1998 Warmwater Fisheries Survey of Liberty Lake

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Abstract

To evaluate the current conditions and to better understand how to best manage the Liberty Lake fishery, personnel from Washington Department of Fish and Wildlife's (WDFW) Warmwater Enhancement Program conducted a fish community survey of Liberty Lake during August and September 1998. Dissolved oxygen levels were within the desirable range for warmwater fish during the sampling period. The low number of stock length fish collected for most species resulted in broad confidence limits for PSDs making their interpretation difficult. Nine species of fish were collected. Bluegill sunfish (55.1%) and pumpkinseed sunfish (13.4%) were the most abundant species by number. Walleye (26.5%) and bluegill sunfish (19.7%) contributed the most to the biomass by weight. Results of this survey indicate that past walleye fry stocking has not contributed to the density of walleye in the lake. Survival of walleye stocked as large fingerlings (130-170mm TL) is higher in Liberty Lake. Therefore, walleye >5 inches (130mm TL) should be used in future stocking plans. In order to establish a walleye population in Liberty Lake, 127-178mm TL (5-7") walleye should be stocked at the rate of 25-50 per surface acre. Liberty Lake data also suggests that it 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. Adopting this regulation for largemouth bass should complement efforts to establish a walleye population for controlling overabundant warmwater fish species in Liberty Lake.

Table of Contents

List of Tables

List of Figures

Introduction And Background

Liberty Lake is a moderately sized (surface area = 288 hectares) body of water [mean depth = 8 meters (m), maximum depth = 11 m] located in Spokane County (Table 1), east of Spokane. Liberty Creek, located on the southeast end, is the inlet. The creek flows through an extensive wetland formed by an artificial dike (Figure 1). The one outlet on the lake discharges through a screened drainage channel. Water discharge from the outlet Liberty Lake is seasonal.

Table 1. Physical parameters of Liberty Lake (Spokane County).

Physical Parameters	Liberty Lake (Spokane County)
Surface Area (acres)	710
Surface Area (hectares)	288
Shoreline Length (m)	7,725
Maximum Depth (m)	11
Mean Depth (m)	8
Volume (m3)	19,735,552
Drainage Area (acres)	8,512
Shoreline Development D_L	1.3

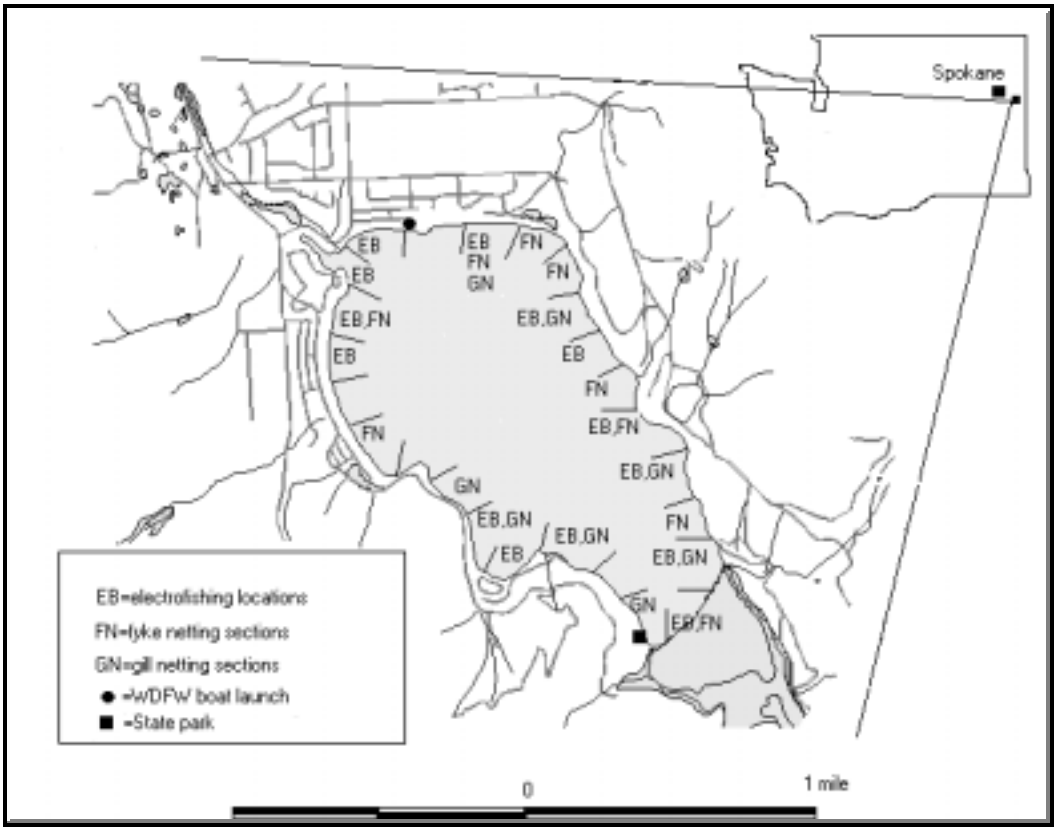

Figure 1. General location of Liberty Lake located East of Spokane, Washington (Spokane County) with sampling sections indicated.

As recently as the 1970s, Liberty Lake supported four resorts offering a wide range of services (e.g., boat rentals, lodging, etc.), however, these resorts are no longer operating (Bob Peck, WDFW, personal communication). Public access on the lake includes a Washington Department of Fish and Wildlife (WDFW) owned and operated boat launch on the north end of the lake, although it is limited to approximately 18 vehicles with trailers. Access is also available through a county park located near the inlet creek. The park offers camping, swimming, and picnicking areas but does not have boat launching facilities.

During the 1960s, and '70s, Liberty Lake had a reputation as one of the best trout fisheries in the State of Washington (Ray Duff, WDFW, personal communication). In 1977, catch rates of rainbow trout in Liberty Lake were 8.2 trout per angler day (Duff et al. 1977). The lake's ability to grow quality trout was based on rehabilitating the lake every six to ten years. Although the lake was rehabilitated often, target fish species returned either because the rehabilitation was not complete or the fish were illegally reintroduced. In 1982, WDFW decided not to go ahead with a scheduled rehabilitation. This was in part due to the lack of local public support and anglers intent on retaining their opportunity to fish for bass in the lake.

From the early 1980s until the mid 1990s Liberty Lake has been managed primarily as a trout fishery, but has also offered warmwater fishing opportunities. The lake has been stocked annually with trout fry and catchable trout (15-20cm). Stocked populations of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), as well as naturally reproducing largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), yellow bullhead (*Ictalurus natalis*), brown bullhead (*Ameiurus nebulosus*), pumpkinseed sunfish (*Lepomis gibbosus*), and bluegill sunfish (*Lepomis macrochirus*) have contributed to the fishery, but have also challenged fisheries biologists attempting to improve the quality of the fishery that was once highly regarded by Washington State anglers.

In 1996, Liberty Lake was selected by regional fisheries staff for walleye (*Stizostedion vitreum*) stocking as a means to enhance fishing opportunity and diversity. In the fall of 1996, the lake received an initial stocking of 100 adult walleye collected from Moses Lake by WDFW biologists. Establishing a self–sustaining population of walleye in Liberty Lake will be difficult because of the lack of suitable spawning habitat. Walleye prefer to scatter their eggs and milt mainly on rock or rubble bottoms in turbulent areas (Balon et al. 1977). In addition to offering a diverse fishing opportunity, it was hoped that walleye stocked as adults would reduce crowding of yellow perch, and overabundant panfish species. Following the initial stocking, WDFW biologists have supplemented the walleye population annually (Figure 2).

