Diamond Lake
Warmwater Fishery Assessment
Fall 1999

by

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Abstract

In an attempt to accurately assess the fish community in Diamond Lake, and to determine how to best manage the lake in the future, personnel from Washington Department of Fish and Wildlife Warmwater Enhancement Program conducted a detailed fisheries stock assessment in fall 1999. Fish were captured using boat electrofishing, gill netting, and fyke netting. Yellow perch (*Perca flavescens*) were the most abundant species collected by number and by total weight (kg). Largemouth bass and yellow perch proportional stock density values (PSD) are similar to those typically recommended for populations managed for panfish. The fish community of Diamond Lake appeared to be dominated by small predator and prey fish species that offer very limited opportunity for both catch and harvest. Age and growth data suggests that Diamond Lake would be a good candidate for inclusion under the current recommended WDFW slot-limit regulation for largemouth bass, if the management objective is to promote warmwater angling opportunities. This regulation consists of a five fish limit, fish 12"-17" are to be released, and only one fish over 17" may be retained. The intent of this regulation is to increase the number of quality length ($300 mm; 12") largemouth bass available for catch and release in the lake. Additionally, under this regulation, the number of largemouth bass predators in the lake should increase and prey upon the now stunted panfish populations.

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Introduction

Diamond Lake is a moderately sized body of water located approximately 9.5 kilometers (km) west of Newport, Washington, in southern Pend Oreille County (Table 1). Moon Creek, the only outlet, flows through an extensive wetland located on the southwest end of the lake. Once leaving Diamond Lake, Moon Creek flows west into Sacheen Lake. Beginning as the outlet of Sacheen Lake, the west branch of the Little Spokane River flows south through Trout Lake, Horseshoe Lake, and Eloika Lake before joining the Little Spokane River. Additionally, Fan Lake is connected to the west fork of the Little Spokane River by a short tributary stream 2 km north of Eloika Lake. Flows in Moon Creek appear to be sufficient to allow for exchange of fish between Diamond Lake, Sacheen Lake, and Trout Lake. The upstream migration of fish from below the inlet on Horseshoe Lake is blocked by a steep waterfall. Recreational access at Diamond Lake is available to the public at a state owned and operated boat launch located on the southeast side of the lake. Although there are no large resorts, additional access includes a Boy Scouts of America summer camp on the north end of the lake, and the Diamond Lake home owners association have a small access on the east side of the lake.

Table 1. Physical parameters of Diamond Lake, Pend Oreille County.

Physical Parameters	Diamond Lake (Pend Oreille County)
Surface Area (hectares)	323
Shoreline Length (m)	11,265
Maximum Depth (m)	17.7
Mean Depth (m)	8.2
Volume (m^3)	27,136,384
Drainage Area (hectares)	4,607
Shoreline Development D_L	1.8

Since 1956, Diamond Lake has been rehabilitated four times to remove “unwanted” fish species. Fisheries biologists have treated the lake with rotenone and re-stocked it with trout fry approximately every ten years. The success of rehabilitation efforts has been variable (WDFW, unpublished data, Region 1). Following a rehabilitation in 1959, biologists reported that the fishery during 1960 was a disappointment due to poor fish growth. In 1962 the fishery was reported to be “outstanding,” although “spiny-rayed” fish were again found in the lake (WDFW, unpublished data, Region 1). During the 1965 season, green sunfish (*Lepomis cyanellus*) and black crappie *(Pomoxis nigromaculatus*) were seen in large schools by scuba divers. The lake was rehabilitated again in 1969. In 1970, biologists reported that the opening day fishery was “nearly a total disaster”and speculated that this may have been due to a growing population of green sunfish. The lake was rehabilitated again in 1977 and last rehabilitated in 1987. In 1987, the target species were again green sunfish and black crappie. Although the lake has been repeatedly rehabilitated to remove unwanted fish species, they tended to reappear quickly. This may be the result of upstream migration from Sacheen Lake, illegal stocking, or incomplete rehabilitations.

On July 20, 1999, the Washington Department of Fish and Wildlife held a public meeting to take comments on a proposal to once again rehabilitate Diamond Lake and manage it as a trout fishery. Due to many anglers concerns about the loss of what they termed a quality largemouth bass fishery, there was limited support for the proposal of another rehabilitation. In response, Diamond Lake was surveyed October 5-8, 1999 to evaluate the warmwater fish community and the quality of angling opportunity that exists under current regulations. Data from this survey is intended to provide regional fisheries biologists additional information on how to best manage Diamond Lake fish populations.

Methods

Diamond Lake was surveyed by two warmwater fish biologists and a fisheries technician October 5-8, 1999. 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 3 to 5 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 monofilament (1.3, 1.9, 2.5, and 5.1 cm stretched mesh). Fyke nets were constructed of a main trap (4.7 m long and 1.2 meters in diameter), a lead net (30.5 m long x 1.2 m deep), and two wings (7.6 m long x 1.2 m deep).

