Warmwater Fish Survey of Bennington Lake, Walla Walla County

by

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Abstract

Bennington Lake was surveyed by a three person investigation team September 22 - 24, 1999. Fish were captured using boat electrofishing, gill netting, and fyke netting. Rainbow trout (*Oncorhynchus mykiss*), yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*), yellow bullhead (*Ameiurus natalis*), black crappie (*Pomoxis nigromaculatus*), bluegill sunfish (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*) and northern pike-minnow *(Ptychocheilus oregonensis)* were collected from the lake. This data revealed a fishery dominated by small (less than stock length) fish, which appear to offer less than quality recreational fishing opportunity. Although the primary management emphasis for the lake is directed at a "put-and-take" rainbow trout fishery, the warmwater fishery could be improved to supplement the trout fishery, especially during the summer and fall. Few fish of any species greater than preferred length were captured. In order to improve the quality of fishing for warmwater fish species in Bennington Lake we propose: 1) remove all current fish populations from the lake by drawing down the water and/or using chemical methods; 2) stocking the lake with largemouth bass and black crappie; 3) imposing the states 12-17" slot-limit on largemouth bass; 4) installing artificial structures to provide cover for juvenile fish; 5) monitoring spawning success and year-class strength of black crappie and supplement the population when necessary; and 6) conducting a creel survey. It is our opinion that the rainbow trout stocking program should be continued as the primary emphasis because of its popularity, despite competition with naturally reproducing fish in the lake.

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Introduction

Bennington Lake is a small (52 acre), shallow (~3 meters mean depth) impoundment located within the Mill Creek Recreation area, approximately 5 km northeast of the city of Walla Walla, in Walla Walla County (Table 1). The water source of Bennington Lake is Mill Creek. The area is under the jurisdiction of the United States Army Corps of Engineers (COE). Recreation activities available at the area includes fishing, hunting, bird watching, horseback riding, hiking, bicycling, swimming, and picnicking. A boat launch, located on the northwest end of the lake, provides access for boats and float tubes. None of the lake's shoreline has been developed.

Table 1. Physical parameters of Bennington Lake (Walla Walla County).

Physical Parameters	**Bennington Lake (Walla Walla County)**
Surface Area (acres)	52
Shoreline Length (miles)	1.9
Maximum Depth (meters)	4[i]
Mean Depth (meters)	3
Volume (acre feet)	870
Shoreline Development D_L	1.9

[i] Water depth varies from month to month.

Bennington Lake was built in 1942 in response to frequent floods in the Walla Walla River valley. Today water is diverted from Mill Creek into Bennington Lake via a diversion canal during the peak spring runoff (Figure 1). Once the lake is at recreational level (1,252 feet, or 410 meters above sea level), typically in June, the lake receives no additional water from the diversion canal until the following spring. During late summer, and especially in dry years, water levels become low due to evaporation and seepage. This unstable water level has resulted in the near complete absence of aquatic vegetation.

Bennington Lake is managed by Washington Department of Fish and Wildlife (WDFW) as a mixed species fishery, but was previously managed as a rainbow trout (*Oncorhynchus mykiss*) fishery. The trout fishery funded by WDFW and the United States Army Corps of Engineers, Lower Snake River Compensation Program. The COE portion of the funding is intended to mitigate for losses of native stocks in the Snake River. The attraction of the recreational fishery offered at Bennington Lake is most realized during the spring when stocked hatchery trout attract numerous anglers. Each year the lake is heavily stocked with catchable (~200 mm TL) rainbow trout. For example, the lake was stocked with 21,213 in 1998 (WDFW 1998), 24,054 in 1999 (WDFW 1999). In addition to catchable rainbow trout approximately 2,000 triploid rainbow trout (~650 grams) have been stocked annually since 1998 (Unpublished data, WDFW Region 1). Natural reproduction of rainbow trout is very unlikely due to the lack of spawning habitat. In addition to rainbow trout, the lake supports naturally reproducing yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*), yellow bullhead (*Ameiurus natalis*), black crappie (*Pomoxis nigromaculatus*), bluegill sunfish (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*). Although no documented cases of warmwater fish being intentionally stocked into Bennington Lake were found, anecdotal information indicates that WDFW and the COE may have stocked warmwater fish during the 1980's. Therefore it is difficult to determine the origin of fish species found in the lake during this survey. All of the fish species currently inhabiting Bennington Lake have been introduced since 1989. During this year, the lake was not filled, which resulted in a dry lake and consequently a total fish kill. Regardless of their origin, warmwater fish are making a contribution to the sport fishery of the lake. Under current WDFW regulations, anglers are allowed to retain five largemouth bass, but only 3 over 15 inches. Five rainbow trout (no minimum length) may also be retained in the daily creel. There is no minimum length or bag limit on black crappie, bluegill sunfish, yellow perch, yellow bullhead, and brown bullhead.