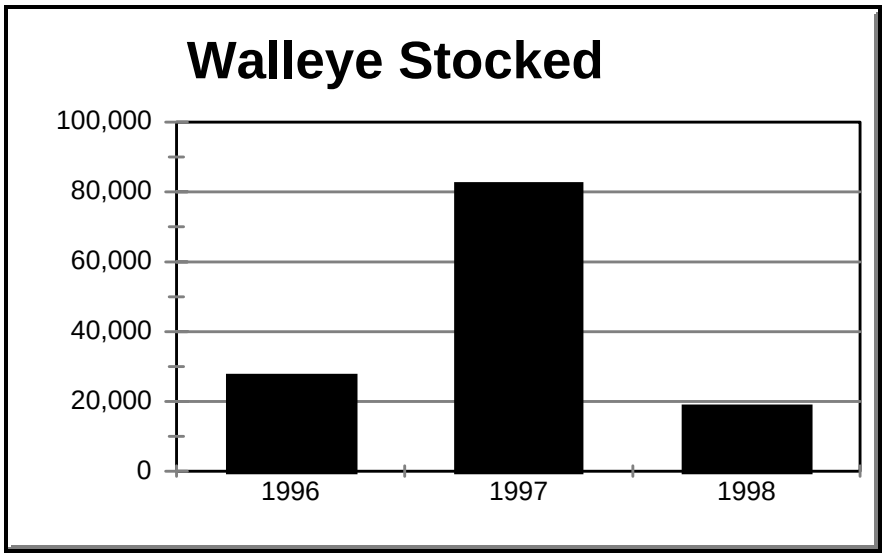

Figure 2. Walleye fry stocked in Liberty Lake, 1996-1998. Fish stocked in 1996 were 12cm; fish stocked in 1997 were sac fry; fish stocked in 1998 were 5cm.

Today, Liberty Lake is managed as a mixed–species fishery. The lake receives an annual stocking of rainbow trout fry, as well as catchable rainbow and brown trout. During the spring of 1999, 60,000 rainbow trout fry, 15,000 rainbow trout (200-250mm TL), and 10,000 brown trout (200-250mm TL) were stocked into the lake. In addition to trout, Liberty Lake received an annual stocking of walleye fry from 1996 to 1998.

To evaluate the current conditions and to better understand how to best manage Liberty Lake fishery, personnel from WDFW's Warmwater Enhancement Program conducted a fish community survey of Liberty Lake during the summer of 1998.

Materials And Methods

Liberty Lake was surveyed by a three–person assessment team August 31 to September 3, 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 (30.5 m long x 1.2 m), a lead net (7.6 m long x 1.2 m deep), and two wings (4.7 m long and 1.2 meters in diameter).

Sampling locations were selected using a map of the lake by dividing the shoreline into 24 consecutively numbered sections of approximately 500m 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 while the large mesh end was anchored offshore. Fyke nets were set perpendicular to the shore with the lead net anchored onshore and the wing nets set at a 45 degree angle 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). Night time electrofishing covered roughly 63 percent of the shoreline. Two gill nets and two fyke nets were set overnight at random locations around the lake (Figure 1). 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). If a sample included several hundred young of the year or small juveniles (TL <100mm) of a given species, a sub–sample (N= ~100 fish) was measured and the remainder counted overboard. Scales were collected for age and growth analysis. Scale samples (up to five per length class) were mounted and pressed, and the fish aged according to Jearld (1983) and Fletcher et al. (1993). Rainbow trout, brown trout, brook trout (*Salvelinus fontinalis*), and members of the bullhead family (*Ictalurus* spp.) were not aged.

Water quality data was collected during the afternoon from the deepest location in the lake on August 31, 1998 (Table 1). Information was gathered on dissolved oxygen, temperature, specific conductance, total dissolved solids, pH, and salinity using a Hydrolab MiniSonde® probe. 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, gill netting, and fyke netting. Fish determined to be less than one year old were excluded from the calculations for species composition. The number of small fish 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 fish ≥stock length. Stock length, which varies by species, is the size of a particular fish species that offer recreational value to an angler (Anderson 1976). Randomly chosen sample sections can contribute to high variability among samples, therefore, 80 percent confidence intervals (CI) were calculated for each mean CPUE by species and by sampling method. Each CI was calculated as the mean $\pm t(\propto,N-1)\times SE$, 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 one year old and greater were included in the length frequency histograms.

Proportional stock densities (PSD), calculated as the number of fish≥quality length/number of fish≥stock length×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 length 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 percentage of world record catch length and vary depending on fish species (Table 2). Stock length (20-26 percent of the world record) refers to the minimum length of fish with recreational value, and quality length (36-41 percent of the world record) refers to the minimum length of a fish anglers would like to catch. In addition to stock and quality length, Gabelhouse (1984) introduced

relative stock density (RSD) which include preferred, memorable, and trophy lengths. Preferred length (45-55 percent of world record length) refers to the minimum length of a fish that anglers would prefer to catch. Memorable length (59-64 percent of the world record length) refers to the minimum length of a fish most anglers remember catching, whereas trophy length (74-80 percent of world record length) refers to the minimum length of a fish worthy of acknowledgment (Table 2). 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 length 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 2. PSD/RSD length categories for fish species collected during Liberty Lake survey. Measurements are total length for each category (Anderson and Neumann 1996). Numbers in parenthesis represent percentages of world record lengths (Gabelhouse 1984) in millimeters (mm).

	Standard Length Categories (mm)				
Species	**Stock (20-26)**	**Quality (36-41)**	**Preferred (45-55)**	**Memorable (59-64)**	**Trophy (74-80)**
Largemouth bass (*Micropterus salmoides*)	200	300	380	510	630
Smallmouth bass (*Micropterus dolomieui*)	180	280	350	430	510
Yellow perch (*Perca flavescens*)	130	200	250	300	380
Walleye (*Stizostedion vitreum*)	250	380	510	630	760
Yellow bullhead[a] (*Ictalurus natalis*)	150	230			
Brown bullhead[b] (*Ameiurus nebulosus*)					
Bluegill sunfish (*Lepomis macrochirus*)	80	150	200	250	300
Black crappie (*Pomoxis nigromaculatus*)	130	200	250	300	380
Pumpkinseed sunfish (*Lepomis gibbosus*)	80	150	200	250	300

[a] no preferred, memorable, or trophy lengths established (Anderson, and Neumann 1996 Anderson).
[b] no standard lengths have been established to calculate PSD.

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 $L_n=(A\times TL)/S$, 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 $L_n=a+A\times(TL-a)/S$, where a is the species–specific standard positive y–axis 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. This "state average" may be more representative of fish growth for the lakes sampled than for the entire state.

Relative weight (W_r) index was used to evaluate the condition of fish in Liberty Lake. This index was calculated as $W_r=W/W_s\times100$, where W is the weight (g) of an individual fish and Ws is the standard weight of a fish of the same length (Murphy and Willis 1991). W_s is calculated from the standard log10weight-log10lenght 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 finding 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

Water Quality

Water quality data collected did not indicate a noticeable thermocline at Liberty Lake (Table 3). The water temperature dropped 1.3° C from 1 to 7m, which is approximately the maximum depth. Although there was no clear hypolimnion, the dissolve oxygen level dropped from 7.29 milligrams per liter (mg/l) at 6m to 5.93 mg/l at 7m. Dissolved oxygen levels were within the desirable range for warmwater fish during the sampling period (Boyd 1990). Liberty Lake should be surveyed during the summer and winter months to identify water quality limitations.

Table 3. Water chemistry data collected at 16:30 on August 31, 1998 from Liberty Lake (Spokane County). The sample was taken on the northeast end of the lake near the Washington State Department of Fish and Wildlife boat launch.

Depth (m)	Temp. (°C)	DO (mg/l)	Cond.(µmhosm)	TDS	pH	Salinity
1	23.64	7.84	48.2	.0308	7.84	.01
2	23.43	7.81	47.9	.0308	7.85	.01
3	23.03	7.84	47.8	.0306	7.86	.01
4	22.84	7.74	47.7	.0306	7.81	.01
5	22.49	7.53	47.6	.0306	7.71	.01
6	22.38	7.29	47.7	.0305	7.61	.01
7 (bottom)	22.34	5.93	47.6	.0305	7.57	.01

Species Composition

Nine species of fish were collected from Liberty Lake in August and September 1998 (Table 4). Bluegill sunfish and pumpkinseed sunfish were the most abundant species by number. Walleye and bluegill sunfish contributed the most to the biomass by weight. Although walleye and brown bullhead collectively accounted for only 6.5 percent of the fish collected they constitute 46.2 percent of the total biomass by weight. Species composition including young–of–the–year differed very little in terms of biomass from the species composition excluding young–of–the–year (Table 5).