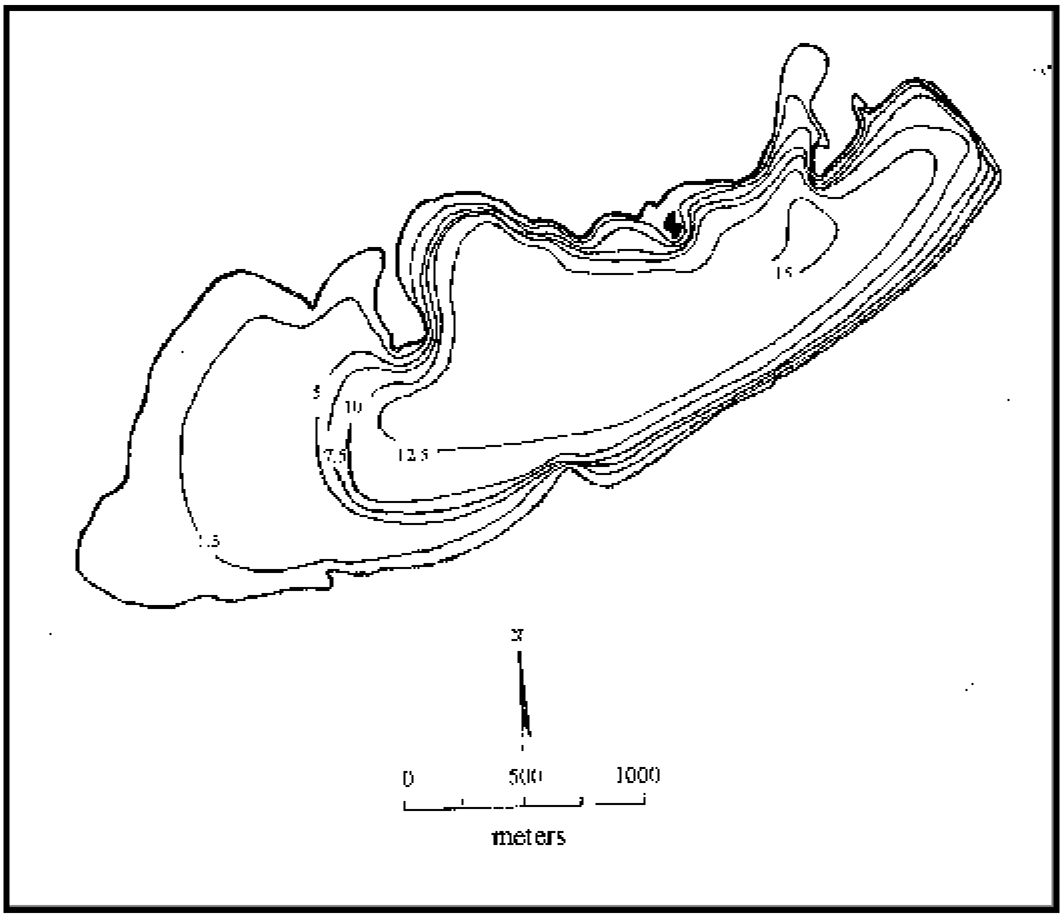

Figure 1. Approximate bathymetry of Diamond Lake, Pend Oreille County, Washington.

Sampling locations were selected by dividing the shoreline into 24 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 (Corel Quattro Pro). While electrofishing, the boat was slowly maneuvered through shallow water (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.

Sampling was conducted during evening hours to maximize size classes 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 63 percent 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:2 nights of gill netting:2 nights 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 8 net nights for each gear type, or four standard units.

Each fish captured was identified to species, measured (mm) to total length (TL) and weighed (g). Scales were collected from up to five fish per 10mm length class for each warmwater fish species. Scales were later mounted, pressed onto acetate film, and aged according to Jearld (1983) and Fletcher et al. (1993). Rainbow trout (*Oncorhynchus mykiss*), and brown bullhead (*Ameiurus nebulosus*) were not aged.

Water quality data was collected during the afternoon of October 7, 1999, from approximately the deepest location in the lake (northeast end). 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). However the absence of young-of-the-year may be the result of poor fry survival, and/or inadequate reproduction.

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, which varies by species, is the length of a particular fish species that offers threshold 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 sampling method. Each CI was calculated as the mean $\pm t(\alpha, N-1) \times SE$, where t=Student's t for α 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. Only fish of stock-length or larger 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×100, was determined for each warmwater fish species collected (Anderson and Neuman 1996, Bister et al. 2000). PSD can provide information about the proportion of various length fish in a population and can be a useful tool when the sample number is adequate (Willis et al. 1993; Divens et al. 1998). Divens et al. (1998) reported that 55 stock length fish are required to calculate useable PSD estimates for management. 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 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 length of fish anglers would prefer to catch. Memorable length (59-64 percent of the world record length) refers to the minimum size fish most anglers remember catching, whereas trophy length (74-80 percent of world record length) refers to the minimum size fish worthy of acknowledgment. Bister et al. (2000) developed and proposed additional length categories for 83 additional species including green sunfish and brown bullhead. Relative stock density (RSD) calculated as the number of fish $\geq$ specific length/number of fish $\geq$ 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 of preferred length and longer, RSD-M is the percentage of stock length fish of memorable length and longer, and RSD-T is the percentage of stock length fish of 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 2. PSD/RSD length categories for fish species collected during the Diamond Lake survey, 1999. Measurements are total length (mm) for each category (Anderson and Neumann 1996; Bister et al. 2000). Numbers in parenthesis represent percentages of world record lengths (Gabelhouse 1984).

	Standard Length Categories				
Species	**Stock (20-26**	**Quality (36-41)**	**Preferred (45-55)**	**Memorable (59-64)**	**Trophy (74-80)**
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
Green sunfish	80	150	200	250	300

Age and growth of warmwater fishes sampled were evaluated using the direct proportion method (Fletcher et al. 1993; Jearld 1983) 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 $L_n=a+A\times(TL\text{-}a)/S$, 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 collected from Diamond Lake. Relative weights are useful for comparing the condition of different size groups within a single population to determine if all sizes are finding adequate forage. *Wr* is calculated as $W_r = W/W_s \times 100$, where *W* is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same length (Murphy and Willis 1991). W_s is calculated from the standard log10weight-log10length relationship defined for the species of interest. 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 was collected at 1:00 PM, on October 7, 1999. The data collected identifies a sharp decline in dissolved oxygen (DO) between 12 meters and the bottom (Table 3). Dissolved oxygen level below 12m may be too low for rainbow trout, which require DO levels above 5mg/L (Wheaton 1977). Many warmwater fish species can withstand lower DO levels for short periods of time, although levels below 3 mg/L may be too low for many warmwater fish species. Dissolved oxygen levels were within the desirable range for all warmwater fish species between the surface and 12m (Boyd 1990). Desirable pH levels for warmwater fish are between 6.5 and 9 (Swingle 1969). The pH level for warmwater fish were acceptable for all warmwater fish species (Table 3).

