1999 Warmwater Fisheries Survey of Alkali Lake, Grant County, Washington

by

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Abstract

Alkali Lake, Grant County, Washington, was surveyed between May 10-12, 1999, using electrofishing, gill netting, and fyke netting. Although sample sizes were low, a total of eight fish species were observed during sampling efforts: largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), channel catfish (*Ictalurus punctatus*), yellow perch (*Perca flavescens*), and Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*). Warmwater gamefish comprised approximately 80 percent of the total fish captured. Largemouth bass was the most abundant (42%) species and contributed the highest proportion (50%) of biomass. Age of largemouth bass ranged from 1 to 8 years and were the only fish species stocked in Alkali Lake that was found to be reproducing. Of the stock length largemouth bass sampled (n = 43), approximately 16 percent were of preferred size. Largemouth bass ranged in total length from 107 to 451 mm and appeared to be in good condition. Few fish had relative weights less than 90. Smallmouth bass (n = 10) comprised 5 percent of the total number and 21 percent of the biomass sampled. Smallmouth bass ranged in age from 3 to 8 years. All smallmouth bass sampled were of quality size or larger. Total lengths of smallmouth bass ranged from 333 to 397 mm. Most smallmouth bass exhibited relative weights greater than 100. Bluegill comprised 12 percent of the total number and 6 percent of the biomass sampled. Bluegill ranged in age from 2 to 3 years. Proportional stock density (PSD) analyses indicate that 64 percent of the bluegill were of quality length. Total lengths of bluegill ranged from 118 to 171 mm. Bluegill were in above average condition and all fish had relative weights greater than 100. Black crappie comprised 7 percent of the total number and 4 percent of the biomass sampled. Black crappie ranged in age from 2 to 4 years. Total lengths of black crappie range from 127 to 205 mm. Most black crappie were in above average condition. Channel catfish were also sampled in Alkali Lake in low numbers (n = 10). Channel catfish ranged in size from 134 to 335 mm. All other fish species found, with the exception of pumpkinseed and yellow perch, were those believed to be stocked following the 1996 rehabilitation. Although the current management plan for Alkali Lake is vague, we recommend that Alkali Lake be managed under the panfish or the largemouth bass and panfish option. We also recommend that the stocking of largemouth bass and panfish be suspended until future monitoring warrants additional stocking.

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Introduction and Background

Alkali Lake is part of the Sun Lakes chain located in Grant County approximately 14.5 kilometers (9 miles) north of the city of Soap Lake, Washington (Figure 1). Alkali Lake has a surface area of 118.6 hectares (293 acres), a mean depth of 2.6 meters (m) (8.4 ft.), and a volume of 2,449 acre feet. Water drains from Blue Lake into Alkali Lake via Blue Creek. Water discharges seasonally from the south end of Alkali Lake through permeable rock-fill under Highway 17 into Lake Lenore. Alkali Lake's shoreline is comprised of approximately 80 percent vegetation and 20 percent cliff and talus (WDFW 1996a) and supports various shrubs and trees such as willow (*Salix spp.*) and Russian olive (*Elaeagnus angustifolia*). Aquatic vegetation found in the lake include water milfoil (*Myriophyllum spp*)., pondweed (*Potamogeton spp*)., and filamentous algae. Waterfowl, such as Canada geese (*Branta canadensis*) and numerous duck species, migrate through this area and use Alkali Lake for both resting and nesting. Although no nests are known to exist near Alkali Lake, bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), and peregrine falcon (*Falco peregrinus*) are found in the area.