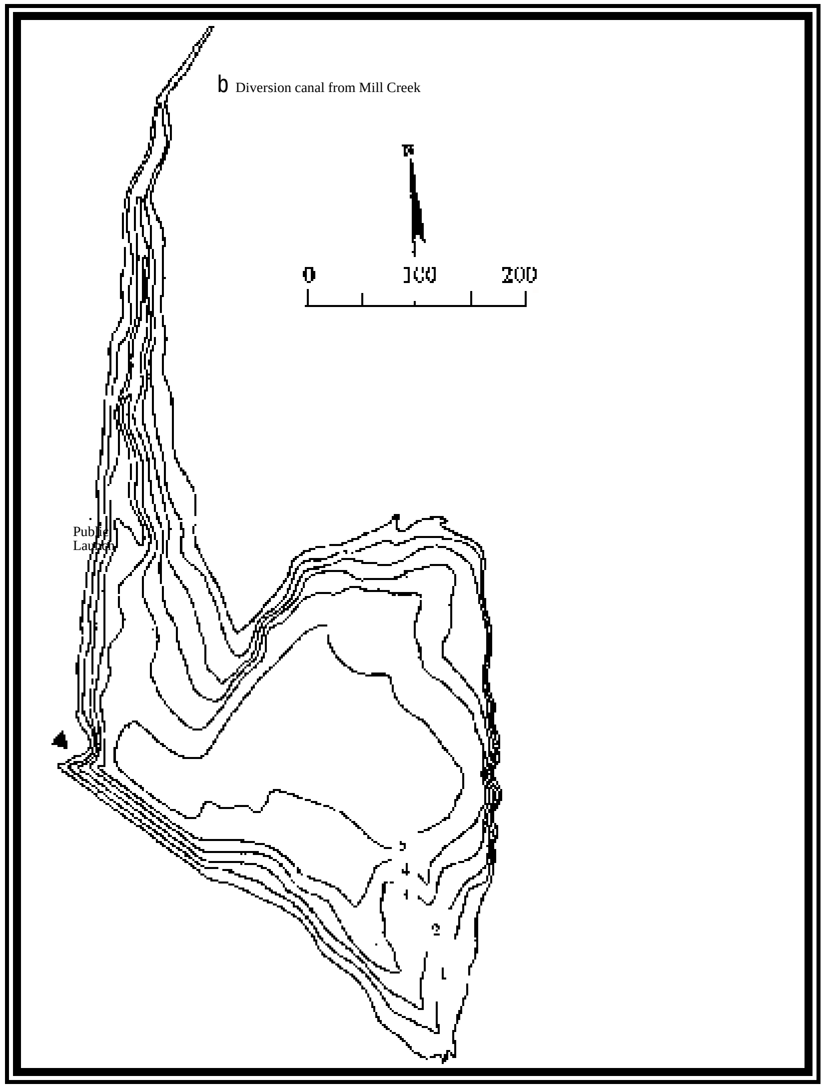

Figure 1. Map of Bennington Lake (Mill Creek Pond, Walla Walla County) with 1 meter contour lines.

Bennington Lake was identified by regional fisheries biologists as a body of water to be surveyed under the Warmwater Fish Enhancement Program. To evaluate warmwater fish populations, and to identify ways to improve the quality of fishing, personnel from the WDFW Warmwater Enhancement Program conducted a fisheries survey on Bennington Lake during September 1999. This report is intended to assist regional fisheries biologists in identifying management options which could improve the quality of warmwater fish angling in Bennington Lake.

Methods

Bennington Lake was surveyed by a three person investigation team September 22 - 24, 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 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 4 sections of approximately 400 meters each. All four sections (the entire shoreline)were sampled by boat electrofishing, two by gill netting, and two by fyke netting. Net sections were selected using a random number table. While electrofishing, the boat was maneuvered through the shallows (depth range = 0.2 - 2 m), adjacent to the shoreline. This 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). The total electrofishing time during the survey was 2410 seconds ("pedal-down" time). 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. Fyke nets were set so that the trap was no deeper than three meters.

Each fish captured was identified to species, measured to total length (mm TL) and weighed (g). Scales were collected for age and growth analysis from largemouth bass, bluegill sunfish, black crappie, and yellow perch. Scale samples (up to five per 10 mm length class for each species) were mounted, pressed, and aged according to Jearld (1983) and Fletcher et al. (1993). Rainbow trout, brown bullhead, yellow bullhead, and northern pike-minnow (*Ptychocheilus oregonensis*) were not aged.

Water quality data was collected from the deepest location in the lake at 11:25 AM on September 24, 1999. Information was gathered on dissolved oxygen, temperature, specific conductance, total dissolved solids, and pH 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; Fletcher et al.

1993). Species composition by weight (kg) and number was calculated using the first three boat electrofishing sections, both gill netting sections, and both fyke netting sections to calculate the species composition of the lake. This methodology was utilized to maintain 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) to compare the species composition in other lakes to the species composition in Bennington Lake. This technique is employed to reduce bias between gear types (Fletcher et al. 1993). 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 method, 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 gear type, 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 longer. 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 percent confidence intervals (CI) were calculated for each mean CPUE by species and gear type. Each CI was calculated as the mean ±t(%,N-1)×SE, where *t*=Student's *t* for % 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 to monitor changes in relative abundance over time.

Length frequency histograms (percent frequency captured by each gear type) were created to evaluate the size structure of largemouth bass, black crappie, bluegill sunfish, and yellow perch. 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$quality length/number of fish$stock length×100, was determined for each warmwater fish species 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 2). Stock length (20-26 percent of the world record) refers to the minimum size of fish with recreational value, and quality length (36-41 percent of the world record) refers to the minimum size fish anglers would like to catch. In addition to stock and quality length, Gabelhouse (1984) introduced relative stock density (RSD) which includes preferred, memorable, and trophy lengths. Preferred length (45-55 percent of world record length) refers to the length fish anglers would prefer to catch. Memorable length (59-64 percent of the world record length) refers to the minimum length fish most anglers remember catching, whereas trophy length (74-80 percent of world record length) refers to the minimum length fish worthy of acknowledgment. Bister et al. (2000) developed and proposed additional length categories for 83 additional species including brown bullhead. 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 2. PSD/RSD length categories for fish species collected from Bennington Lake (Walla Walla County) in September 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 (2–26%)**	**Quality (36-41%)**	**Preferred (45-55%)**	**Memorable (59-64%)**	**Trophy (74-80%)**
Black Crappie	130	200	250	300	380
Bluegill Sunfish	80	150	200	250	300
Brown Bullhead	130	200	280	360	430
Largemouth Bass	200	300	380	510	630
Yellow Bullhead	100	180	230	280	360
Yellow Perch	130	200	250	300	380

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 calculated to evaluate the relationship between the length of fish collected and their weight. W_r is calculated as the actual weight of a fish divided by the standard weight

(W_s) for the same species at the same length times 100 ($W_r = W/W_s \times 100$, where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same length). W_s is calculated from the standard log 10 weight-log10 length relationship defined for the species of interest. Standard weight equations have been established for many freshwater game and non-game fish species (Anderson and Neumann 1996; Bister et al. 2000). 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. A W_r value of 100 generally indicates that a fish is in average condition when compared to the national average for that species (Anderson and Guetreuter 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.

Water Quality

Dissolved oxygen levels varied very little from the surface to the bottom (4 m) and were within the desirable range for fish species collected from the lake (Boyd 1990). 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 (Table 3).

