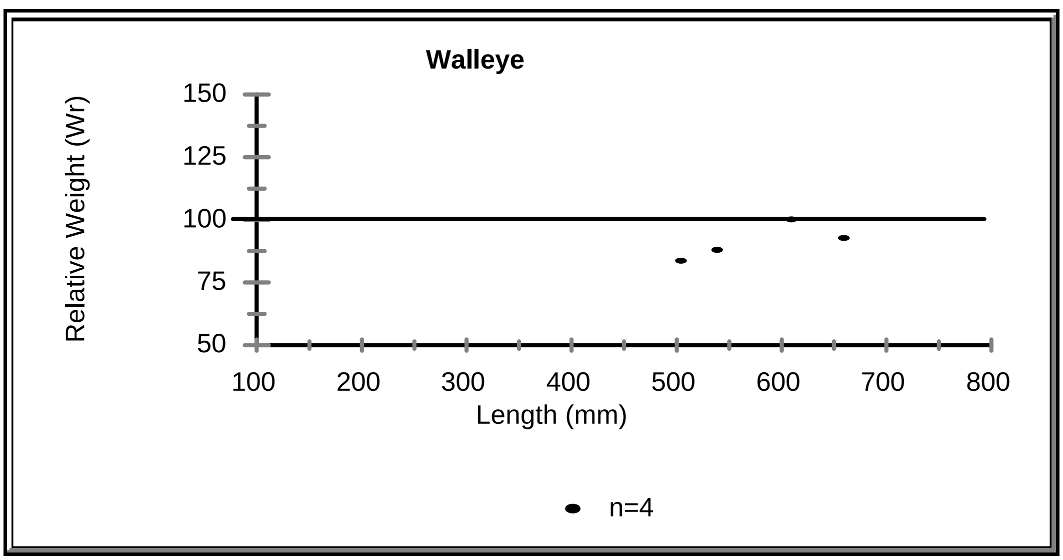

Figure 9. Relationship between total length and relative weight (Wr) of walleye, excluding young–of–the–year, compared to the national average (horizontal line 100), collected at Clear Lake (Spokane County) during September, 1998.

Trout Species

Rainbow trout, brown trout and lake trout were collected during this survey. These species are annually stocked into the lake and are not believed to be naturally reproducing. Together, trout consisted of only 2.0% of the total biomass collected by weight and less than .3% of the biomass by number (Table 4).

The warmwater sampling techniques used in this survey are largely restricted to the littoral zone of lakes surveyed, and therefore, salmonid species may by under represented using this approach. Although trout species comprised 2.0% of the total biomass, this figure may not be an accurate assessment of their true contribution to the species composition of Clear Lake.

Discussion

During the fall of 1998, the Clear Lake warmwater fish community was dominated by an abundance of prey–size fish (e.g., brown bullhead, pumpkinseed sunfish and young largemouth bass) and adult largemouth bass. The high relative abundance, high CPUE, low relative weights, and slow growth rates observed for fish < 200mm of these species may be the result of intense inter– and intraspecific competition for available resources among small fish in the community. The abundance of quality–size largemouth bass sampled in Clear Lake was higher than in many other lakes surveyed in Region 1. Although slightly lower than the values typically observed for balanced largemouth bass populations nationwide (Willis et al. 1993), Clear Lake largemouth bass PSD (22±5) and RSD-P (11±4) values are indicative of a high quality largemouth bass population compared to many other populations surveyed in the Spokane area. High condition or relative weight of larger bass (>300 mm) in the population indicates adequate forage. Considering these factors, Clear Lake could be managed as a quality largemouth bass fishery with minimal effort or change in the current management strategy.

Water quality limitations are likely affecting the fish community of Clear Lake. Intense thermal stratification at 6 m limited the amount of habitat available for all fish species at the time of this survey in September. The dissolved oxygen content of the water below 6m was lower than 1 mg/L, which is too low for even low oxygen tolerant species (Swingle 1969). This anoxic condition likely crowded all fish species into the top 6 m which may increase competition for available resources. Future water quality monitoring should include monthly sampling to identify water quality problems that could negatively impact the Clear Lake fishery.

Dense submerged macrophytes may be contributing to the crowding of pumpkinseed sunfish by limiting effective foraging by largemouth bass (Bettoli et al. 1992). Submerged macrophytes cover most of the bottom of the Clear Lake in all areas less than 4 m deep (Jennifer Parsons, DOE, personal communications). High densities of macrophytes can reduce the quality of a fishery (Wiley et al. 1984). Dense macrophytes can cause panfish and other game fish to become stunted by reducing the ability of predators to effectively forage (Olson et al. 1998) and by reducing the ability of panfish to forage effectively (Crowder and Cooper 1982). Reducing the abundance of aquatic macrophytes in Clear Lake may have a positive effect on the fishery.

The removal of aquatic vegetation by introducing grass carp in Texas resulted in increased growth of black crappie (Maceina et al. 1991). However, managers should keep in mind that reducing submerged vegetation to less than 20% of the lakes surface area can result in decrease recruitment and standing crop of largemouth bass (Durocher et al. 1984).

Aquatic macrophytes can be reduced by mechanical, chemical, and biological methods (Wiley et al. 1984). Reducing submerged macrophytes mechanically to increase the quality of the fishery can have short–term positive results (Olson et al. 1998). Although mechanical removal is a quick way to remove unwanted submerged macrophytes it should be considered a short–term solution that requires labor intensive annual effort. Grass carp (*Ctenopharyngodon idella*) have been used in Washington to remove aquatic vegetation with variable success (Bonar et al. 1996). Chemicals are also an effective method for the removal of dense aquatic vegetation.