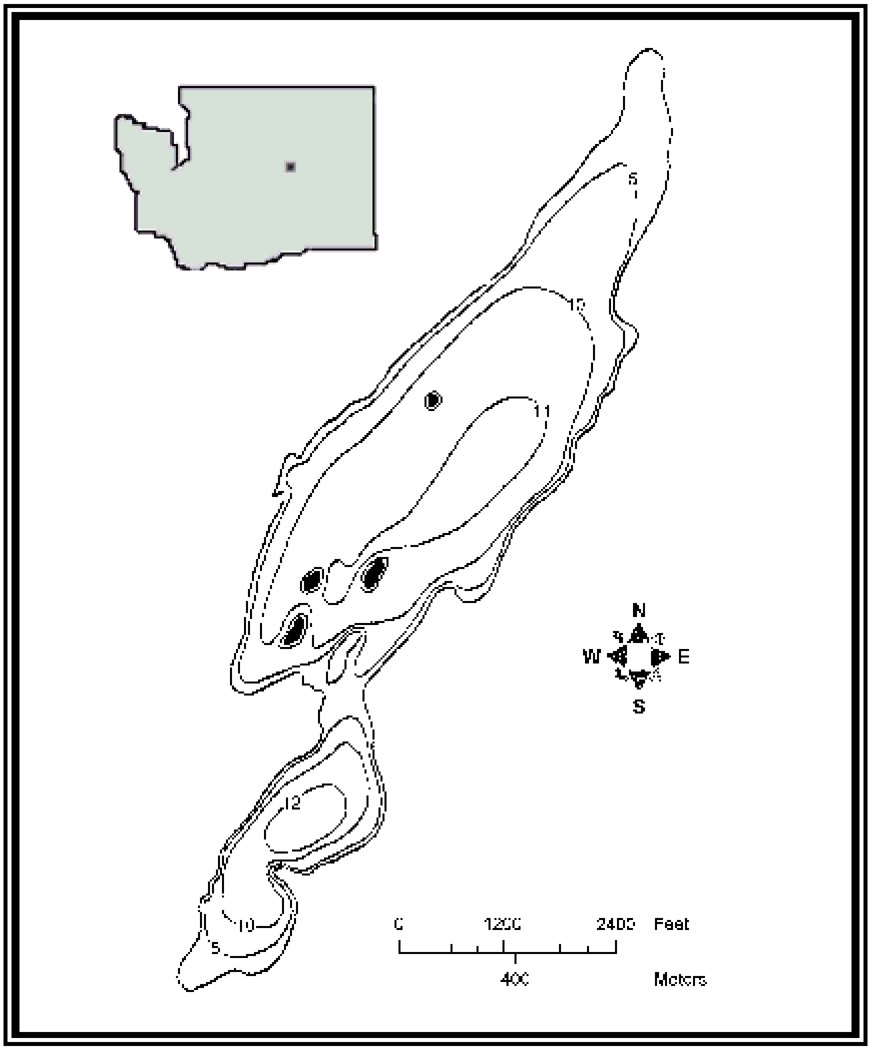

Figure 1. Map of Alkali Lake (Grant County).

Alkali Lake once exhibited pH levels that were too alkaline to support fish populations. However, fish survival was documented by the 1940's. Since then, the lake has a history of summer fish kills due to low dissolved oxygen levels (WDFW 1996a). Rehabilitation efforts by the Washington Department of Fish and Wildlife (WDFW) were first conducted on Alkali Lake in 1952 (WDFW 1996a). Yellow perch (*Perca flavescens*), sculpins (*Cottus spp.*), pumpkinseed (*Lepomis gibbosus*), suckers (*Catostomus spp.*), mudminnows (*Novumbra hubbsi*), northern pikeminnow (*Ptychocheilus oregonensis*), and grass pickeral (*Esox americanus vermiculatus*) were observed during the 1952 treatment. Washington Department of Fish and Wildlife managed the lake as a trout fishery from 1952 into the early 1970's through annual stocking (WDFW 1996b). Until the early 1960's, catches of rainbow trout (*Oncorhynchus mykiss*) were good, however, fish growth was poor. Trout management efforts by WDFW included repeated rehabilitations (1959, 1963, 1969). Catches began to decline by the late 1960's and WDFW reduced annual trout stocking. In the early 1970's, illegally introduced largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*) became the primary target of anglers. However, the bass and crappie populations were soon out of balance which led to stunted populations of yellow perch and pumpkinseed (WDFW 1996a). In an attempt to replace stunted pumpkinseed populations, WDFW stocked bluegill (*L. macrochirus*)into Alkali Lake in 1979 which was only marginally effective. In addition, WDFW conducted a partial rehabilitation in 1983 and stocked the lake in 1993 with a sterile strain of walleye (*Stizostedion vitreum*) with no success. Alkali Lake was last rehabilitated in fall 1996 in an attempt to eradicate yellow perch and pumpkinseed populations. Following the 1996 rehabilitation, WDFW stocked the lake with largemouth bass, smallmouth bass (*M. dolomieu*), channel catfish (*Ictalurus punctatus*), bluegill, black crappie, rainbow trout, and Lahontan cutthroat trout (*O. clarki henshawi*) in 1997 (Table 1).

Table 1. Fish stocked in Alkali Lake between spring 1997 and spring 1999 (prior to warmwater fish survey, May 10-12).

Year	Species	Size	Number
1997	largemouth bass	adults	158
		fingerlings	15
		fry	10,800
	smallmouth bass	adults	11
		juveniles	133
	black crappie	adults	230
		fry	6,732
	channel catfish	fingerlings	2,508
	bluegill	fry	6,028
	rainbow trout	fingerlings	5,180
	Lahontan cutthroat	fry	5,040
1998	largemouth bass	sub-adults	100
	channel catfish	fingerlings	2,002
	rainbow trout	advanced fingerlings	5,007
	Lahontan cutthroat	fingerlings	5,016
1999	black crappie	fingerlings	150

Although there is no minimum size or daily limit on small bluegill and crappie, current regulations on Alkali Lake allow anglers to harvest only five bluegill over six inches in length and five crappie over eight inches in length. All bass species are protected by a slot-length limit regulation which allows anglers to harvest five bass less than 12 inches to include no more than 1 fish over 17 inches in length. Moreover, anglers can harvest 5 channel catfish over 12 inches in length with only 1 exceeding 24 inches in length. There is no minimum size or daily limit on yellow perch and pumpkinseed and anglers are allowed to fish in Alkali Lake throughout the entire year.

This survey was conducted to determine the effectiveness of the fall 1996 rehabilitation, measure warmwater gamefish stocking success, and to monitor growth, condition, reproduction, and survival of warmwater gamefish species in the lake. Moreover, information collected during this survey was used to identify possible management strategies that would improve the quality of fishing in Alkali Lake.

Methods and Materials

Alkali Lake was surveyed by a three-person team May 10-12, 1999. All fish were collected using a boat electrofisher, gill nets, and fyke nets. The electrofishing unit consisted of a 5.5 m (18 ft.) Smith-Root GPP electrofishing boat, supplying a DC current at a setting of 120 cycles/sec at 3 to 4 amps power (Bonar et al. 2000). Experimental gill nets (45.7 m x 2.4 m) consisted of variable size (13, 19, 25, and 51 mm stretched) monofilament mesh. Fyke nets were constructed of a main trap (four 1.2 m aluminum rings), a single 30.3 m lead, and two 15.2 m wings. All netting material was constructed of 13 mm nylon mesh.