Table 3. Water quality data from Diamond Lake (Pend Oreille County) collected midday October 7, 1999.

		Water Quality		
Depth	**Temperature**	**DO**	**pH**	**Conductivity**
Surface	14.0	8.89	8.34	71.2
2	14.0	8.50	8.29	71.2
4	13.9	8.40	8.25	71.2
6	13.9	8.40	8.20	71.2
8	13.9	8.50	8.24	71.2
10	13.9	8.47	8.23	71.2
12	11.7	6.10	8.00	71.2
14 (bottom)	10.6	2.70	7.75	71.2

Although no serious water quality limitations were identified during this survey, additional data should be collected during the fall, winter, and summer to accurately assess seasonal limitations.

Species Composition

Seven species of fish were collected from Diamond Lake during the sampling period (Table 4). Yellow perch (*Perca flavescens*) were the most abundant species collected by number and by total weight (kg). Green sunfish composed 14.9% of the species composition by number, but only 3.1% by biomass. Several species were represented in the sample by low numbers. For example only three rainbow trout and only one black crappie were collected. Although rainbow trout were collected during the sampling period their true abundance may have been under represented due to the limitations of our sampling methods.

Table 4. Species composition (young-of-the-year excluded) by weight (kg) and number of fish collected from Diamond Lake (Pend Oreille County) in October 1999.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Type of Fish	(Kg)	(%w)	(#)	(%n)	Min	Max
Yellow perch (*Perca flavescens*)	92.379	61.3	1150	69.8	71	234
Brown bullhead (*Ameiurus nebulosus*)	24.935	16.5	148	9.0	132	333
Largemouth bass (*Micropterus salmonides*)	23.291	15.4	84	5.1	96	515
Rainbow trout (*Oncorhynchus mykiss*)	5.150	3.4	3	0.2	575	585
Green sunfish (*Lepomis cyanellus*)	4.607	3.1	246	14.9	51	202
Pumpkinseed sunfish (*Lepomis gibbosus*)	0.205	0.1	15	0.9	57	177
Black crappie (*Pomoxis nigromaculatus*)	0.205	0.1	1	0.1	234	234

CPUE

Electrofishing catch rates were higher than both fyke nets and gill nets for all species except pumpkinseed sunfish (*Lepomis gibbosus*) (Table 5). Although more green sunfish were collected while electrofishing, gill nets were more effective at collecting larger fish.

Table 5. Mean catch per unit effort by sampling method, including 80% confidence intervals, for fish collected from Diamond Lake (Pend Oreille County) in October 1999.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
Species	(#/hour)	Site	#/Net Night	Nights	#/Net Night	Nights
Black crappie	0	15	.1 ± .1	8	0	8
Brown bullhead	43.1 ± 20.0	15	.6 ± .5	8	4.3 ± 2.8	8
Largemouth bass	27.9 ± 7.0	15	.1 ± .2	8	0	8
Green sunfish	52.7 ± 24.3	15	.9 ± .5	8	0	8
Pumpkinseed sunfish	.8 ± .7	15	0	8	0	8
Rainbow trout	.4 ± .5	15	.3 ± .2	8	0	8
Yellow perch	182.3 ± 110.8	15	48.5 ± 32.7	8	.3 ± .3	8

Stock Density Indices

Stock length largemouth bass *(Micropterus salmoides)*, yellow perch, green sunfish, and brown bullhead were abundant in the sample. Largemouth bass and yellow perch proportional stock density values (PSD) are similar to those typically recommended for populations managed for panfish. Although the PSD values are high, RSD values are at or near zero of all species, with the exception of largemouth bass (Table 6). Low PSD values for green sunfish and brown bullhead catfish populations are likely the result of inter- and intraspecific competition. Additionally, slow growth rates in Washington state, lack of adequate predation, and/or insufficient angling pressure can limit the quality of panfish populations.

Table 6. Traditional stock density indices, including 80% confidence intervals, of fish collected from Diamond Lake (Pend Oreille County), October 1999, by sampling method.

	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Brown bullhead	109	0	5 ± 3	0	0
Green sunfish	132	11 ± 4	0	0	0
Largemouth bass	70	21 ± 6	7 ± 4	1 ± 1	0
Pumpkinseed sunfish	2	50 ± 45	0	0	0
Yellow perch	456	77 ± 3	0	0	0
		Gill Netting			
Brown bullhead	5	100 ± 0	20 ± 23	0	0
Green sunfish	7	43 ± 4	14 ± 17	0	0
Yellow perch	388	90 ±2	0	0	0
		Fyke Netting			
Brown bullhead	34	100 ± 0	0	0	0
Yellow perch	2	0	0	0	0