Table 3. Water quality data from Bennington Lake (Walla Walla County) collected at 11:25 a.m. on September 24, 1999.

Depth	Temp (EC)	Dissolved Oxygen	Conductivity	pH
0	19.2	8.2	75.8	8.5
2	19.1	7.9	75.8	8.4
4	19.0	7.9	75.8	8.4

Secci disk reading .5 meters.

Dissolved oxygen levels did not limit the amount of available habitat for fish in Bennington Lake during the time of this survey. Warmwater fish species, which are more tolerant of low dissolved oxygen levels than coolwater species, cannot survive at levels below 1mg/l (Swingle 1969), and can show signs of decreased health such as low relative weight and slow growth when oxygen levels are below 2.5 mg/l. Coolwater fish species such as rainbow trout, which are less tolerant of low oxygen levels and high water temperatures, cannot survive when dissolved oxygen levels drop below 2.5mg/l (Wheaton 1977). Although no serious water quality limitations were identified during this one time evaluation, a monthly water quality profile over the entire year should be completed to identify seasonal water quality limitations.

Species Composition

Eight different fish species were collected from Bennington Lake. Although eight species were collected, half of the species collected were represented by less than ten individuals. For example, yellow bullhead were represented in the sample by four individuals and northern pike-minnow were represented by five individuals. Yellow perch were the most abundant species collected, both in total kilograms (kg) and number collected (Table 4). Although many yellow perch were collected, none were greater than 150 mm. Very few rainbow trout were collected. Rainbow trout may have been under represented because of our sampling methods. Sampling methods used during this survey are directed toward warmwater fish populations, which typically occupy litoral habitat. Therefore, these methods may under represent fish species such as rainbow trout that occupy deep offshore or pelagic habitats. However, due to the limited depth and surface area of the lake, it is doubtful that rainbow trout were present in high numbers during this time of year.

Table 4. Species composition (including only fish $1 year old) by weight (kg) and by number of fish collected from Bennington Lake (Walla Walla County), September 1999.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Type of Fish	**(kg)**	**(%w)**	**(#)**	**(%n)**	**Min**	**Max**
Yellow Perch	7.69	26.9	410	64.3	97	147
Black Crappie	7.07	24.7	96	15.0	144	273
Largemouth Bass	6.28	22.0	80	12.5	76	389
Bluegill	2.65	9.3	30	4.7	92	210
Brown Bullhead	1.92	6.7	9	1.4	219	270
Yellow Bullhead	1.67	5.9	4	0.6	257	336
Rainbow Trout	0.70	2.5	4	0.6	244	270
Northern Pike-Minnow	0.60	2.1	5	0.8	220	266

Catch Per Unit of Effort

Catch rates were highest while electrofishing (number of stock length or larger fish/hour of shocking) for yellow perch, bluegill sunfish, and black crappie, respectively (Table 5). With the exception of northern pike-minnow, which was only represented in the sample by 5 individuals, fyke netting was the least effective collection method for all species of fish.

Table 5. Mean catch per unit effort for each fish species, by sampling method, including 80% confidence intervals, for stock length fish collected from Bennington Lake (Walla Walla County) in September 1999.

	Collection Method					
	Electrofishing		Gill Netting		Fyke Netting	
Species	**fish/hour**	**# Sites**	**Fish/GN Night**	**# of Nights**	**Fish/FN Night**	**FN Nights**
Black Crappie	25.5 ± 21.8	4	23.0 ± 11.5	2	16.5 ± 21.2	2
Bluegill Sunfish	41.9 ± 20.6	4	1.0 ± 1.0	2	0	2
Brown Bullhead	6.0 ± 4.4	4	1.0 ± 1.0	2	1.5 ± 1.9	2
Largemouth Bass	1.5 ± 1.9	4	1.5 ±1.9	2	0	2
Northern Pike-minnow	0.0	4	1.0 ± 1.3	2	1.5 ± 1.9	2
Rainbow Trout	1.5 ± 1.9	4	1.0 ± 1.3	2	0	2
Yellow Bullhead	4.5 ± 5.8	4	0.5 ± 0.6	2	0	2
Yellow Perch	88.2 ± 31.5	4	0	2	1.5 ± 1.9	2

Small sample size and broad confidence intervals limit the interpretation of CPUE data. However, as the number of lakes sampled under the Warmwater Fish Program increases, this information will be valuable for comparison. CPUE data collected in this survey will serve as a baseline to evaluate any changes in management and the success of future enhancement programs.

Proportional Stock Density

Proportional stock density values can be a good indication of the fish population size structure of a lake when adequate stock length fish are collected to calculate acceptable confidence (Gustafson 1988). Few fish greater than stock length were collected from Bennington Lake, which resulted in broad confidence limits around PSD values (Table 6). These broad confidence limits make any interpretation about PSD difficult. It is apparent that the fish community in the lake is dominated by small fish with little recreational opportunity.

Even fewer fish greater than quality length were collected during the survey. With the exception of one largemouth bass, one yellow bullhead, and one bluegill sunfish, no fish greater than preferred length were collected.

Table 6. Traditional stock density indices, including 80% confidence intervals, of fish collected from Bennington Lake (Walla Walla County) September 1999, by sampling method.

Species	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Black Crappie	17	18 ± 12	0	0	0
Bluegill Sunfish	28	82 ± 9	4 ± 4	0	0
Brown Bullhead	4	100 ± 0	0	0	0
Yellow Bullhead	3	100 ± 0	100 ± 0	33 ± 35	0
Yellow Perch	59	0	0	0	0
		Fyke Netting			
Black Crappie	33	9 ± 6	0	0	0
Brown Bullhead	3	100 ± 0	0	0	0
Yellow Perch	3	0	0	0	0
		Gill Netting			
Black Crappie	46	15 ± 7	2 ± 3	0	0
Bluegill Sunfish	2	0	0	0	0
Brown Bullhead	2	100 ± 0	0	0	0
Largemouth Bass	3	100 ± 0	33 ± 35	0	0
Rainbow Trout	2	0	0	0	0

Largemouth Bass

Largemouth bass collected from Bennington Lake ranged in size from 52 to 398 mm TL, and were up to five years old (Table 7; Figure 2). No fish from the 1995 year class were represented in the sample which may indicate a year-class failure. Growth was higher than the average growth of largemouth bass from 22 lakes in eastern Washington (Fletcher et al. 1993). The absence of fish 200-350 mm is likely the result of the 1995 year-class failure. The relative weight of largemouth bass less than 200 mm was far below the national standard. This may be the result of intensive competition between the different fish species in the lake (Figure 3). Although only a few largemouth bass greater than 350 mm were collected, they had a much higher average relative weight. Largemouth bass, which typically feed on smaller fish, may be finding adequate forage in this fish community, which appears to be dominated by abundant juvenile fish.