Sampling locations were selected by dividing the shoreline into 400 m sections determined from a map. The number of randomly selected sections surveyed are as follows: electrofishing - 15, gill netting - 6, and fyke netting - 6. Electrofishing occurred in shallow water (depth range: 0.2 - 1.5 m), adjacent to the shoreline at a rate of approximately 18.3 m/minute for 600 second intervals (Bonar et al. 2000). Gill nets were set perpendicular to the shoreline with the small-mesh end attached on or near the shore and the large-mesh end anchored offshore. Fyke nets were set perpendicular to the shoreline with the wings extended at 70E angles from the lead. Gill nets and fyke nets were set overnight prior to electrofishing and were pulled the following morning (1 net night each). All sampling was conducted during night-time hours when fish are most numerous along the shoreline thus maximizing the efficiency of each gear type.

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

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

Species composition, by weight in kilograms (kg) and number, was determined from fish captured. Fish less than one year old, i.e. young-of-the-year (YOY), were excluded from all analyses. Eliminating YOY fish will prevent distortions in analyses that may occur due to sampling location, method, and specific timing of hatches (Fletcher et al. 1993).

Catch per unit effort (CPUE) of each sampling gear was determined for each warmwater fish species collected. The CPUE of electrofishing was determined by dividing the number of fish captured by the total amount of time electrofished. Similarly, CPUE of gill nets and fyke nets was determined by dividing the number of fish captured by the total time that the nets were deployed. Since CPUE is standardized, it can be useful in comparing catch rates between lakes or between sampling dates on the same water.

A relative weight (W_r) index was used to evaluate the condition of fish in Alkali Lake. As presented by Anderson and Neumann (1996), a W_r of 100 generally indicates that the fish is in a condition similar to the national average for that species and length. The index is defined 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 total length (mm). W_s was derived from a standard weight-length ($\log_{10}$) relationship which was defined for each species of interest in Anderson and Neumann (1996). Minimum lengths were used for each species as the variability can be significant for small fish (YOY). Relative weights less than 50 were also excluded from our analyses as we suspected unreliable weight measurements.

Age and growth of warmwater species in Alkali Lake were evaluated using procedures described by Fletcher et al. (1993). All samples were evaluated using both the direct proportion method (Fletcher et al. 1993) and Lee's modification of the direct proportion method (Carlander 1982). Mean back-calculated lengths-at-age for all warmwater species were then compared to those of Eastern Washington and/or statewide averages (Fletcher et al. 1993).

The proportional stock density (PSD) of each warmwater fish species was determined following procedures outlined in Anderson and Neumann (1996). PSD uses two measurements, stock length and quality length, to provide useful information about the proportion of various size fish in a population. Stock length is defined as the minimum size of a fish which provides recreational value or approximate length when fish reach maturity (Table 2). Quality length is defined as the minimum size of a fish that most anglers like to catch or begin keeping (Table 2). PSD is calculated using the number of quality sized fish, divided by the number of stock sized fish, multiplied by 100. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Stock length is 20-26 percent of the world record length, whereas quality length is 36-41 percent of the world record length.

Relative stock density (RSD) of each warmwater fish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality lengths, the Gabelhouse model adds preferred, memorable, and trophy categories (Table 2). Preferred length (RSD-P) is defined as the minimum size of fish anglers would prefer to catch. Memorable (RSD-M) length refers to the minimum size fish anglers remember catching, and trophy length (RSD-T) refers to the minimum size fish worthy of acknowledgment. Preferred, memorable, and trophy length fish are also based on percentages of world record lengths. Preferred length is 45-55 percent of world record length, memorable length is 59-64 percent of world record length, and trophy length is 74-

80 percent of world record length. RSD differs from PSD in that it is more sensitive to changes in year class strength. RSD is calculated as the number of fish within the specified length category, divided by the total number of stock length fish, multiplied by 100. Eighty percent confidence intervals for PSD and RSD are selected from tables in Gustafson (1988).

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

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

Results/Discussion

Species Composition

A total of eight fish species were observed during sampling efforts on Alkali Lake (Table 3). Warmwater gamefish comprised 80.0 percent of the total fish captured and 85 percent of the total biomass. Largemouth bass was the most abundant species (38.4%) sampled and contributed the highest proportion of biomass (50.3%). Lahontan cutthroat comprised the remaining 20 percent of the fish sampled in Alkali lake, and were the second most abundant species captured. Although less abundant, smallmouth bass comprised 20.5 percent of the total biomass sampled.

Table 3. Species composition by weight, number, and size range of fish captured at Alkali Lake during a warmwater fish survey in May, 1999.

Type of Fish	Species Composition					
	Weight		Number		Size Range (mm TL)	
	kg	%	No.	%	Min.	Max.
Black crappie	1.50	3.81	15	7.14	127	205
Bluegill	2.41	6.10	25	11.90	118	171
Channel catfish	0.60	1.51	10	4.76	134	335
Lahontan cutthroat	5.97	15.14	42	20.00	178	420
Largemouth bass	19.90	50.45	88	41.90	77	451
Pumpkinseed sunfish	0.80	2.02	19	9.05	67	136
Smallmouth bass	8.09	20.50	10	4.76	333	397
Yellow perch	0.19	0.47	1	0.48	239	239

With the exception of rainbow trout, all species were sampled in proportions relative to which they were stocked. The overall number of fish sampled in Alkali Lake was low in comparison to the number stocked. Rainbow trout were the second-most abundant species stocked (10,187 total in 1997 and 1998) (Table 1) but were not observed in our samples. This may be explained, in part, by angler exploitation, predation, warm water temperatures and low dissolved oxygen levels in the summer. Excessive temperatures and low dissolved oxygen were found to be a problem during the late 1960's which led to the demise of WDFW's trout management efforts in Alkali Lake (WDFW 1996a). Since Lahontan cutthroat were stocked in numbers (10,056 total in 1997 and 1998) similar to rainbow trout (Table 1), we would have expected to sample equal numbers of each species. Largemouth bass were both the most abundant species stocked during 1997 and 1998, and the most abundant species observed in our samples. The majority of these fish were stocked as fry, which exhibit high mortality. Given the fact that Alkali Lake was recently rehabilitated and that approximately 75 percent of the shoreline was sampled by electrofishing, we would expect this number to be higher.