Largemouth Bass

Diamond Lake largemouth bass ranged in size from 55 to 515 mm TL (age 1 to 7, Table 7). Although numerous stock-length largemouth bass (≥ 200 mm) were collected, few were greater than quality-length (≥ 300 mm) (Figure 2). Largemouth bass growth was higher than the average growth of largemouth bass sampled across Washington (Fletcher et al. 1993). Growth rates were between those observed at some nearby lakes in Spokane County. For example, Diamond Lake largemouth bass growth rates in 1999 were lower than those seen at Liberty Lake in 1998, but higher than growth rates of largemouth bass sampled from Clear Lake in 1998 (WDFW unpublished data 1998). With the exception of a few large fish, the relative weight of largemouth bass were below the national average (Figure 3). Low relative weights for fish less than 300 mm may be an indication of interspecific competition between young largemouth bass, yellow perch, and green sunfish. Increased condition of larger largemouth bass may indicate reduced interspecific competition as diet changes. Only five young-of-the-year largemouth bass were collected. This may be the result of poor spawning success or poor fry survival. Intense angling pressure and harvest of larger fish may also be contributing to low number of largemouth bass >400mm TL.

Table 7. Age and growth of largemouth bass sampled from Diamond Lake (Pend Oreille County), October 1999. Unshaded values are mean back-calculated lengths at age using the direct proportion method (Fletcher et al. 1993; Jearld 1983). Shaded values are mean back-calculated lengths using Lee's modification (Carlander 1982). Spokane area lake data (WDFW unpublished data 1998).

		Mean total length (mm) at age								
Year class	**# fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1998	6	71								
		80								
1997	8	65	136							
		79	142							
1996	24	66	145	186						
		80	152	189						
1995	18	59	146	207	241					
		74	155	211	243					
1994	10	64	133	192	234	263				
		79	144	199	237	264				
1993	6	67	181	281	347	391	423			
		84	192	287	350	391	422			
1992	3	71	116	192	247	287	322	347		
		87	130	202	254	292	325	349		
1991	1	59	138	230	262	302	330	347	377	
		76	150	237	267	305	331	348	376	
1990	1	39	156	281	312	332	379	396	484	511
		51	168	287	316	336	381	396	480	506
Overall mean		62	144	224	274	315	364	363	430	511
Weighted mean		79	153	209	261	310	384	358	428	506
State Average		60	146	222	261	289	319	368	396	440
Liberty Lake		67	149	210	302	355	407			
Newman Lake		64	123	172	238	314	398	434	473	
Clear Lake		63	138	192	236	273	331	355	376	406

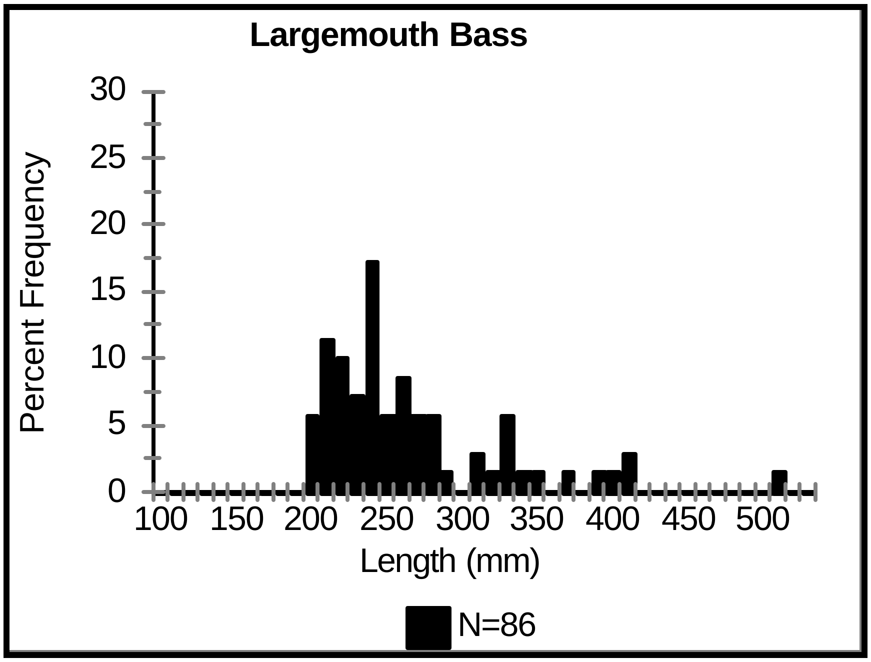

Figure 2. Length distribution of largemouth bass, excluding the young-of-year, captured while electrofishing (EB) at Diamond Lake (Pend Oreille County) during October 1999.