Table 7. Age and growth of largemouth bass collected from Bennington Lake(Walla Walla County) in September 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**	**5**
1998	18	70				
		82				
1997	6	72	146			
		83	148			
1996	3	86	150	219		
		98	157	221		
1995	0					
1994	3	72	149	219	280	345
		89	161	228	285	347
Direct Proportion Overall Mean		75	148	219	280	345
Lee's Weighted Mean		84	154	225	285	347
Direct Proportion State Average	766	60	146	222	261	289

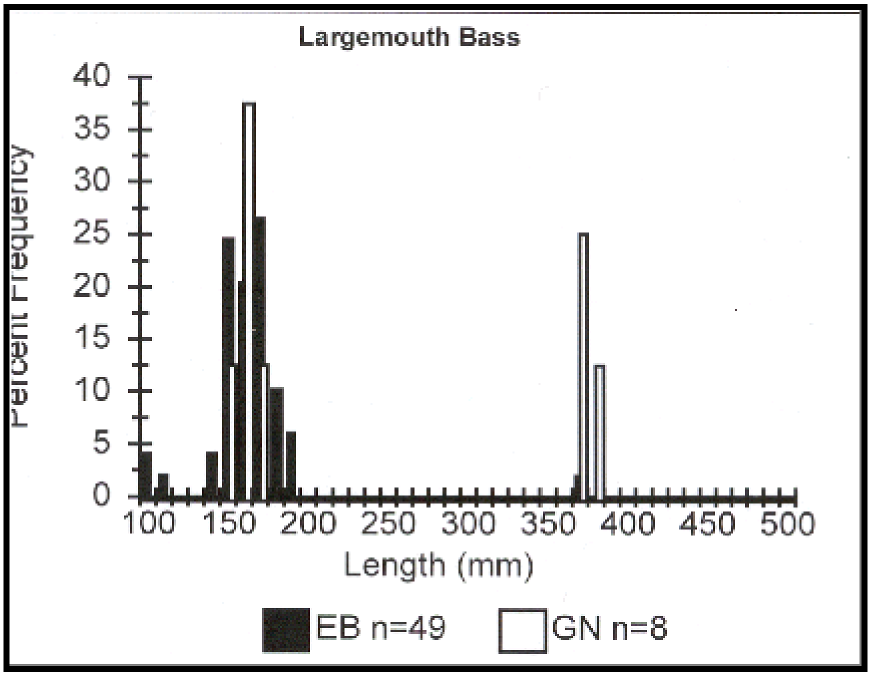

Figure 2. Length frequency of largemouth bass, excluding the young-of-the-year, captured while electrofishing (EB), and gill netting (GN) at Bennington Lake (Walla Walla County) during September 1999.

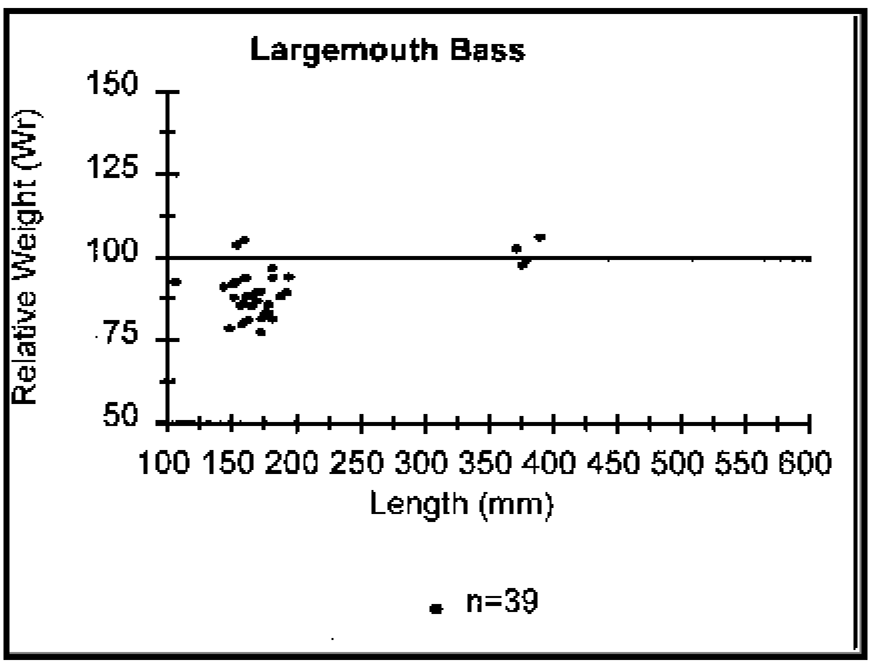

Figure 3. Relationship between total length and relative weight (Wr) of largemouth bass, excluding young-of-the-year, compared to the national standard (horizontal line 100), collected at Bennington Lake (Walla Walla County) during September 1999.

Bluegill Sunfish

Bluegill sunfish collected during the warmwater fish survey of Bennington Lake ranged in length from 21 to 210 mm and were one to . However, only two of the fish collected were larger than 200 mm (Figure 4). The growth rate of bluegill sunfish collected from Bennington Lake was similar, or slightly higher than average growth rate of 405 bluegill sunfish collected from 17 different lakes in Washington state (Table 8) (Fletcher et al. 1993). It is difficult to make any conclusion about the relative weight of bluegill sunfish collected because there were individuals above and below the national standard (Figure 5).