Catch Per Unit Effort (CPUE)

Whether using active (electrofishing) or passive (gill netting or fyke netting) techniques to sample a lake or reservoir, CPUE can be a useful index to monitor size structure and relative abundance (Hubert 1996). Past data collection efforts on Alkali Lake have been sporadic. This information will be used as a baseline which will allow fishery managers to monitor the effectiveness of future management techniques used on the lake.

Overall, more fish were captured by electrofishing in Alkali Lake than by gill or fyke nets. Electrofishing catch rates of warmwater species were highest on largemouth bass (28.7 fish/hr) and bluegill (10.0 fish/hr) (Table 4). Gill netting and fyke netting catch rates of warmwater species were highest on largemouth bass (0.7 fish/net-night) and black crappie (1.7 fish/net-night) (Table 4). Gill nets also captured Lahontan cutthroat trout at a rate of 5.2 fish/net-night, the highest catch rate of all species captured by gill netting.

Table 4. Mean catch per unit effort by sampling method, including 80 percent confidence intervals (CI), for fish collected from Alkali Lake in May, 1999.

Species	Gear Type								
	Electrofishing			Gill Netting			Fyke Netting		
	No. Hour	CI (+/-)	No. Sites	No. Night	CI (+/-)	Net Nights	No. Night	CI (+/-)	Net Nights
Black crappie	1.59	1.18	15	0.00	—	6	1.67	1.50	6
Bluegill	10.00	6.86	15	0.00	—	6	0.00	—	6
Channel catfish	0.40	0.51	15	0.00	—	6	0.00	—	6
Lahontan cutthroat	4.40	2.54	15	5.17	2.49	6	0.00	—	6
Largemouth bass	28.74	7.03	15	0.67	0.54	6	0.00	—	6
Pumpkinseed sunfish	4.80	2.28	15	0.50	0.44	6	0.50	0.64	6
Smallmouth bass	2.77	2.07	15	0.50	0.64	6	0.00	—	6
Yellow perch	0.40	0.51	15	0.00	—	6	0.00	—	6

With few exceptions, electrofishing captured the same size fish as did gill and fyke nets (refer to length-frequency histograms under species sections). Some species, such as walleye and yellow perch, inhabit littoral areas as juveniles and tend to be sampled more effectively by electrofishing. Similarly, these same species inhabit pelagic water as adults and, thus, are sampled more effectively using gill nets. Walleye were not observed in our samples and yellow perch were sampled in very low numbers (n = 1). Had these pelagic species been more prevalent in Alkali Lake, larger individuals would have probably dominated our gill net samples. Likewise, juveniles from these species would more likely have dominated samples collected near shore by electrofishing. In addition, most species were sampled in low numbers. If the sample size were larger, differences in the sizes of fish sampled by electrofishing, gill netting, and fyke netting may have been shown more clearly.

Stock Density Indices

A total of 43 stock length largemouth bass, and 25 stock length bluegill were sampled by electrofishing (Table 5). The PSD's of largemouth bass and bluegill were 16 ± 7 and 64 ± 12, respectively. Of the stock length largemouth bass, 16 percent were of preferred size.

Table 5. Stock density indices, including 80 percent confidence interval, for warmwater fishes collected by electrofishing, gill netting, and fyke netting in Alkali Lake (Grant County) during May,1999. PSD = proportional stock density, RSD = relative stock density, RSD-P = relative stock density of preferred fish, RSD-M = relative stock density of memorable fish, and RSD-T = relative stock density of trophy fish.

Species	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Black crappie	4	75 ± 28	0	0	0
Bluegill	25	64 ± 12	0	0	0
Largemouth bass	43	16 ± 7	16 ± 7	0	0
Smallmouth bass	7	100	71 ± 22	0	0
		Gill Netting			
Largemouth bass	4	75 ± 28	50 ± 32	0	0
Smallmouth bass	3	100	67 ± 35	0	0
		Fyke Netting			
Black crappie	10	10 ± 12	0	0	0

The sample size of stock length fish in our samples were below the minimum required (n = 55) for a sound PSD estimate (Bonar et al. 2000). Because of low sample sizes, the PSD estimates calculated were suspect and should be viewed accordingly. Moreover, Alkali Lake was rehabilitated in the fall of 1996, and stocked in 1997 and 1998. Most of the fish collected, with the exception of age 1 largemouth bass, were most likely stocked as adults and fry following the rehabilitation and did not represent annual fish production and growth. As a result, the utility of the stock density indices was less than optimum under these circumstances.