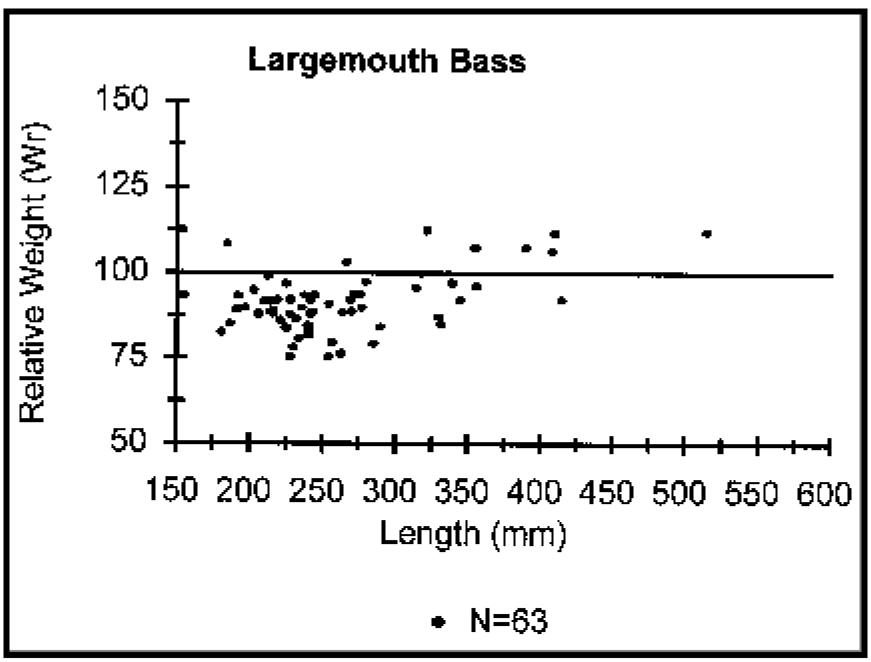

Figure 3. Relationship between total length (mm) and relative weight (Wr) of largemouth bass, excluding young-of-the-year, compared to the national standard (horizontal line 100), collected at Diamond Lake (Pend Oreille County) during October 1999.

Pumpkinseed Sunfish

Relatively few pumpkinseed sunfish were collected from Diamond Lake during the survey. Fish sampled were dominated by young fish. Only two pumpkinseed sunfish >2 years old were collected (Table 8). Evaluation of pumpkinseed sunfish growth rates is limited due to low sample size (Figure 4). However, growth of the few pumpkinseed sunfish aged was higher than the average for other populations sampled in Washington (Fletcher et al. 1993). The relative weights of pumpkinseed sunfish were below the national average (Figure 5). Due to their low abundance, angling opportunities for pumpkinseed sunfish appear to be limited.

Table 8. Age and growth of pumpkinseed sunfish collected from Diamond Lake (Pend Oreille County), October 1999. Unshaded values are mean back-calculated lengths 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**
1998	10	27			
		34			
1997	1	20	60		
		28	62		
1996	0	0	0	0	
		0	0	0	
1995	1	45	131	150	168
		52	133	152	169
Overall mean		31	95	150	168
Weighted mean		35	98	152	169
Direct proportion state average		24	72	102	123

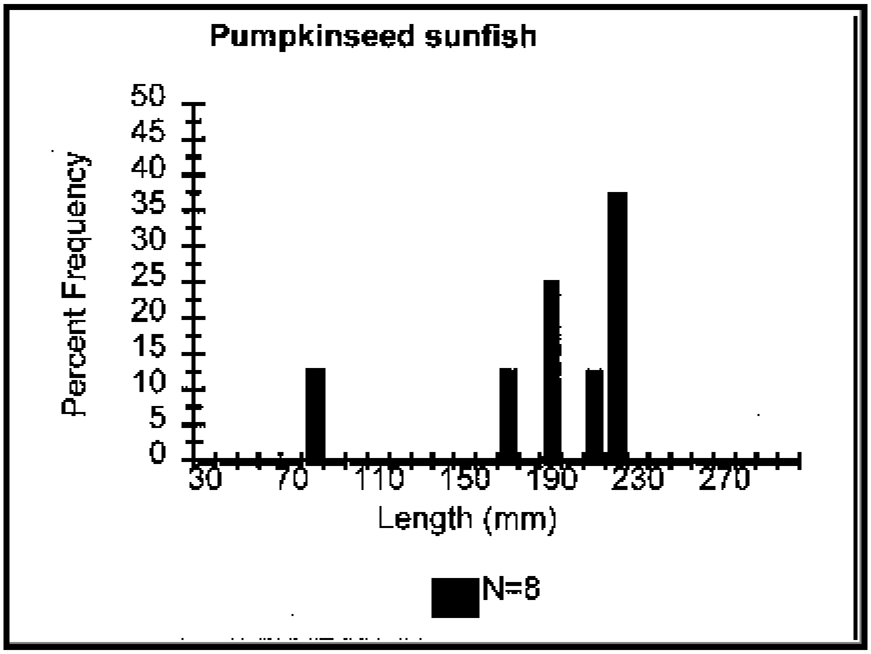

Figure 4. Length distribution of pumpkinseed sunfish, excluding the young-of-the-year, captured while electrofishing (EB) at Diamond Lake (Pend Oreille County) during October 1999.

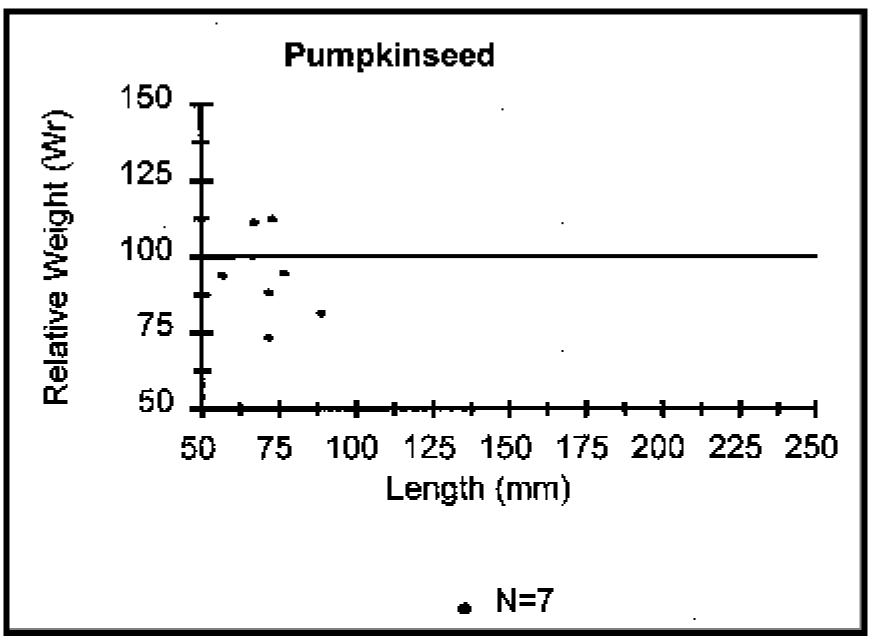

Figure 5. Relationship between total length (mm) and relative weight (Wr) of pumpkinseed sunfish, excluding young-of-the-year, compared to the national standard (horizontal line 100), collected at Diamond Lake (Pend Oreille County) during October 1999.