Table 4. Species composition (excluding young of the year) by weight, kilograms (kg), and by number collected during the fall 1998 warmwater fish survey of Liberty Lake (Spokane County).

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Type of Fish	(kg)	(%w)	(#)	(%n)	Min	Max
Walleye	42.2	26.5	50	2.6	189	680
Bluegill Sunfish	31.3	19.7	1071	55.1	67	198
Brown Bullhead	24.7	15.5	75	3.9	112	385
Largemouth Bass	11.5	7.2	120	6.2	79	492
Yellow Perch	11.6	7.2	113	5.8	99	230
Pumpkinseed Sunfish	10.8	6.7	260	13.4	52	188
Yellow Bullhead	10.7	6.7	97	5.0	98	297
Brown Trout	7.2	4.5	21	1.1	255	401
Black Crappie	6.1	3.8	120	6.2	65	305
Rainbow Trout	1.7	1.1	3	0.2	272	486
Smallmouth Bass	1.1	0.7	12	0.6	82	415
Eastern Brook Trout	0.4	0.2	2	0.1	265	289

Table 5. Species composition (including the young of year) by weight (Kg) and by number collected during the fall 1998 warmwater fish survey of Liberty Lake (Spokane County).

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Type of Fish	(kg)	(%w)	(#)	(%n)	Min	Max
Walleye	42.2	26.4	50	2.3	189	680
Bluegill Sunfish	31.7	19.8	1200	55.4	33	198
Brown Bullhead	24.8	15.5	76	3.5	76	385
Largemouth Bass	11.7	7.3	201	9.3	40	492
Yellow Perch	11.6	7.3	120	5.5	54	230
Pumpkinseed Sunfish	10.8	6.7	260	12.0	52	188
Yellow Bullhead	10.7	6.7	97	4.5	98	297
Brown Trout	7.2	4.5	21	1.0	255	401
Black Crappie	6.1	3.8	125	5.8	36	305
Rainbow Trout	1.7	1.1	3	0.1	272	486
Smallmouth Bass	1.1	0.7	12	0.6	82	415
Eastern Brook Trout	0.4	0.2	2	0.1	265	289

C P U E

Electrofishing was typically more effective at catching all warmwater fish species found in Liberty Lake, although gill netting was more effective at capturing smallmouth bass, yellow perch, and yellow bullhead (Table 6). Fyke netting was least effective sampling method for all species except brown bullhead, which were caught at a slightly lower rate with gill nets. Bluegill sunfish were captured at the highest rate while electrofishing (347.6 fish per hour). Only one

smallmouth bass was collected using all sampling methods indicating their relative low abundance.

Table 6. Mean catch per unit of effort, by species and sampling technique (number of fish collected/one hour electrofishing, number of fish collected/one net night of gill netting, and number of fish colleted/one night of fyke netting), including 80 percent confidence intervals for each species collected using different sampling types in Liberty Lake (Spokane County).

	Sampling Method								
	Electrofishing			Gill Netting			Fyke Netting		
Species	(# / hour)	EB CI	# Sites	# /GN night	GN CI	# Nights	# /FN night	FN CI	# Nights
Brown Bullhead	16.8	±8.6	15	1.9	±1.0	8	2.1	±1.5	8
Black Crappie	10.4	±6.5	15	4.9	±1.3	8	0.4	±0.4	8
Bluegill Sunfish	347.6	±63.4	15	2.4	±1.5	8	0.9	±0.3	8
Largemouth Bass	2.8	±1.6	15	0.8	±0.5	8	0.1	±0.1	8
Pumpkinseed Sunfish	85.6	±19.7	15	1.5	±0.5	8	1.1	±0.5	8
Smallmouth Bass	0.0	NA	15	0.1	±0.1	8	0.0	NA	8
Walleye	2.8	±1.2	15	5.3	±1.9	8	0.0	NA	8
Yellow Bullhead	7.2	±3.7	15	8.9	±4.3	8	0.0	NA	8
Yellow Perch	4.4	±2.1	15	11.9	±8.5	8	0.0	NA	8

Stock Density Indices

The low number of stock length fish collected for most species resulted in broad confidence limits for PSDs making their interpretation difficult. Low PSD values for fish collected in high numbers may be an indication of a crowded population. For example, 854 bluegill sunfish stock length or larger had a PSD value of 3±1 (Table 7). Additionally, relatively few largemouth bass (≤200mm TL) were collected. Although the PSD for largemouth bass collected while electrofishing was 57, confidence limits of ±24 are extremely broad and should be viewed with caution. Anderson (1980) suggests PSD values of from 40 to 60 for largemouth bass and 20 to 40 for bluegill sunfish in balanced ponds.

The number of fish preferred length or larger was zero for all fish species except walleye and largemouth bass (Table 7). Walleye had a RSD-P value of 33±9, and an RSD-M value of 12±6. No trophy size fish were collected. The largemouth bass RSD-P value was 57±24. No memorable or trophy size largemouth bass were collected.

Table 7. Traditional stock density indices for warmwater fish (by sampling method) collected from Liberty Lake during fall 1998, including 80 percent confidence intervals (PSD=proportional stock density, RSD=relative stock density, RSD P=proportional stock density of preferred length fish, RSD M= proportional stock density of memorable length fish, PSD T=proportional stock density and trophy length fish).

Electrofishing

Species	# Stock Length	PSD	PSD CI	RSD-P	RSD-P CI	RSD-M	RSD-M CI	RSD-T	RSD-T CI
Brown Bullhead[b]	----	----	----	----	----	----	----	----	----
Black Crappie	25	0	0	0	0	0	0	0	0
Bluegill Sunfish	854	3	1	0	0	0	0	0	0
Largemouth Bass	7	57	24	57	24	0	0	0	0
Pumpkinseed Sunfish	214	13	3	0	0	0	0	0	0
Walleye	7	14	17	0	0	0	0	0	0
Yellow Bullhead[a]	18	0	0	----	----	----	----	----	----
Yellow Perch	11	36	19	0	0	0	0	0	0

Gill Netting

Species	# Stock Length	PSD	PSD CI	RSD-P	RSD CI	RSD-M	RSD-M CI	RSD-T	RSD-T CI
Brown Bullhead[b]	----	----	----	----	----	----	----	----	----
Black Crappie	39	18	8	5	5	3	3	0	0
Largemouth Bass	6	0	0	0	0	0	0	0	0
Pumpkinseed Sunfish	12	0	0	0	0	0	0	0	0
Walleye	42	45	10	33	9	12	6	0	0
Yellow Bullhead[a]	71	6	4	----	----	----	----	----	----
Yellow Perch	95	80	5	0	0	0	0	0	0

Fyke Netting

Species	# Stock Length	PSD	PSD CI	RSD-P	RSD CI	RSD-M	RSD-M CI	RSD-T	RSD-T CI
Brown Bullhead[b]	----	----	----	----	----	----	----	----	----
Black Crappie	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed Sunfish	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] no preferred, memorable, or trophy lengths established (Anderson, and Neumann 1996 Anderson).
[b] no standard lengths have been established to calculate PSD.

Black Crappie

Black crappie collected from Liberty Lake ranged from 36 to 305mm TL (age 1+ to 5+) and displayed variable class strength (Table 8). Growth of black crappie in Liberty Lake was good when compared to the average growth of black crappie from 15 lakes in Washington State. From these lakes, a state average length for black crappie at two years of age was 111.3mm TL (Fletcher et al. 1993). The average size of black crappie at two years of age collected during this survey from Liberty Lake was 100.9mm TL. Only eight young of the year black crappie were collected during the survey which may be an indication of poor recruitment, and no black crappie larger than 305mm were collected. Several black crappie were collected >200mm TL (Figure 3), all of which had relative weight below the national average (Figure 4). The origin of black crappie collected from Liberty Lake is unknown.