Water Chemistry

Alkali Lake was relatively homogeneous in terms of temperature, dissolved oxygen, pH, and conductivity throughout the entire water column (Table 6). This probably relates to the time of sampling. Water quality was sampled in May and the lake had not yet been influenced by warm summer temperatures that can contribute to low dissolved oxygen concentrations and lead to thermal stratification. Historically, Alkali Lake exhibited pH levels too alkaline to support fish populations. Alkali Lake pH levels recorded in May 1999 were slightly higher than levels (6.5 - 9.0) desired by warmwater fish species (Swingle 1969). Nonetheless, water quality did not appear to be limiting warmwater species' ability to maintain good health and growth. Water temperature varied only slightly, ranging from approximately 12.5 to 12.9EC. Similarly, dissolved oxygen ranged from approximately 11.4 to 12.8 mg/l. These parameters were measured only once. Although these data can be used as a baseline, numerous measurements must be made annually at more locations to fully understand the water quality dynamics of Alkali Lake.

Table 6. Water quality data from Alkali Lake collected during a warmwater fish survey in May, 1999.

Location	Depth (m)	Temp (C)	pH	Dissolved O2	Conductivity
Center lake	0.1	12.84	9.68	11.78	447.2
	1	12.87	9.69	11.4	447.1
	2	12.56	9.73	11.91	445.7
	3	12.48	9.78	12.86	444.7

Largemouth Bass

Largemouth bass ranged in age from 1 to 8 years with age 2 being the most abundant (Table 7, Figure 1). Most growth of ages 3 through 8 largemouth bass was achieved in the waters from which they were collected prior to stocking. Largemouth bass reproduction and survival was evident with the presence of age 1 fish, while age 2 largemouth bass might have been those stocked as fry in 1997 (n = 10,800). Adult largemouth bass (n = 158) were stocked in Alkali Lake in early May 1997. If spawning occurred by these fish in 1997, the age 2 fish that were observed may be a combination of in-lake production and fry stocking. Additionally, the number of adult largemouth bass stocked in 1997 was sufficient to have produced a higher number of age 1 fish than was observed in our samples. All other age classes appear to be those largemouth bass stocked as adults and fry following the rehabilitation in 1996 and do not represent annual fish production and growth from Alkali Lake. Largemouth bass were the most abundant species in our samples (38.4%). Due to the low number of prey species (i.e., bluegill, black crappie), some cannibalization by larger bass might have occurred. As the prey base continues to develop, we expect largemouth bass survival to improve.

Total lengths of largemouth bass sampled at Alkali Lake ranged from 77 to 451 mm (Table 3, Figure 2). Overall, largemouth bass exhibited above average condition (Figure 3). Few fish had relative weights less than 90. Condition of age 1 and 2 largemouth bass, whether hatched in Alkali Lake or stocked as fry, were above average. This indicated that these age classes were not limited by food or fish density. Largemouth bass ages 3 and older were in above average condition, however, the initial condition of these fish stocked as sub-adults and adults is uncertain.

Table 7. Age and growth of largemouth bass captured at Alkali Lake during May, 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

Year Class	# Fish	Mean length (mm) at age 1	2	3	4	5	6	7	8
1998	28	106.3							
		107.3							
1997	36	104.4	206.4						
		114.8	207.5						
1996	2	118.6	187.4	217.7					
		128.3	190.9	218.5					
1995	1	57.1	164.9	323.2	365.7				
		74.1	176.2	326.3	366.5				
1994	2	88.4	166.2	304.4	362.9	401.9			
		104.1	178.2	309.5	365.2	402.3			
1993	2	98.3	210.3	296.7	352.2	400.0	422.2		
		113.8	220.7	303.2	356.2	401.8	423.0		
1992	1	86.8	184.6	243.7	302.8	345.2	380.3	409.8	
		102.8	196.1	252.4	308.8	349.2	382.7	410.9	
1991	1	145.9	190.3	221.7	260.5	315.9	371.3	406.4	434.2
		159.3	201.6	231.5	268.5	321.4	374.3	407.8	434.2
Overall mean		104.6	202.2	269.6	337.0	377.5	399.0	408.1	434.2
		119.9	205.0	274.7	341.0	379.8	400.8	409.3	434.2
E. Washington Average		68.8	135.6	189.2	248.9	300.0	351.5	421.6	437.6

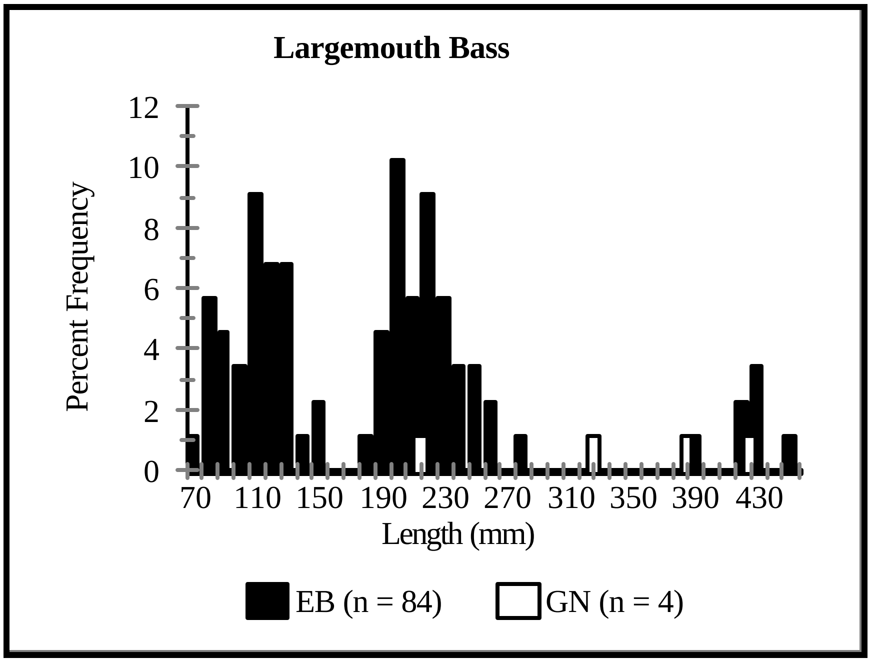

Figure 2. Length frequency distribution of largemouth bass sampled by electrofishing (EB) and gill netting (GN) in Alkali Lake during May, 1999.