Yellow Perch

Diamond Lake yellow perch ranged from 37 to 234mm TL (age 1+ to 4+). Length frequency distribution shows some indication of variable year-class strength (Figure 6). The population appears to be dominated by 1995 and 1996 strong year-classes (Table 9). Overall, yellow perch growth rates in Diamond Lake were similar to the average growth of 922 yellow perch collected from 29 lakes throughout the state (Fletcher et al. 1993). No yellow perch greater than 235 mm TL were collected (Figure 6). Condition, as indicated by relative weight, was below the national average (Figure 7). This may be an indication of inter- and intraspecific competition for available resources.

Table 9. Age and growth of yellow perch sampled from Diamond Lake (Pend Oreille County), October 1999. Unshaded values are mean back-calculated lengths 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**
1998	3	58			
		74			
1997	6	36	107		
		59	116		
1996	34	53	118	162	
		75	130	167	
1995	11	66	131	165	192
		87	142	172	194
Overall mean		54	119	164	192
Weighted mean		76	131	168	194
Direct proportion state average		60	120	152	193

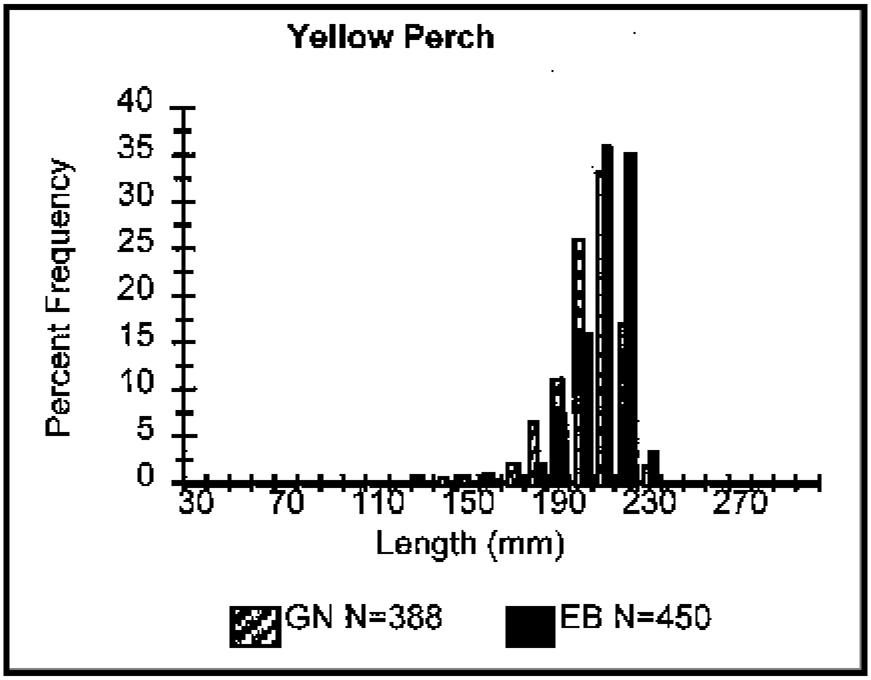

Figure 6. Length distribution of yellow perch, excluding the young-of-the-year, captured while electrofishing (EB), and gill netting (GN) at Diamond Lake (Pend Oreille County) during October 1999.

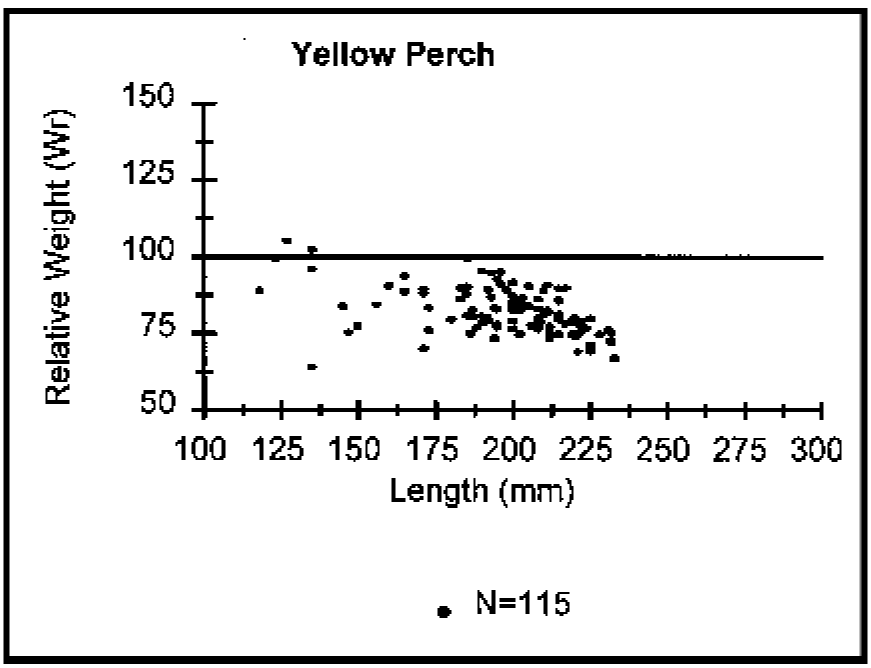

Figure 7. Relationship between total length (mm) and relative weight (Wr) of yellow perch, excluding young-of-the-year, compared to the national standard (horizontal line 100), collected at Diamond Lake (Pend Oreille County) during October 1999.