Table 8. Age and growth of black crappie collected from Liberty Lake (Spokane County) during fall 1998. Unshaded values are unweighted mean back–calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are weighted mean back–calculated lengths using the Lee's modification (Carlander 1982).

		Mean length (mm) at age				
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**
1997	16	67				
		43				
1996	9	58	120			
		28	105			
1995	1	49	115	175		
		17	93	164		
1994	1	60	112	136	164	
		31	93	122	156	
1993	2	60	134	181	215	253
		28	113	166	205	248
Lee's weighted mean		63	121	168	198	253
Direct proportion overall mean		29	101	151	180	248
Direct proportion state average		46	111	157	183	220

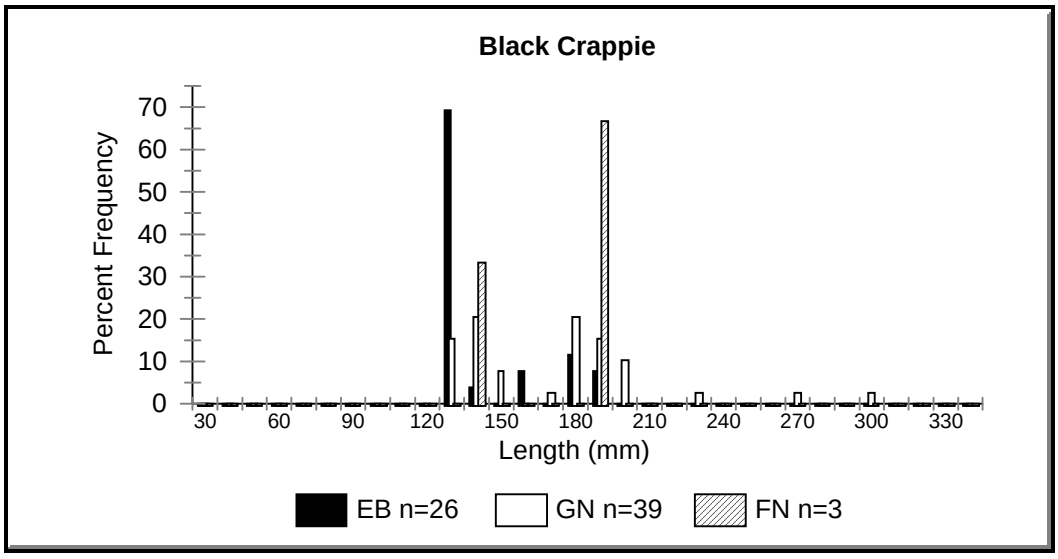

Figure 3. Length distribution of black crappie, excluding the young–of–the–year, captured while electrofishing (EB), gill netting (GN), and fyke netting (FN) at Liberty Lake (Spokane County) during fall 1998.

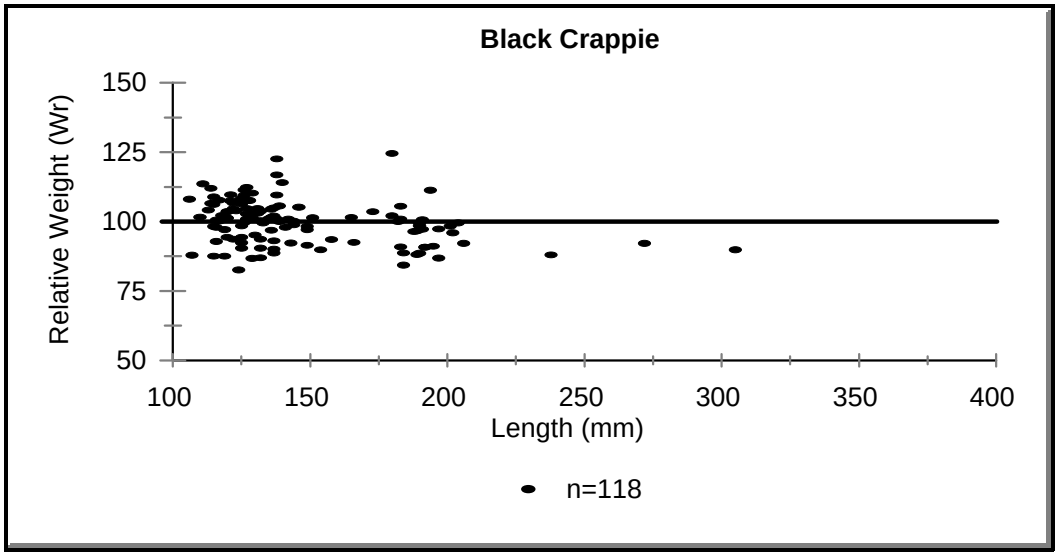

Figure 4. Relationship between total length and relative weight (W_r) of black crappie, excluding young–of–the–year, compared to the national standard (horizontal line 100) collected at Liberty Lake (Spokane County) during fall 1998.

Bluegill Sunfish

Bluegill sunfish collected during the warmwater fish survey of Liberty Lake ranged in size from 33 to 198mm. Over 170 young of the year bluegill sunfish were collected while electrofishing indicating strong reproduction for the species. More than 800 bluegill sunfish were collected during the survey, although none of the fish collected were larger than 200 mm TL (Figure 5). The relative weight of fish below 160 mm TL was consistent with bluegill sunfish nationwide. However, the condition of bluegill sunfish >160mm TL was consistent with the national average (Figure 6). The average growth of bluegill sunfish from Liberty Lake was higher than the average (state average) growth of bluegill collected from 12 lakes throughout the state of Washington average (Fletcher et al. 1993). The origin of bluegill sunfish collected from Liberty Lake is unknown.

Table 9. Age and growth of bluegill sunfish collected from Liberty Lake (Spokane County) during fall 1998. Unshaded values are mean back–calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using the Lee's modification (Carlander 1982).

		Mean length (mm) at age		
Year Class	**# Fish**	**1**	**2**	**3**
1997	22	64		
		52		
1996	6	77	142	
		65	139	
1995	3	68	128	160
		53	122	157
Lee's weighted mean		67	138	160
Direct proportion overall mean		57	131	154
Direct Proportion State Average		37	96	132

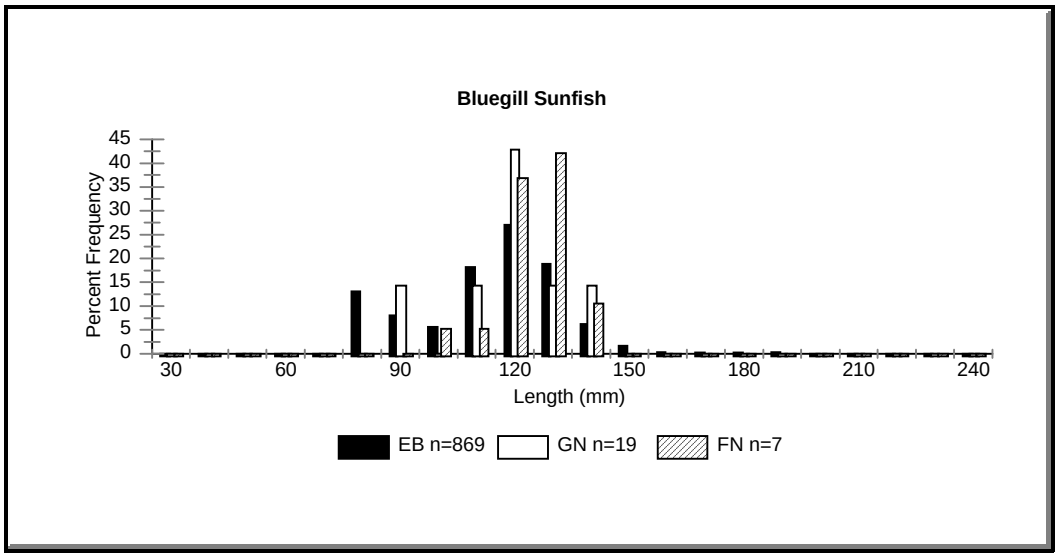

Figure 5. Length frequency distribution of bluegill sunfish, excluding the young–of–the–year, captured while electrofishing (EB), gill netting (GN), and fyke netting (FN) at Liberty Lake (Spokane County) during fall 1998.