Although walleye were collected during the survey they have not been stocked by WDFW. They are thought to be the result of illegal stocking. Because Clear Lake is not managed for walleye the removal of the minimum size and bag limits may help remove unwanted fish from the lake.

Management Options

The following options are intended to assist Regional Fisheries Biologists in their efforts to improve the quality of warmwater angling opportunities on Clear Lake, Spokane County. We believe that the following management techniques used independently or in combination will increase the quality of largemouth bass and/or black crappie angling. Because of the current quality of largemouth bass angling on the lake, the option to make no changes in current regulations is included.

Continue Mixed–Species Management

Currently, Clear Lake is managed as a mixed–species fishery which offers angling opportunity for several fish species. Current regulations for Clear Lake are statewide general rules which allow anglers to retain five trout and five bass (no minimum size; no more than three over 15"). There is no limit on panfish such as pumpkinseed sunfish, brown bullhead catfish, or black crappie. Although it is difficult to evaluate the contribution of panfish to the sport fishery without creel survey data, the current trout and largemouth bass fishery appears to offer some quality angling opportunity. WDFW annually stocks rainbow trout, and recently lake trout, which has resulted in a quality trout fishery that receives considerable angler effort (Bob Peck, WDFW, personal communications). Shrader and Moody (1997) concluded it is possible to manage for both quality largemouth bass and quality trout after studying the fish community of Crane Prairie Reservoir, Oregon, following the illegal introduction of largemouth bass. A similar management strategy for Clear Lake might offer angling satisfaction to multiple user groups. However, managing Clear Lake as a mixed–species fishery likely reduces the harvest potential for warmwater fish species other than largemouth bass. The quality of panfish under a mixed species management strategy may continue to show signs of being stunted. Although little management emphasis has been directed toward the warmwater fish species in Clear Lake historically, the quality of the largemouth bass population is prized by local bass clubs.

Quality Black Crappie Option

Slow growth, compared to other states, may be contributing to the low relative abundance and limited angling opportunity for quality and preferred black crappie in Clear Lake. Although Clear Lake black crappie appear to have higher growth rates than what has been found in other lakes throughout the state of Washington, published growth rates for black crappie in other states are much higher (Boxrucker 1987; Reed and Davies 1991; Larson et al. 1991). The average length of black crappie at age 4 from Clear Lake was 206mm TL compared to an age 4 average of 183 mm TL from sixteen lakes around the state of Washington (Fletcher et al. 1993). No black crappie >4 years old were collected. The growth rates of black crappie in Clear Lake appear to be unaffected by angling pressure and may continue to be slow regardless of harvest. Black crappie may be susceptible to harvest for several fishing seasons before reaching quality length (200 mm). Low spawning success and poor recruitment may also be contributing to the low density of quality length black crappie in Clear Lake, although it was not evaluated during this survey.

Currently, there are no management regulations to increase the quality of black crappie angling in Region 1 (Ferry, Stevens, Pend Oreille, Lincoln, Spokane, Adams, Whitman, Franklin, Columbia, Garfield, and Asotin Counties). Current statewide regulations for black crappie in Washington allow anglers to retain as many fish as they can catch with no minimum length. Minimum length and daily bag limits have been used in other states to increase the quality of black crappie fisheries. The mean length of crappie increased by 66 mm while maintaining pre-regulation growth rates following the implementation of a 254 mm (10") minimum length limit in the Delaware Reservoir, Ohio (Hale et al. 1999). Similarly, Colvin (1991a) and Colvin (1991b) saw an increase in the length of fish creeled following the implementation of length and bag limit restrictions on white crappie (*Pomoxis annularis*) in Missouri Reservoirs. Considering the above average growth rate of black crappie collected from Clear Lake compared to Washington State's average (Fletcher et al. 1993), black crappie would likely grow to larger lengths if allowed to remain in the lake for more than four years.

The implementation of a 254 mm (10") minimum length limit and a bag limit of five fish per day for black crappie could increase the average size at harvest, increase the opportunity to catch a quality length fish, and offer a unique fishing opportunity in Region 1. The intention of this regulation is not to increase the number of fish harvested. In fact, the total harvest of black crappie under this regulation would likely decrease. The intention of this regulation is to give anglers a unique opportunity by increasing the average size of black crappie retained.

Prior to the implementation of creel and size limits, managers should have a good understanding of growth and mortality rates (Colvin 1991a; Reed and Davies 1991). Currently, there is no data on angling mortality rates for black crappie in Clear Lake. To better understand the impact anglers have on the population structure, and to evaluate the potential benefits of a minimum size and creel limit, a detailed creel survey should precede any regulation change.

Largemouth Bass Slot–Limit Regulation

Survey data suggests that Clear Lake would be a good candidate for inclusion under the current recommended WDFW slot–limit regulation for largemouth bass. This regulation consists of a five fish limit, fish 12-17 inches are to be released, and only one fish over 17 inches may be retained. The intent of this regulation is to increase the number of quality length ($\geq$300 mm; 12") largemouth bass in the lake. Under this regulation the number of largemouth bass predators in the lake should increase and prey upon the now stunted pumpkinseed sunfish populations. Additionally, this regulation would increase the number of larger bass available for catch and release angling opportunities. Slot–limits have been used successfully in other states as well as in some Washington lakes to improve the quality of both bass and panfish angling (Eder 1984; Wilde 1997).

The intention of this slot–limit is to increase the average size, not the number, of largemouth bass in the lake. Although the number of small largemouth bass may decrease following slot–limit implementation, the average size of largemouth bass would increase. Slot–limits can be a useful tool to increase the quality of largemouth bass populations, however, they can fail to restructure the populations if anglers do not harvest sufficient numbers of smaller fish and recruitment is high (Martin 1995). If adopted, periodical sampling should be conducted to monitor the effectiveness of this regulation.

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