Green Sunfish

Green sunfish ranged in size from 47 to 202 mm (Table 10). Growth rates of green sunfish in Washington are not available for the comparison, but were similar to those reported in Montana (Wydoski and Whitney 1979). Although no green sunfish older than four were collected from the lake, one, two, three, and four year old fish were common in the sample (Table 10). No fish greater than 205mm were collected from the lake which is common for populations found in western waters (Figure 8). The relative weight of green sunfish was well below the national standard for all but a few individuals (Figure 9). Considering their small size and low condition, green sunfish are unlikely to significantly contribute to Diamond Lake recreational fishing opportunities.

Table 10. Age and growth of green sunfish sampled from Diamond Lake (Pend Oreille County), October 1999. Unshaded values are mean back-calculated lengths 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**
1998	18	35			
		40			
1997	8	32	69		
		39	71		
1996	18	33	74	104	
		41	78	106	
1995	14	34	73	106	131
		41	78	109	131
Overall mean		35	75	107	134
Weight mean		41	78	108	134

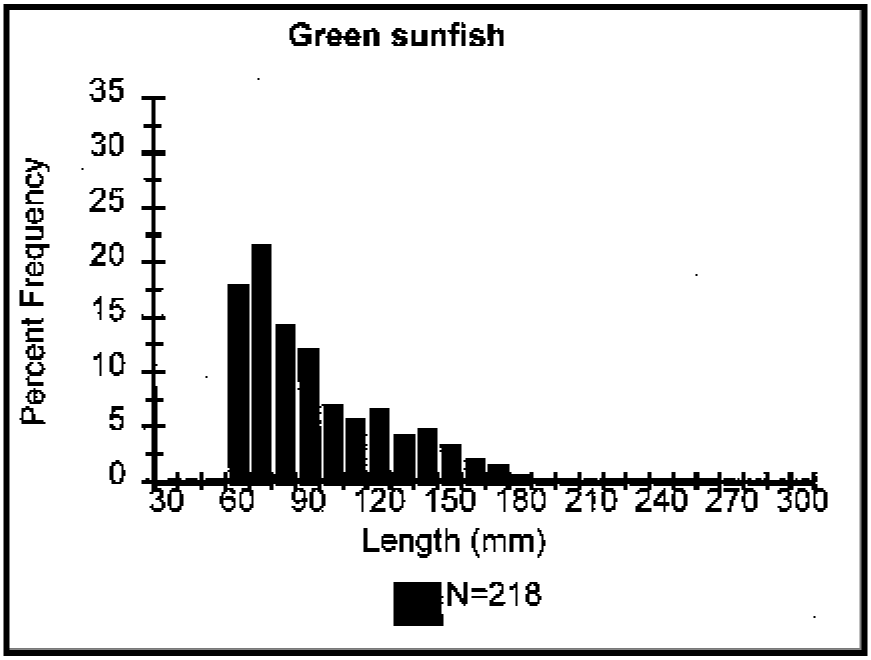

Figure 8. Length distribution of green sunfish, excluding the young-of-the-year, captured while electrofishing (EB) at Diamond Lake (Pend Oreille County) during October 1999.

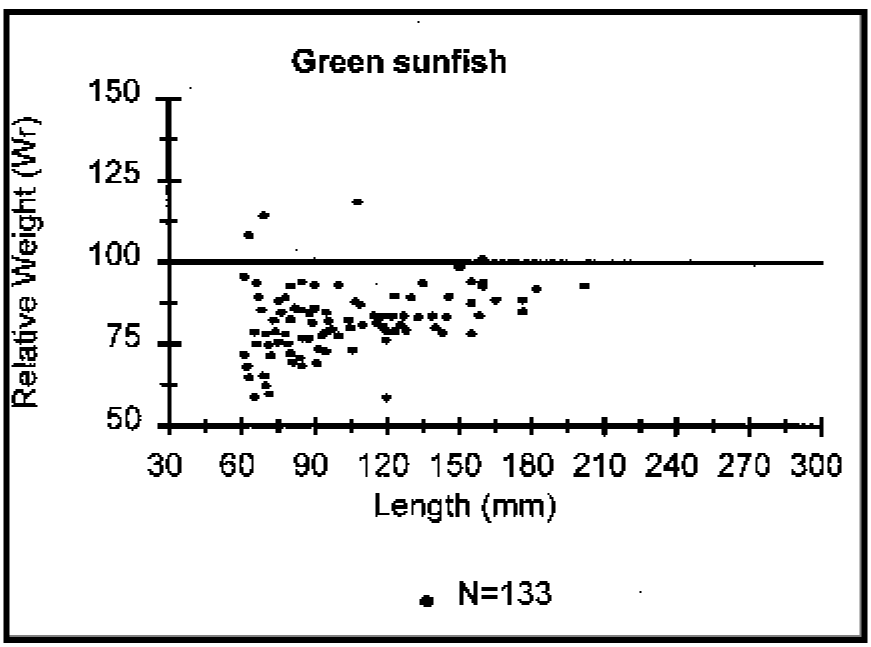

Figure 9. Relationship between total length (mm) and relative weight (Wr) of green sunfish, excluding young-of-the-year, compared to the national standard (horizontal line 100), collected at Diamond Lake (Pend Oreille County) during October 1999.