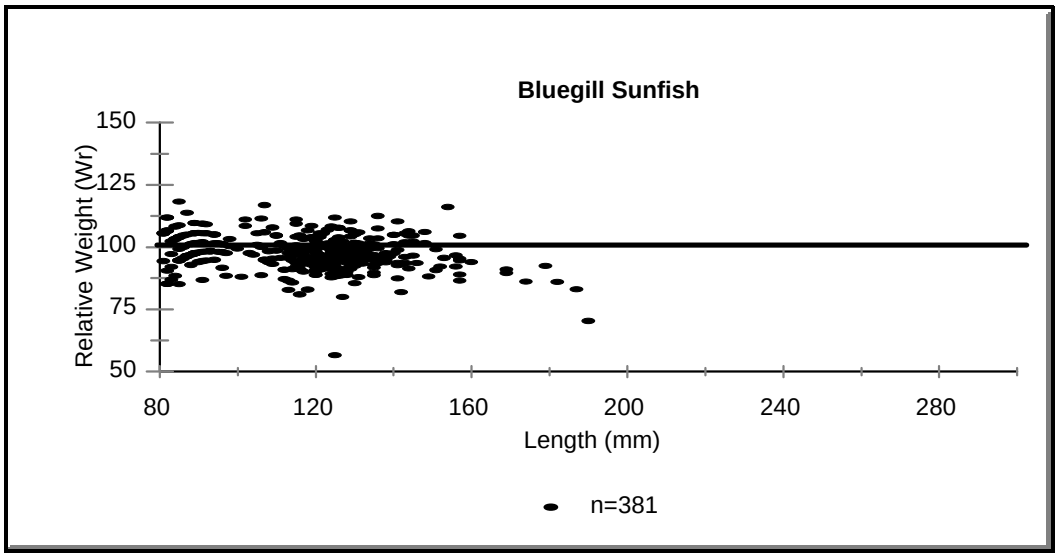

Figure 6. Relationship between total length and relative weight (W_r) of bluegill sunfish, excluding young–of–the–year, compared to the national standard (horizontal line 100) collected at Liberty Lake (Spokane County) during fall 1998.

Pumpkinseed Sunfish

Liberty Lake pumpkinseed sunfish ranged from 52 to 188mm TL (age 0+ to 4+ years old). Like bluegill sunfish, pumpkinseed sunfish exhibited variable year class strength (Table 10). Growth was lower than the state average for pumpkinseed sunfish, although the growth was similar to the growth of the species from other lakes in Spokane County (Fletcher et al. 1993). For example, the average growth of 17 pumpkinseed sunfish at age 4 collected in 1998 from Clear Lake, Spokane County, was 105.9mm TL (WDFW, unpublished data). No pumpkinseed sunfish greater than 190mm TL were collected (Figure 7). The relative weight of pumpkinseed sunfish was close to the national average (Figure 8). Abundant pumpkinseed sunfish likely contribute to extensive interspecific competition for food resources with more deliverable warmwater fish species. The origin of pumpkinseed sunfish in Liberty Lake is unknown.

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

		Mean length (mm) at age			
Year Class	**# Fish**	**1**	**2**	**3**	**4**
1997	1	53			
		38			
1996	13	38	69		
		17	58		
1995	10	40	71	108	
		19	56	101	
1994	4	39	54	79	115
		18	36	67	111
Lee's weighted mean		39	68	100	115
Direct proportion overall mean		23	50	85	111
Direct proportion state average		24	72	102	123

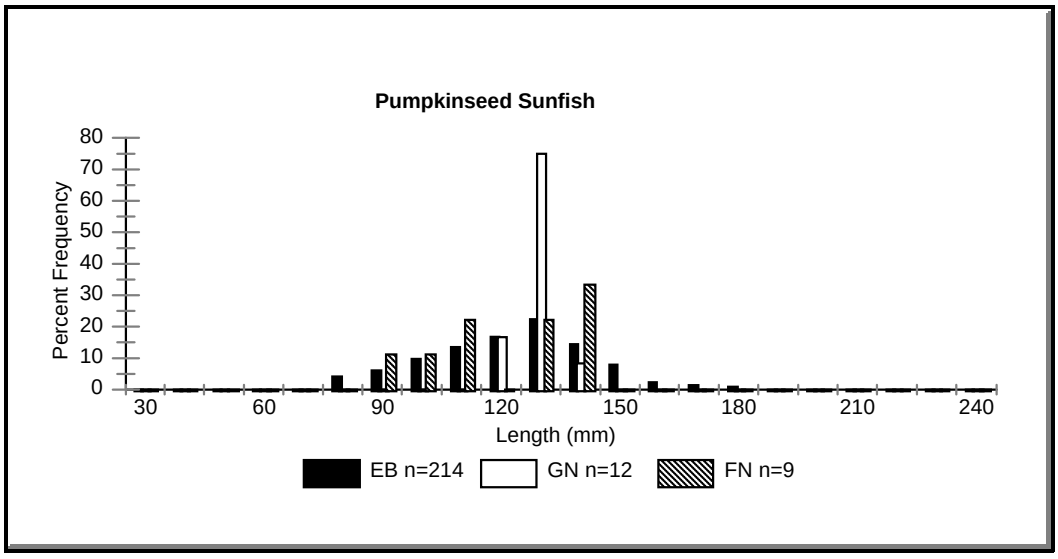

Figure 7. Length distribution of pumpkinseed sunfish, excluding the young–of–the–year, captured while electrofishing (EB), gill netting (GN), and fyke netting (FN) at Liberty Lake (Spokane County) during fall 1998.

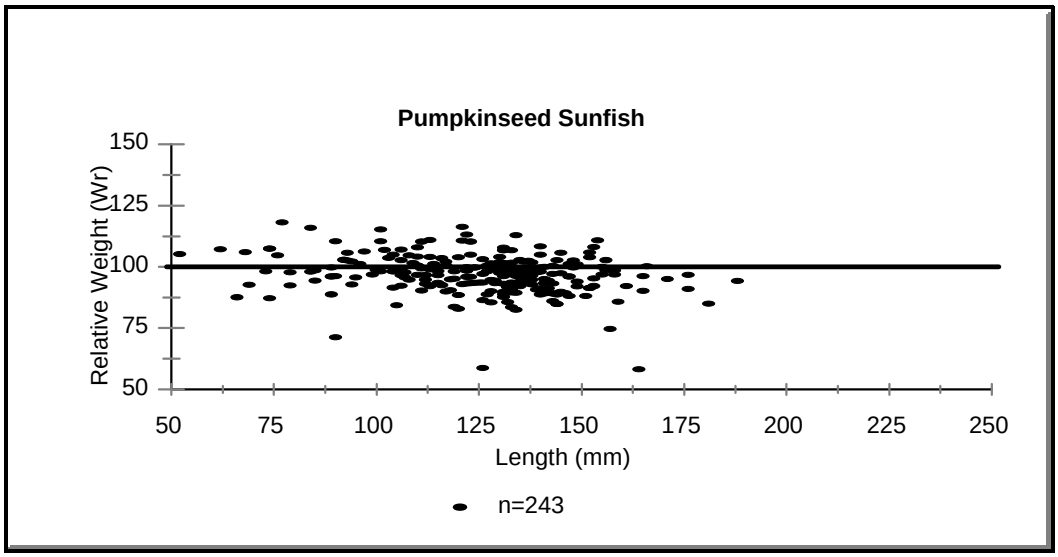

Figure 8. Relationship between total length and relative weight (W_r) of pumpkinseed sunfish, excluding young–of–the–year, compared to the national standard (horizontal line 100) collected at Liberty Lake (Spokane County) during fall 1998.