Table 8. Age and growth of bluegill sunfish collected from Bennington Lake (Walla Walla County) in September 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**	**5**
1997	7	65				
		76				
1996	4	61	129			
		73	133			
1995	8	36	119	159		
		52	125	161		
1994	5	50	108	144	166	
		65	116	148	167	
1993	2	50	106	142	169	190
		64	115	148	172	191
Direct Proportion Overall Mean		52	115	148	167	190
Lee's Weighted Mean		65	123	155	169	191
Direct Proportion State Average	405	37	97	132	148	170

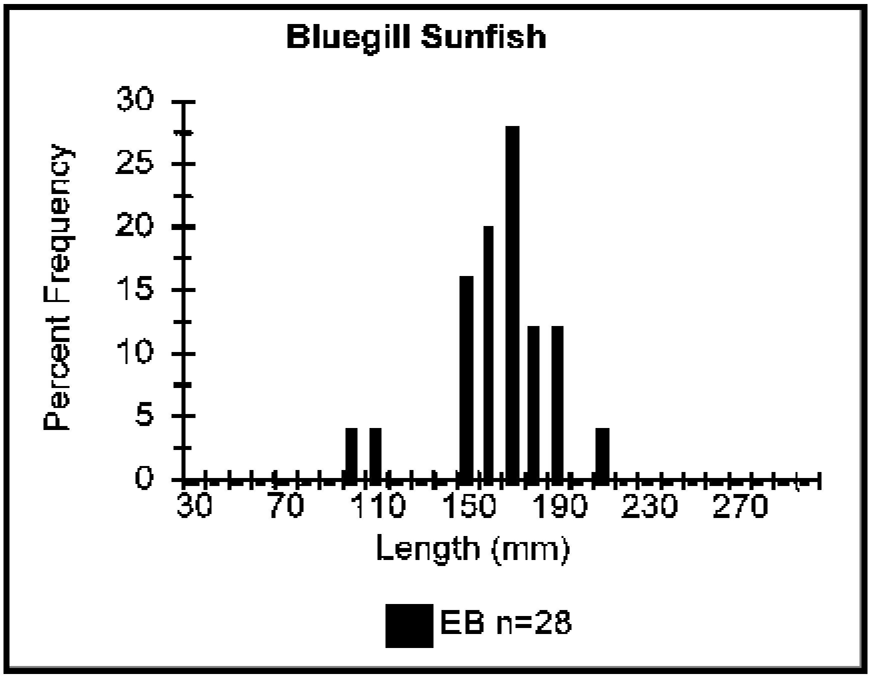

Figure 4. Length distribution of bluegill sunfish, excluding the young-of-the-year, captured while electrofishing (EB) at Bennington Lake (Walla Walla County) during September 1999.

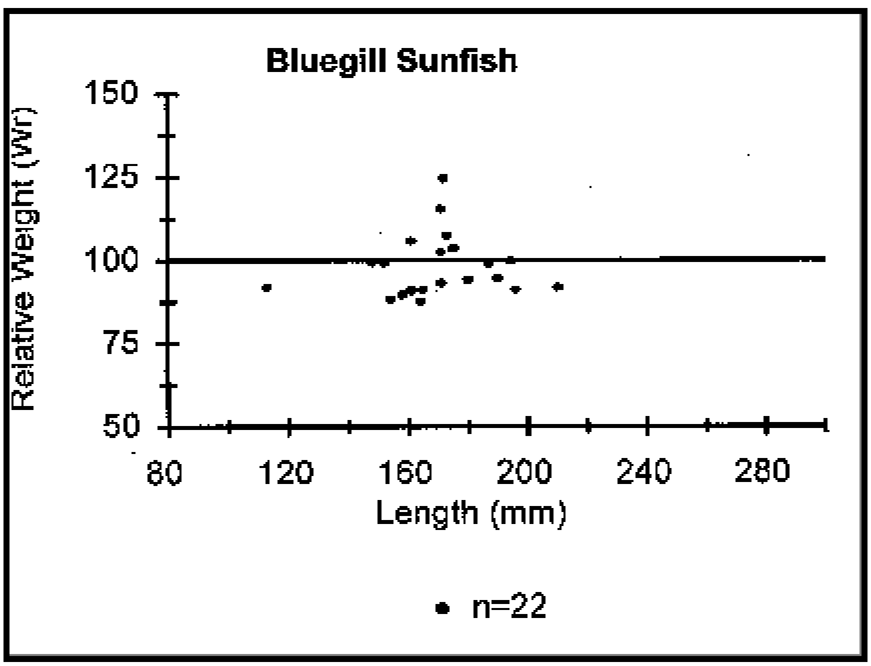

Figure 5. Relationship between total length and relative weight (Wr) of bluegill sunfish, excluding young-of-the-year, compared to the national standard (horizontal line 100), collected at Bennington Lake (Walla Walla County) during September 1999.

Yellow Perch

Yellow perch collected from Bennington Lake ranged in length from 37 to 147 mm, and were 1 to 3 years old (Table 9). Of the 412 yellow perch collected, none were >147 mm (Figure 6). The absence of larger fish (>150 mm) in our sample may be an indication of variable year-class strength or high annual total mortality. Yellow perch growth rates for the age one fish collected in Bennington Lake were higher than the average growth of yellow perch collected from 29 lakes throughout Washington state (Table 9). The low relative weight of these fish was far below the national standard, which may indicate intense interspecific competition for available food resources (Figure 7). The low relative weight of yellow perch may also be an indication of low primary productivity, which may be limiting the production of zooplankton, a main forage item of yellow perch (Craig 1987).