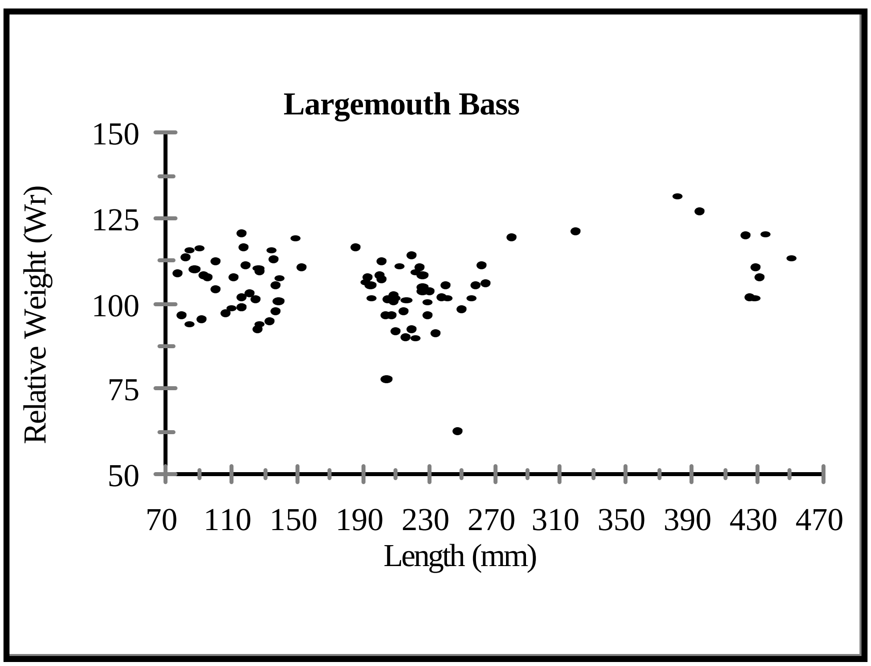

Figure 3. Relative weights of largemouth bass sampled (n = 88) at Alkali Lake during May, 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Smallmouth Bass

Smallmouth bass were sampled from Alkali Lake in low numbers (n = 10) (Table 3). This was expected, given the fact that only 11 adults and 133 juveniles were stocked in 1997. Smallmouth bass ranged in age from 3 to 8 years with age 5 fish (n = 3) being the most abundant (Table 8). Back-calculated lengths-at-age indicate that smallmouth bass from Alkali Lake were shorter than the Eastern Washington average at all ages (Table 8), although most growth was achieved in the water from where they were collected prior to stocking. The absence of YOY and age 1 smallmouth bass in our samples indicates reproduction has not occurred. We expected some age 1 fish from the adults that were stocked in 1997 even though stocked numbers were low. Since smallmouth bass were stocked in July 1997, absence of age 2 fish was as expected.

Table 8. Age and growth of smallmouth bass captured at Alkali Lake during May, 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean length (mm) at age							
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1998	0	—							
1997	0	—	—						
1996	1	64.5	172.5	294.5					
		92.9	190.0	299.6					
1995	1	83.7	135.8	223.2	331.1				
		109.9	156.5	234.8	331.3				
1994	3	47.5	98.5	149.2	264.7	349.5			
		78.0	124.1	170.0	274.4	351.1			
1993	0	—	—	—	—	—	—		
1992	1	28.7	70.8	99.5	151.2	195.2	287.1	373.2	
		61.0	99.2	125.3	172.1	212.1	295.4	373.5	
1991	2	23.8	45.8	73.7	112.1	160.5	249.5	321.5	385.6
		56.6	76.7	102.0	137.0	181.0	261.9	327.5	385.8
Overall mean		45.9	95.8	151.5	214.4	260.8	262.0	338.7	385.6
		76.4	121.5	171.7	228.7	271.2	273.1	342.8	385.8
E. Washington Average		68.8	135.6	189.2	248.9	300.0	351.5	421.6	437.6

Fingerling smallmouth bass were stocked at 7 fish per pound (65 grams each). These fish were collected from Hayden Lake in northern Idaho, and when compared to smallmouth bass of similar weights collected from Palmer Lake, Washington (Osborne et al. in prep), we estimate their average age at 2 to 3 years. Smallmouth do not spawn until at least age 3 (Wydoski and Whitney

1979), therefore we expected a few of the smallmouth bass stocked as fingerlings in 1997 to have contributed to reproduction in 1998.   All other age classes appear to be those smallmouth bass stocked as adults and juveniles following the rehabilitation in 1996 and do not represent annual fish production from Alkali Lake.

Total lengths of smallmouth bass sampled at Alkali Lake ranged from 333 to 397 mm (Table 3, Figure 4). Smallmouth bass appeared to be in good condition with few fish having relative weights less than 100 (Figure 5). Since the sample size of smallmouth bass was low, analyses of age and growth, stock density, and relative weight indices may have little reliability.