Largemouth Bass

Liberty Lake largemouth bass ranged from 40 to 492mm TL (age 1 to 6). Although three largemouth bass >400mm TL were collected, 41 percent of the 201 fish collected were young–of–the–year (<67mm TL) indicating good reproduction, but poor survival of young fish. The growth rate of Liberty Lake largemouth bass was higher when compared to the average growth of 766 largemouth bass collected from 22 lakes in eastern Washington (Fletcher et al. 1993). The average size of 6–year old largemouth bass collected from Liberty Lake was 407.4mm TL and the average length of largemouth bass from 22 eastern Washington Lakes was 351.5mm TL. Only four fish >300mm TL were collected (Figure 9). Relative weights were low for largemouth bass <275mm TL, although better for larger fish (Figure10).

Table 11. Age and growth of largemouth bass collected from Liberty Lake (Spokane County) during fall 1998. Unshaded values are mean back–calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using the Lee's modification (Carlander 1982).

		Mean length (mm) at age					
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**
1997	21	78					
		68					
1996	6	70	157				
		55	150				
1995	1	84	149	191			
		69	140	185			
1994	1	77	172	244	317		
		60	160	236	313		
1993	1	88	147	213	297	356	
		71	134	203	292	355	
1992	3	96	175	227	308	360	410
		80	162	216	301	356	407
Direct proportion weighted mean		79	161	221	308	359	410
Lee's overall mean		67	149	210	302	355	407
Direct proportion Eastern Washington average		69	136	189	249	300	352

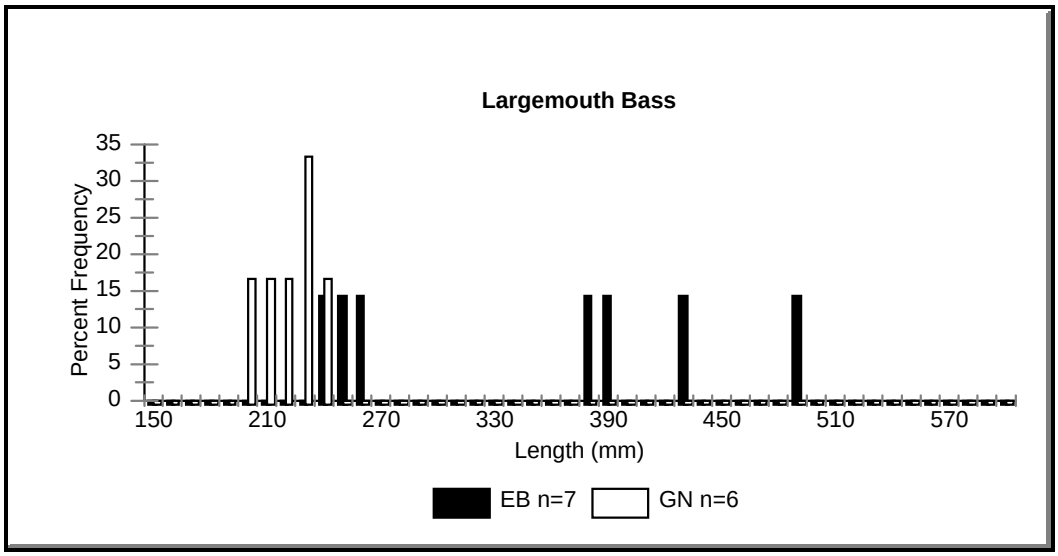

Figure 9. Length distribution of largemouth bass, excluding young–of–the–year, captured while electrofishing (EB) and gill netting (GN) at Liberty Lake (Spokane County) during fall 1998.

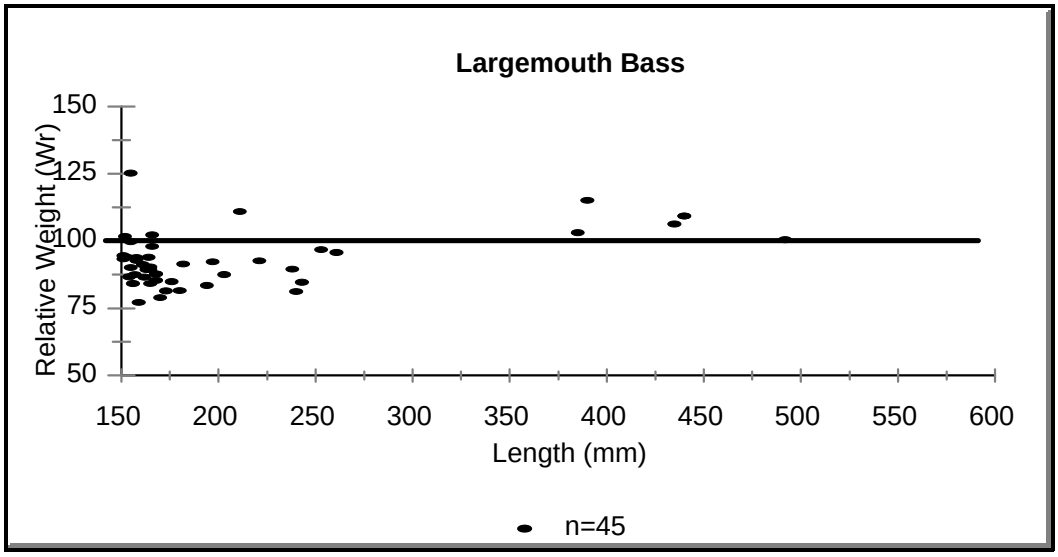

Figure 10. Relationship between total length and relative weight (W_r) of largemouth bass, excluding young–of–the–year, compared to that national standard (horizontal line 100) collected at Liberty Lake (Spokane County) during fall 1998.

Smallmouth Bass

Liberty Lake smallmouth bass ranged from 82 to 415mm TL (0+, and 7+). Over 90 percent of the smallmouth bass collected were young–of–the–year fish (<93.7mm TL). Only one of the smallmouth bass collected was >100mm TL. The growth of young–of–the–year fish collected during the survey was higher than the average back–calculated size of one year old smallmouth bass collected from ten lakes throughout the state of Washington (Fletcher et al. 1993). The average size of one year old smallmouth bass collected from ten lakes in the state of Washington was 70.4mm TL (Table 12). The back–calculated length at age 1 for the single smallmouth bass collected was 93.7mm TL. Due to the small sample size, no length frequency histogram or relative weight figures were created.

Table 12. Age and growth of smallmouth bass collected from Liberty Lake (Spokane County) during fall 1998. Unshaded values are mean back–calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using the Lee's modification (Carlander 1982).

		Mean length (mm) at age						
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1991	1	124	171	237	277	307	344	378
		94	149	220	264	298	338	375
Lee's weighted mean		124	171	237	277	307	344	378
Direct proportion state average		70	146	212	268	334	356	393

Walleye

Liberty Lake walleye ranged from 189 to 680mm TL (age 1-3 and 5-7). The 1995 year class was not represented in the sample. This is not surprising considering that natural reproduction of walleye is unlikely in Liberty Lake, and only brood stock (~400mm TL) and juvenile (<200mm TL) walleye were stocked in 1996. The walleye stocked prior to 1997 were from the 1994 or older year classes. Following the initial 1996 stocking, WDFW stocked Liberty Lake with sac fry in 1997 and 50-75mm TL fry in 1998. These year classes were represented in the 1998 fall sample by only one fish, therefore, survival is thought to be poor. Growth rates of walleye >300mm TL collected from Liberty Lake were higher than the growth of similar size walleye collected from Lake Roosevelt (McLellan et al. 1997). However, the growth of walleye <300mm TL was lower than the growth of walleye collected from Lake Roosevelt. Relative weight for all lengths were below the national average (Figure 12). Interpretation of growth rates for Liberty Lake walleye is difficult due to the lack of 1997 and 1998 year class walleye in the sample. Most of the fish collected during this survey were collected as adult fish from other lakes and growth may be more representative of the water of their origin.