Table 9. Age and growth of yellow perch collected from Bennington Lake (Walla Walla County) in September 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**
1997	21	75			
		87			
Direct Proportion Overall Mean		75	0	0	0
Lee's Weighted Mean		87	0	0	0
Direct Proportion State Average	919	60	120	152	193

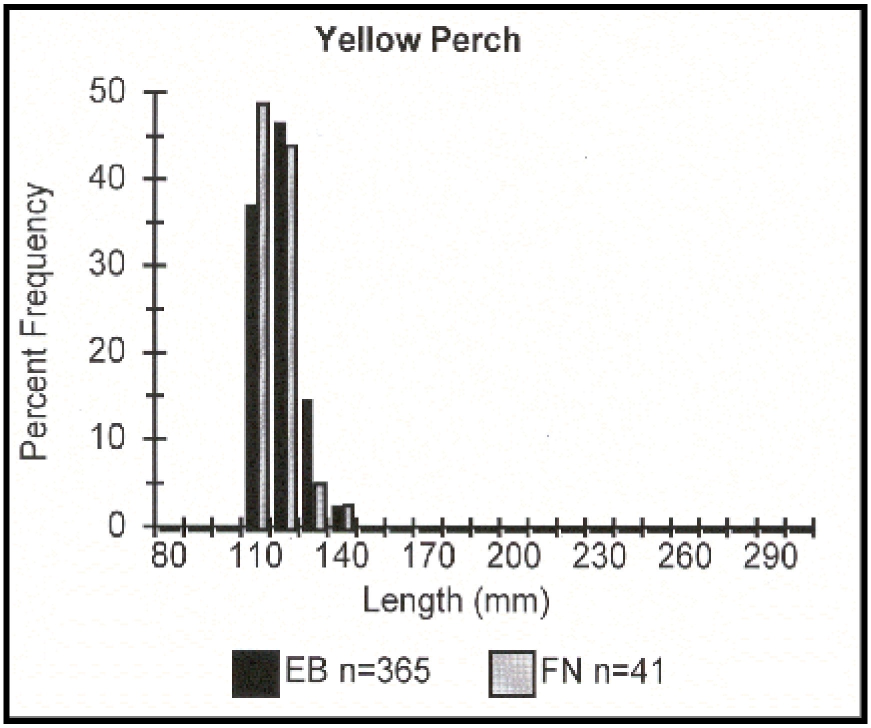

Figure 6. Length distribution of yellow perch, excluding the young-of-the-year, captured while electrofishing (EB), and fyke netting (FN) at Bennington Lake (Walla Walla County) during September 1999.

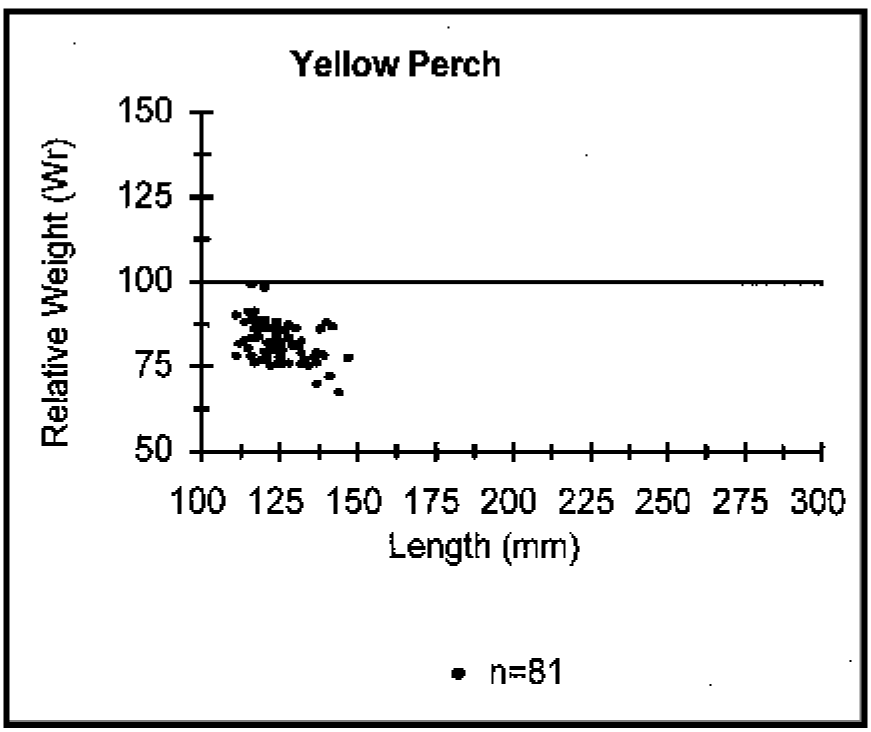

Figure 7. Relationship between total length and relative weight (Wr) of yellow perch, excluding the young-of-the-year, compared to the national standard (horizontal line 100), collected at Bennington Lake (Walla Walla County) during September 1999.

Black Crappie

Black crappie collected from Bennington Lake ranged in length from 41 to 273 mm, and were age 1 to 5 (Table 10). The growth rate of the fish collected was slightly higher than the average growth of 290 black crappie collected from 16 different locations in Washington (Fletcher et al. 1993). The relative weight of black crappie <200 mm was higher than the national standard while black crappie >200 mm had relative weights lower than the national standard (Figure 9). Black crappie are either suffering natural mortality or are being harvested from the population before reaching preferred length. Only two young-of-the-year-black crappie were collected, which may be an indication of poor spawning success in 1999. Only one black crappie greater than 250 mm was collected during the survey (Figure 8).

Table 10. Age and growth of black crappie collected from Bennington Lake (Walla Walla County) in September 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**	**5**
1997	21	66				
		87				
1996	7	57	154			
		82	163			
1995	6	81	131	192		
		103	145	197		
1994	1	36	130	184	220	
		65	144	191	221	
1993	1	32	73	135	208	236
		63	99	153	216	241
Direct Proportion Overall Mean		54	122	170	214	236
Lee's Weighted Mean		88	150	191	219	241
Direct Proportion State Average	290	46	111	157	183	220