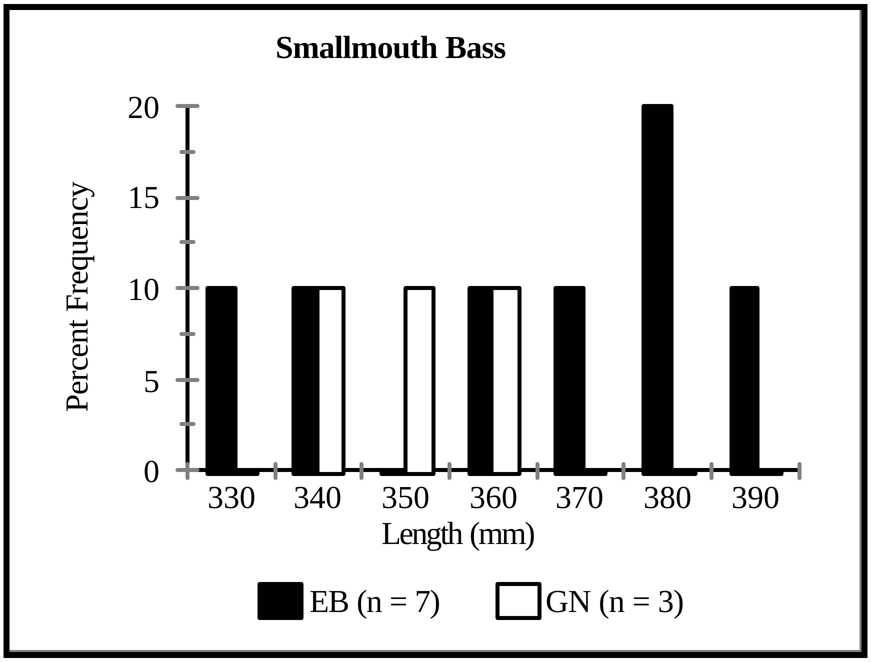

Figure 4. Length frequency distribution of smallmouth bass sampled by electrofishing (EB) and gill netting (GN) in Alkali Lake during May, 1999.

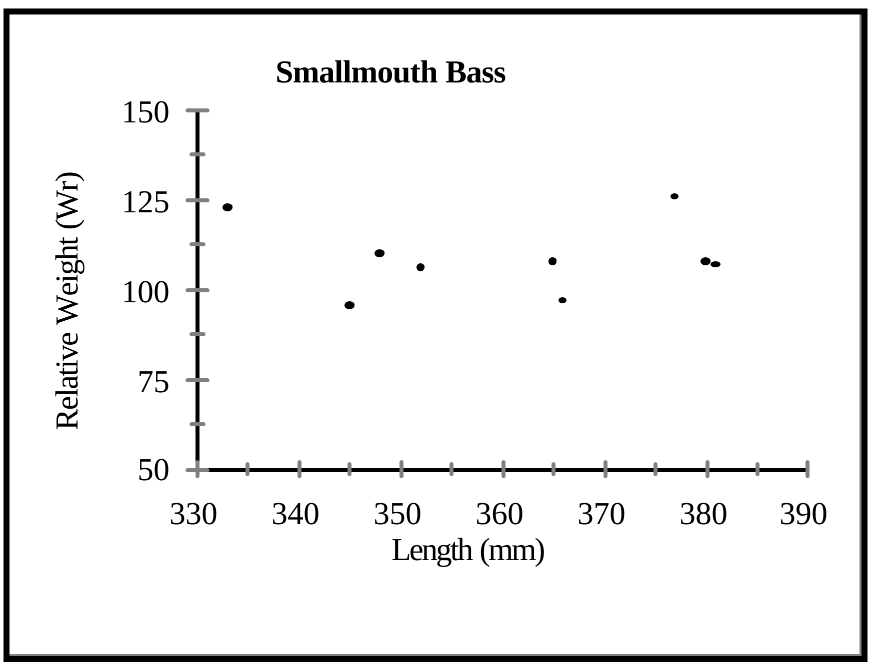

Figure 5. Relative weights of smallmouth bass sampled (n = 10) at Alkali Lake during May, 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Bluegill

A total of 25 bluegill were sampled at Alkali Lake in 1999 (Table 3), all by electrofishing. Although bluegill were stocked in 1997 as fry (n = 6,028)(Table 1) which suffer high mortality, the numbers collected were expected to be higher. Since Alkali Lake was recently rehabilitated (fall 1996), fish stocked in low numbers should experience low levels of competition for food, space and allow higher survival. Bluegill ranged in age from 2 to 3 years with age 2 fish being the most abundant (Table 9). No YOY or age 1 bluegill were observed. This was expected, as bluegill were stocked as fry in 1997 and usually do not mature until 2 or 3 years of age (Wydoski and Whitney 1979). Since bluegill usually begin to spawn in late spring (late May - June), even the most mature fish would not have spawned at the time of our survey (early May). Age 2 bluegill appeared to be those stocked as fry following the rehabilitation in 1996 and do not represent fish produced in Alkali Lake. However, we did not expect to observe age 3 bluegill in Alkali Lake. Age 3 bluegill were most likely those that either survived the rehabilitation or were age 1 fish stocked incidentally with fry in 1997.

Table 9. Age and growth of bluegill captured at Alkali Lake during May, 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean length (mm) at age		
Year Class	**# Fish**	**1**	**2**	**3**
1998	0	—		
1997	16	65.1	132.3	
		76.5	134.7	
1996	4	61.0	108.4	146.1
		73.3	114.4	147.4
Overall mean		64.3	127.5	146.1
		75.9	130.6	147.4
Statewide Average		37.3	96.8	132.1

Growth of Alkali Lake bluegill was above the statewide average at both ages. Total lengths of bluegill sampled at Alkali Lake ranged from 118 to 171 mm (Table 3, Figure 6). Bluegill sampled from Alkali Lake were in above average condition indicating these age classes are not limited by food or density. No fish were observed with relative weights less than 100 (Figure 7). We observed numerous bluegill with robust bellies and believe these fish had reached maturity and likely spawned in 1999. Sample size for bluegill was also low, therefore stock density and relative weight indices may be unreliable.