Table 13. Age and growth of walleye collected from Liberty Lake (Spokane County) during fall 1998. Unshaded values are mean back–calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using the Lee's modification (Carlander 1982).

		Mean length (mm) at age						
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1997	1	171						
		163						
1996	35	158	257					
		122	242					
1995	1	174	267	341				
		139	248	334				
1994	0	0	0	0	0			
		0	0	0	0			
1993	5	187	278	370	442	510		
		146	246	348	428	502		
1992	3	212	321	426	480	530	570	
		173	292	408	468	522	567	
1991	5	200	285	351	417	484	539	603
		159	251	324	395	469	530	599
Lee's weighted mean		169	266	373	441	504	551	603
Direct proportion overall mean		150	256	353	430	498	548	599
Lake Roosevelt Lee's weighted mean		173	279	363	425	478	535	618

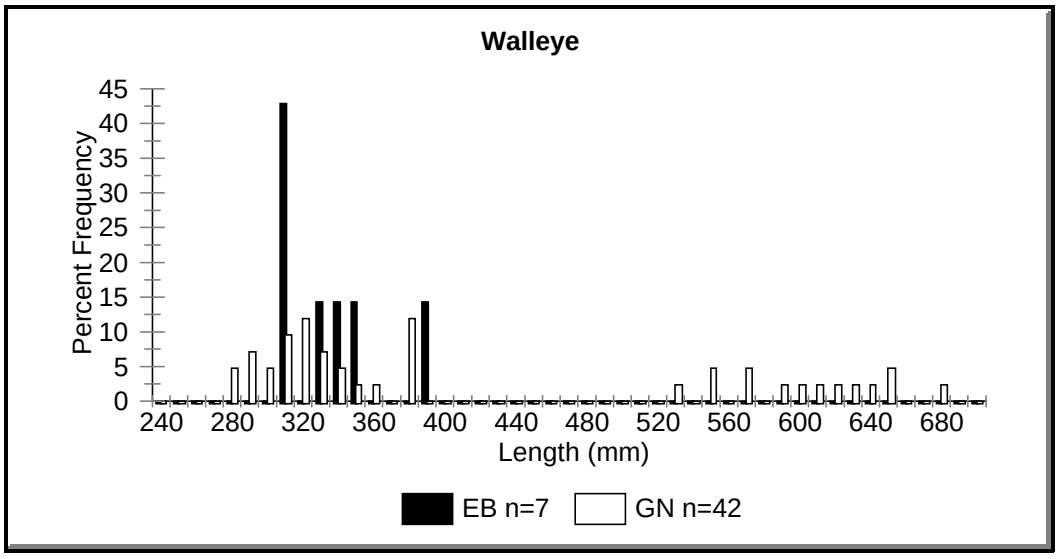

Figure 11. Length distribution of walleye, excluding young–of–the–year, captured while electrofishing (EB) and gill netting (GN) at Liberty Lake (Spokane County) during fall 1998.

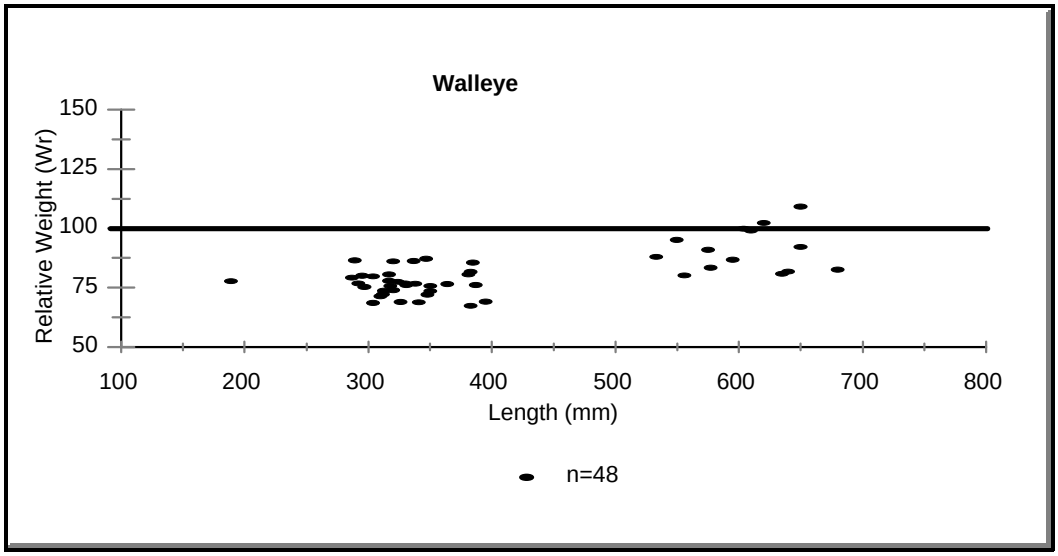

Figure 12. Relationship between total length and relative weight (W_r) of walleye, excluding young–of–the–year, compared to the national standard (horizontal line 100) collected at Liberty Lake (Spokane County) during fall 1998.

Yellow Perch

Liberty Lake yellow perch ranged from 54 to 230mm TL (age 1+ to 3+). The sample of yellow perch collected from Liberty Lake showed variable year class strength (Table13). Of the 167 yellow perch collected none were >230mm TL (Figure 14). Overall, yellow perch growth rates were higher in Liberty Lake than the state average. For example, the average size of two–year old yellow perch from Liberty Lake was 145.1mm TL and the State average is 120mm TL (Fletcher et al. 1993). The low relative weight (Figure 14) of yellow perch in Liberty Lake may be an indication of extensive interspecific competition for available resources.

Table 14. Age and growth of yellow perch collected from Liberty Lake (Spokane County) during fall 1998. Unshaded values are mean back–calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back–calculated lengths using the Lee's modification (Carlander 1982).

		Mean length (mm) at age		
Year Class	**# Fish**	**1**	**2**	**3**
1997	9	72		
		56		
1996	13	74	161	
		52	154	
1995	1	112	148	188
		94	136	183
Lee's weighted mean		75	160	188
Direct proportion overall mean		68	145	183
Direct proportion state average		60	120	152

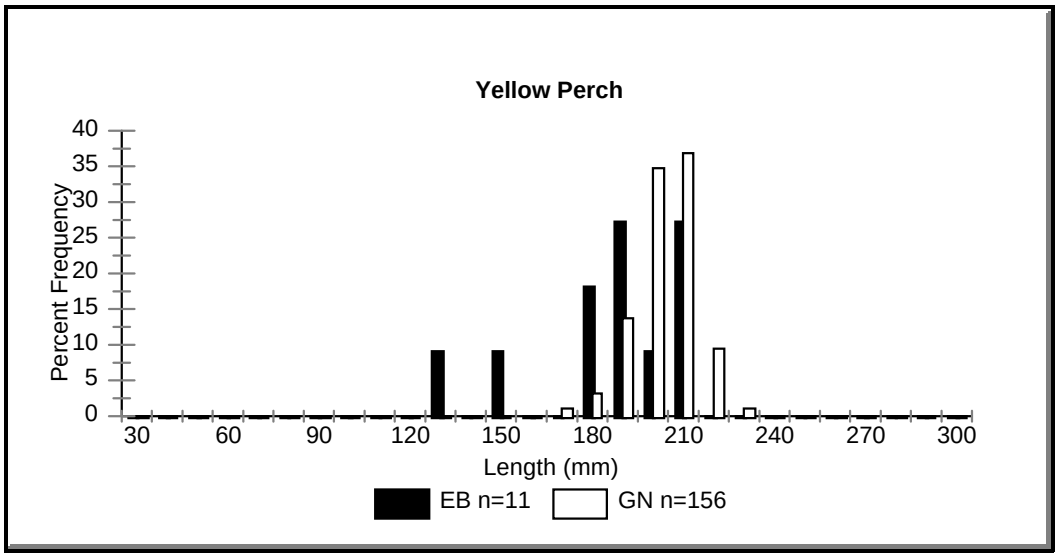

Figure 13. Length distribution of yellow perch, excluding young–of–the–year, captured while electrofishing (EB) and gill netting (GN) at Liberty Lake (Spokane County) during fall 1998.