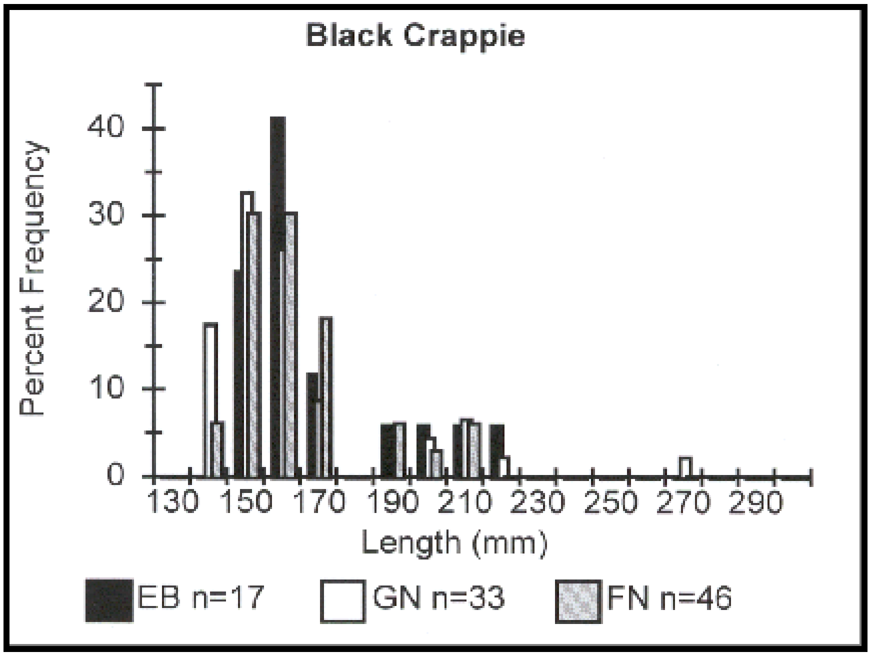

Figure 8. Length distribution of black crappie, excluding the young-of-the-year, captured while electrofishing (EB), fyke netting (FN), and gill netting (GN) at Bennington Lake (Walla Walla County) during September 1999.

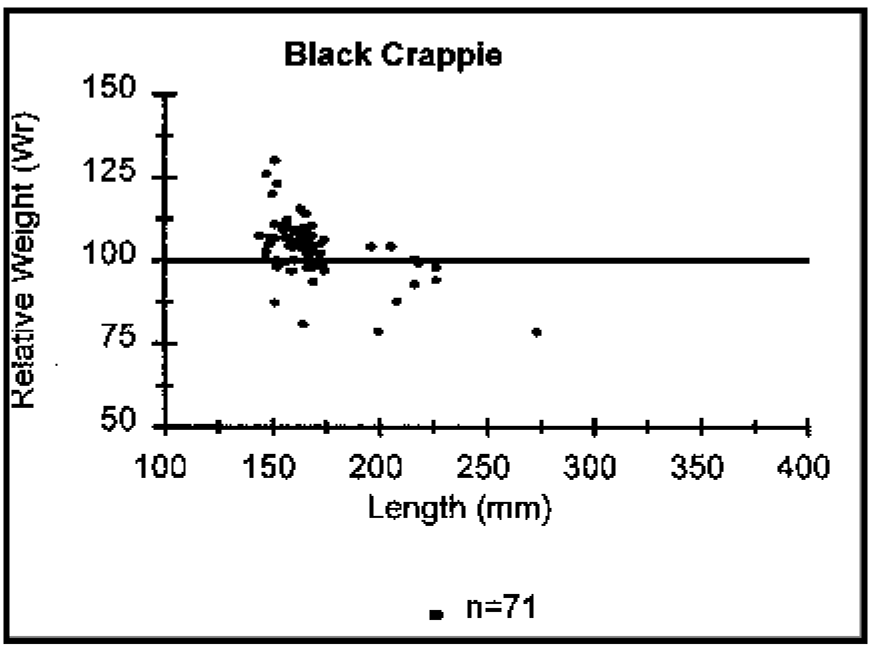

Figure 9. Relationship between total length and relative weight (Wr) of black crappie, excluding the young-of-the-year, compared to the national standard (horizontal line 100), collected at Bennington Lake (Walla Walla County) during September 1999.

Brown Bullhead and Yellow Bullhead

The nine brown bullhead collected from Bennington Lake ranged in length from 219 to 270 mm. Yellow bullhead were represented in the sample by only four individuals that ranged in length from 257 to 336 mm. Because so few bullhead were collected it is unknown what contribution these species are making to the recreational fishery. Bullhead collected from the lake are most likely the result of illegal stocking or have entered the lake when water is diverted each spring.

Northern Pike-minnow

Northern pike-minnow and rainbow trout were the only species collected that are not introduced to the state of Washington, although rainbow trout are introduced in Bennington Lake. Northern pike-minnow were represented in the sample by five individuals ranging in length from 220 to 266 mm TL. It is unknown if the northern pike-minnow are naturally reproducing in Bennington Lake. The fish were likely introduced through the diversion canal during the spring when water is diverted into the lake from Mill Creek.

Rainbow Trout

Only four rainbow trout were collected during this survey. Rainbow trout provide angling opportunity early in the fishing season when cooler water temperature limits the catch rates of spiny-rayed fish. The species is not believed to be naturally reproducing due to the lack of suitable spawning habitat. During mid to late summer (July-September), the water level decreases, and water temperature increases. This results in a lowering of total dissolved oxygen. These conditions may dramatically reduce the number of rainbow trout available after the spring harvest season. This is evident by our low catch rate for the species, which was stocked at very high densities a few months earlier. In addition, it is thought that few, if any, rainbow trout survive from one fishing season to the next. We do acknowledge that the warmwater fish sampling techniques used in this survey are largely restricted to the littoral zone, and therefore salmonid species may by under represented using this approach. However, given the relatively shallow depth and size of Bennington Lake, we believe the collection of rainbow trout during our sampling was much closer to the actual relative abundance of rainbow trout than what we would expect to collect from larger, deeper lakes.

Discussion

With the exception of fishing for rainbow trout in the spring, there is very limited opportunity for anglers to harvest fish of any species in Bennington Lake. Data collected during the warmwater fish evaluation of Bennington Lake revealed a fishery dominated by small (less than stock length) fish. Although the causes for the conditions were not evaluated, it is our opinion based on year-class variability, low relative weight, and species composition that this condition exists largely due to annual reservoir draw-down. Reservoirs with large annual changes in water levels are likely to have unstable fish assemblages (Carline 1986). Additionally, harvest of largemouth bass >200 mm TL and the lack of offshore habitat may be contributing to the poor quality of this fishery. The lowering of water annually has resulted in the total absence of aquatic vegetation, which gives young fish little chance for survival.