Discussion

Warmwater fish biologists typically consider the balance of warmwater fish populations when assessing the status of fish communities. The term balance is used loosely to describe a system in which omnivorous prey fish maximize food resources to produce harvestable-size fish stocks for anglers and an adequate forage base for piscivorus fish (Bennett 1962). Fish communities may otherwise typically be described as being prey-crowded or predator crowded. To provide quality warmwater fishing opportunities, predatory gamefish species such as largemouth bass must be able to reproduce and grow to control overpopulation of both prey and predator species. At the time of this survey, the fish community in Diamond Lake appeared to be dominated by small predator and prey species. Low condition values and slow overall growth rates suggest the abundant number of small fish of all species are likely to be competing for resources. The concept of "balance" has additional interpretations, Anderson (1978) described balanced fish communities as ones that have satisfactory catch and harvest of both game fish (predator) and panfish (prey). Considering this definition, Diamond Lake did not appear to have a balanced fish community at the time of this survey as small fish likely offer limited opportunity for both catch and harvest. Angler creel data is needed to confirm actual harvest rates.

Diamond Lake warmwater fish populations offer less than quality angling opportunity. Yellow perch populations appear to offer some opportunity to catch and harvest fish to nine inches, however harvest potential for largemouth bass over 300mm appears to be limited. Harvesting these larger predatory fish may be contributing to competition for resources among smaller fish (<300 mm). Existing populations of warmwater fish most likely originated from fish that survived past rehabilitation efforts, were illegally stocked, or migrated upstream from Sacheen Lake. Green sunfish or yellow perch likely became established and outproduced predation which contributed to crowding. Currently, predation and angling pressure are not sufficiently reducing the number of small fish in the lake to reduce competition. Adult yellow perch diet does include fish (Carlander 1997) and adult perch do forage on young-of-the-year yellow perch (Tarby 1972), however this predation is apparently not sufficient to reduce competition for resources.

The quality of trout fishing at Diamond Lake is a direct reflection trout which are stocked at catchable size (170-200mm). Catchable trout can make a much better contribution to the fishery in the presence of predatory species. However, the cost to rear fish to this length in hatcheries is high. The ability of WDFW to stock trout fry that survive, grow and contribute to the fishery is greatly impaired by the presence of predatory fish species such as largemouth bass, as well as warmwater panfish species, which can compete with trout fry for available food resources. The difficulty in managing Diamond Lake with trout fry has been even greater with the presence of green sunfish due to their small size, slow growth in western waters, and high tolerances to water temperature and adverse conditions (Wydoski and Whitney 1979). Green sunfish can become sexually mature at only three inches and can often become overcrowded or stunted in colder waters (Wydoski and Whitney 1979). Historically, rehabilitation has been widely used in the state of Washington to remove warmwater fish which compete with trout fry. This management technique typically results in increased survival and growth of trout stocked as fry. The quality of the trout angling produced, as well as the savings in trout hatchery production, is considerable.

Past efforts to rehabilitate Diamond Lake to remove “unwanted” fish species and restock with trout has been largely unsuccessful. Past treatments of the lake have have not been sufficient to completely remove target species, or undesirable species quickly made their way back into the lake. Past rehabilitation efforts have however been successful at removing some target species. For example, tench (*Tinca tinca*) which were once found in the lake, were not present during this survey. Due to the limited success of past rehabilitations, the success of future rehabilitation efforts cannot confidently be expected to result in lasting benefits to the fishery without extensive treatment. A successful treatment would certainly include treating outlet channels and associated wetland areas to increase treatment benefits. Additionally, future treatment efforts would be bolstered by addressing upstream migration of undesirable fish species.

Diamond Lake’s connectivity to other lakes within the West Fork Little Spokane River watershed limits fisheries management possibilities. Future management plans for Diamond Lake should include careful consideration for all lakes within the watershed. Ideally, a fisheries management plan could be developed for all lakes in the drainage. Eloika Lake is scheduled to be surveyed in May, 2000, Sacheen Lake and Fan Lake are scheduled to be surveyed in September and October, 2000. Following the completion of surveys for these lakes, combined with the results of this Diamond Lake survey, regional biologists should have the information needed to develop a comprehensive plan for the entire watershed.

Management Options

Currently, Diamond Lake is managed as a mixed species fishery which offers less than quality angling opportunity for several fish species. Current regulations for Diamond Lake follow 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, green sunfish, yellow perch or brown bullhead. Although it is difficult to evaluate the contribution of panfish to the sport fishery without creel survey data, it appears the current rainbow trout, largemouth bass, and yellow perch populations appear to be offering only limited angling opportunity. The quality of warmwater fish caught under a mixed species management strategy may continue to show signs of being stunted. Trout fishing opportunities would continue to be a result of WDFW annual spring stocking, survival, and growth of rainbow trout and brown trout (*Salmo trutta*) catchables.

Largemouth Bass Slot–Limit Regulation

Survey data suggests that Diamond Lake would be a good candidate for inclusion under the current recommended WDFW slot-limit regulation for largemouth bass, if the management objective is to promote warmwater angling opportunities. This regulation consists of a five fish limit, fish 12"-17" are to be released, and only one fish over 17" may be retained. The intent of this regulation is to increase the number of quality length ($300 mm; 12") largemouth bass available for catch and release in the lake. Additionally, under this regulation, the number of largemouth bass predators in the lake should increase and prey upon the now stunted panfish populations. This should improve the quality of panfish angling available. 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 the slot-limit is to increase the average size, and not necessarily 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 should increase. Slot- limits can be a useful tool to increase the quality of largemouth bass populations, however; they can fail to restructure populations if anglers do not harvest sufficient numbers of smaller fish (Martin 1995). If adopted, periodical sampling should be conducted to monitor the effectiveness of this regulation.

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