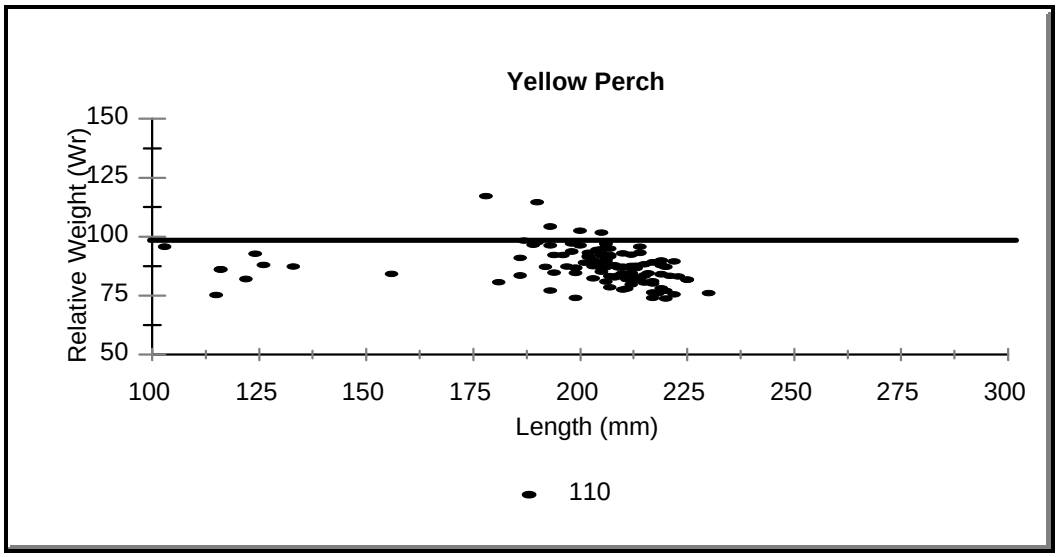

Figure 14. Relationship between total length and relative weight (W_r) of yellow perch, excluding young–of–the–year, compared to the national standard (horizontal line 100) collected at Liberty Lake (Spokane County) during fall 1998.

Trout Species

Rainbow trout, brown trout, and eastern brook trout were collected during this survey. Rainbow trout and brown trout are annually stocked into the lake, however, eastern brook trout may be naturally reproducing. Together trout consisted of only 5.8 percent of the total biomass collected by weight and 1.4 percent of the biomass by number (Table 4).

Creel data collected on opening–day of trout season, April 6, 1999, showed very little difference in catch rates between brown trout and rainbow trout. On opening–day, 82 anglers caught 38 rainbow trout and 37 brown trout (WDFW, unpublished data). Catch rates on opening–day were 7.0 hours/fish for rainbow trout and 7.1 hours/fish for brown trout. Although the catch rates for these two trout species are similar, return rates of stocked trout were higher for brown trout even though they were stocked at lower densities. During the spring of 1999, hatchery personnel stocked Liberty Lake with 15,000 rainbow trout and 10,000 brown trout. No trout originating from fry plants were observed during the opening–day survey. All rainbow trout observed on April 6, 1999, which were caught by anglers, had worn caudal and dorsal fins.

The warmwater sampling techniques used in this survey are largely restricted to the littoral zones of the lakes surveyed, and therefore, salmonid species may by under represented using this approach. Although trout species consisted of 5.8 percent of the total biomass, this figure may not be an accurate assessment of their true contribution to the species composition of Liberty Lake.

Discussion

Liberty Lake has become difficult to manage as a trout fishery in part because rotenone became an unpopular way to manage the fishery in the 1980s. Today the quality of the trout fishery is directly related to the number of catchable size trout stocked in the lake annually. Stocking large quantities of trout into established naturally reproducing populations of warmwater fish may be having a negative effect on warmwater fish growth and recruitment.

Liberty Lake has a mix of predatory and prey species, however, predation by walleye and bass does not appear to be sufficient to control competition between small fish (≤200mm TL). The length distribution of the fish collected during the survey is not consistent with that of a desirable fishery. Over 87 percent of all fish collected were below 200mm TL and 94 percent were below 250mm TL. Only 55 fish >350mm TL were collected, although 13 of these were brown bullhead which may not be contributing to the fishery.

Stocking adult walleye to reduce crowding of pumpkinseed sunfish and increase length at age of yellow perch has been successful in Washington. Bolding et al. (1997) found that by maintaining a population of 16 adult walleye per hectare in a pond near Yakima, Washington, yellow perch length at age increased for the four–, five–, and six–year old age classes 18 and 30 months post walleye–stocking. Additionally, yellow perch and pumpkinseed sunfish abundance declined.

In 1996, the 100 adult walleye stocked into Liberty Lake represented a stocking rate of .34 adult walleye per hectare. Walleye stocked as fry have Liberty Lake has not been sufficiently stocked with walleye to effectively impact stunted warmwater fish populations. The results of this survey indicate that past walleye fry stocking has not contributed to the density of walleye in the lake. In fact, no fish stocked as fry were collected as adults during the survey (based on age analysis). This is likely the result of poor survival and/or low stocking rate. Survival of walleye stocked as large fingerlings (130-170mm TL) is higher in Liberty Lake, as well as in others lakes (Ellison and Franzin 1992). Therefore, walleye >5" (130mm TL) should be used in future stocking plans.

Management Options to Enhance Warmwater Fishing Opportunities

The following management options are intended to assist Regional Fishery Biologists in managing the complex warmwater fish community of Liberty Lake. Although warmwater fish are a major component of the current Liberty Lake fishery, the lake could once again produce a quality trout fishery if biologists are allowed to rehabilitate the lake. However, without the ability to use rehabilitation as a management tool, we believe the following warmwater fish options will provide the best chance to increase fishing opportunities at Liberty Lake. It is also our opinion, based on creel data (WDFW, unpublished data), that the continued stocking of trout fry on top of the established warmwater fishery does not produce a measurable increase in trout fishing opportunity. In fact, this practice may be increasing the interspecific competition for available food resources for all fish species.

Walleye Option

Walleye can reduce the crowding of forage fish species (Bolding et al. 1997), as well as provide additional angling opportunity, when stocked at an appropriate rate. However, studies looking at the success of walleye stocking strategies are variable (Laarman 1978; Fielder 1992). Although stocking rates and sizes have been evaluated for the supplementation of natural reproducing populations (Fielder 1992), we were unable to find literature on stocking rates for fry or fingerling walleye to establish a new population in an existing naturally reproducing fish community. Ellison and Franzin (1992) suggest that walleye stocking should be tailored for each body of water, not based on a set number and size of fish.

In order to establish a walleye population in Liberty Lake, 127-178mm TL (5-7") walleye should be stocked at the rate of 25-50 per surface acre (David Willis, South Dakota State University, personal communication). The number and size of walleye stocked may be reduced following the establishment of a walleye population that effectively reduces crowding of warmwater fish. However, maintenance stocking of walleye will be necessary to maintain the population because natural reproduction is doubtful.

Largemouth Bass Slot–Limit Regulation

Liberty Lake data suggests that it 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 would be to increase the number of quality size ($\geq$300mm, 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 yellow perch, bluegill sunfish, and

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 and in some lakes in Washington to improve the quality of both bass and panfish angling (Rasmussen and Michaelson 1972; Eder 1984; Wilde 1997). Adopting this regulation for largemouth bass should complement efforts to establish a walleye population for controlling overabundant warmwater fish species in Liberty Lake.

Access

Currently, Liberty Lake has limited access for both angling from shore and by boat. The State owned boat launch has deteriorated and is scheduled for extensive renovation in the fall of 1999. Additions to the facility will allow unrestricted handicap access as well as a much safer boat launch. Part of the project is being funded by the Warmwater Fish Enhancement Program. This project is scheduled to be completed before the general lowland lake opening, 2000.

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