According to the United States Army Corp of Engineers (COE), the lake filled to 1205 ft (above sea level) each spring after the threat of flood has passed. The water level in the lake is then maintained at 1205 ft as long as there is sufficient water in Mill Creek or until June 15th. Water rights only allow the COE to take water from the creek until this date. Once water diversion into the lake stops, the only additional water comes from rain and snowfall. The result of this management is a very low water level in September. During the time of this survey the water level of the lake was 1194 ft above sea level. With the water at this level, the maximum depth of the lake is ~4 m. According to the COE, water levels in the lake drop to a low of approximately 1187 ft each fall (Army Corp of Engineers, personal communications). Therefore, the maximum depth of Bennington Lake during the late summer and early fall is approximately 2.5-3 m. According to the COE, the volume of water in the lake when full is ~866 acre feet. The volume of water in the lake at low level is ~146 acre feet.

Water level fluctuations are likely limiting cover availability and productivity in Bennington Lake. Water fluctuations can significantly influence spawning success, which may account for the variability in year-class strength observed. Additionally, crowding of fish into less water volume at low pool likely results in an increase in inter- and intraspecific competition for available resources as well as increasing predation rates on smaller fish. The riparian area of the lake is located at 1205 ft, and as water levels drop, available cover is reduced. Aquatic vegetation (emergent and submersed) is almost entirely absent from the lake. The lack of aquatic vegetation and poor bank stability may contribute to high turbidity especially during windy periods. This high turbidity may also be limiting phytoplankton growth, which is likely limiting the production of zooplankton. Water quality data collected during this brief survey did not include an evaluation of productivity. An evaluation of productivity and water quality throughout the year would likely improve our understanding of fish management limitations in Bennington Lake.

Management Recommendation

The following management recommendations are intended to assist WDFW Regional Fishery Biologists in providing angling opportunities throughout the fishing season. Bennington Lake habitat limitations will undoubtedly prove a challenge to fisheries biologists attempting to manage the lake as a self sustaining warmwater fishery. It is likely that the quality of the warmwater fishery will continue to pose problems as the water level in the lake fluctuates. After speaking with personnel from the COE, it is doubtful that the water level in the lake can be stabilized. According to the COE, stabilizing the water level at 1205 ft above sea level would require a change in water rights to allow water diversion after June 15^{th}. However, even with a change in water rights, the flow in Mill Creek may not be sufficient to allow the removal of additional water. Any management option directed at improving the quality of this fishery will have to consider fluctuating water.

These management recommendations are intended to improve the quality of the warmwater fishing in the lake. This program, which is funded by the Lower Snake River Compensation Program and WDFW, is intended to compensate anglers for lost fishing opportunity after the Snake River dams were constructed. It is our opinion, based on the data collected during this survey, that managing Bennington lake as a mixed species fishery will provide the greatest opportunity throughout the fishing season. This recommendation includes the continuation of the popular trout program to provide for angling during the spring and early summer when water levels are highest and water temperatures are cooler. To provide angling during the remainder of the season, we recommend reducing the warmwater fish community to two species, largemouth bass and black crappie. This would make the most of the limited resources available at Bennington Lake during the summer months when conditions become less desirable of rainbow trout.

Largemouth Bass and Black Crappie Option

To implement a change in the warmwater fish community in Bennington Lake, we propose: 1) remove all current fish populations from the lake by drawing down the water and/or using chemical methods; 2) stocking the lake with largemouth bass and black crappie; 3) imposing the states 12-17" slot-limit on largemouth bass; 4) installing artificial structures to provide cover for juvenile fish; 5) monitoring spawning success and year-class strength of black crappie and supplement the population when necessary; and 6) collecting creel survey data.

During the time of this survey, it was nearly impossible, given the available resources, to determine how the eight different fish species found in the lake are impacting one another. By limiting the number of warmwater fish in the lake to largemouth bass and black crappie, biologists will better understand the population dynamics of the lake. A complete removal of the current fish community is highly possible because Bennington Lake can be drawn down to a low level in the summer and fall. It is also likely that this fish removal could coincide with any maintenance effort by COE, who periodically lowers the water in the lake. If the water is drawn down to a low level during late summer, increased water temperature and decreased oxygen might result in a complete fish kill. If a complete fish kill is not achieved, any remaining fish could be removed using chemical or mechanical techniques.

Following fish removal, artificial structures should be installed below the 1187 ft level to provide refuge for juvenile fish. Increasing the amount of offshore deepwater habitat may reduce annual variability in year-class strength by allowing smaller fish to survive during periods of low water.
However, supplementation may still be required to assist poor year classes when natural reproduction is not sufficient.

During the following spring, adult largemouth bass and black crappie should be stocked. These fish can be managed for balance, or possibly to promote a quality black crappie fishery, depending on objectives. Limiting warmwater fish to two species should bolster efforts to improve the quality of warmwater fish available to anglers. Supplemental stocking of largemouth bass and/or black crappie in future years should be carried out if monitoring efforts suggest that stock densities are not within desired ranges for management goals.

Black crappie can provide a sustainable fishery of desirable length fish if the balance between predatory and prey species is managed to reduce the number of small black crappie in the lake. Boxrucker (1987) found that small lakes could be managed for black crappie if the number smaller individuals (<200 mm) was reduced through predation by largemouth bass.

In order to maintain a dense largemouth bass population, the harvest of larger bass must be restricted. This is especially true in Washington where growth rates for largemouth bass are much lower than growth in other areas. Anglers would have to accept harvesting smaller largemouth bass.

Considering this, Bennington Lake is 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" are to be released, and only one fish over 17" may be retained. The intent of this regulation is to maintain the number of quality length ($300 mm; 12") largemouth bass in the lake. Under this regulation the number of largemouth bass predators in the lake should reduce chances for stunting of the black crappie population. Additionally, this regulation would increase the number of larger bass available for catch and release angling while still allowing for smaller bass (<300 mm; 12") to be retained by anglers. Slot limits are only successful when anglers harvest sufficient fish on the small end of the slot to eliminate stunting. Therefore, for this regulation to be effective, anglers must accept harvesting smaller largemouth bass. 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).

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