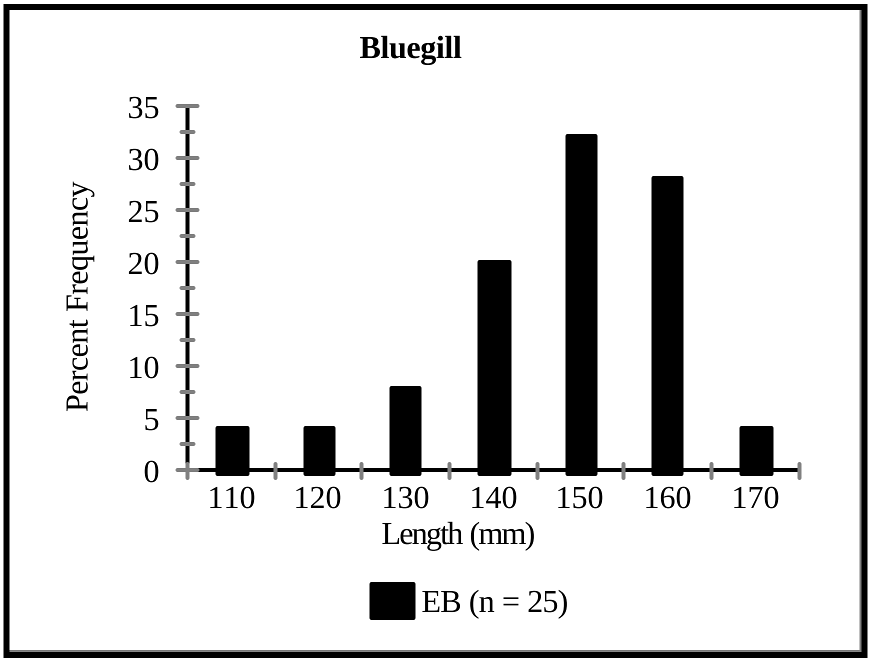

Figure 6. Length frequency distribution of bluegill sampled by electrofishing (EB) in Alkali Lake during May, 1999.

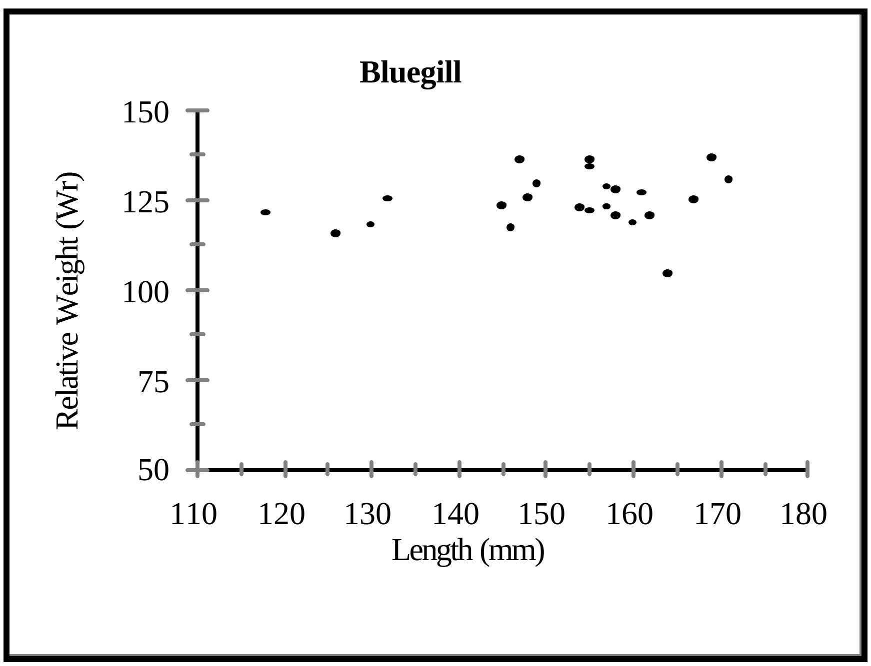

Figure 7. Relative weights of bluegill sampled (n = 25) at Alkali Lake during May, 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Black Crappie

A total of 15 black crappie were sampled at Alkali Lake in 1999 (Table 3). Black crappie were stocked in Alkali Lake as adults (n = 230) and fry (n = 6,732) in 1997 and as fingerlings (n = 150) prior to our survey in 1999 (Table 1). While fry exhibit high mortality, we expected to collect higher numbers of age 2 fish. Additionally, no age 1 black crappie were observed. Age 1 black crappie were expected in our samples, as adults stocked in 1997 should have reproduced in 1998. Although no evidence of previous reproduction was observed, several black crappie exhibited signs of sexual maturity (robust bellies) and reproduction was expected in 1999. Black crappie ranged in age from 2 to 4 years (Table 10) and appeared to be those stocked following the rehabilitation. Alkali Lake black crappie were longer than the Eastern Washington average at all ages, however, the sample size was too small for an accurate age and growth analysis.

Table 10. Age and growth of black crappie captured at Alkali Lake during May, 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean length (mm) at age			
Year Class	**# Fish**	**1**	**2**	**3**	**4**
1998	0	—			
1997	1	50.8	146.3		
		74.4	148.5		
1996	1	96.4	162.4	203.0	
		114.8	169.4	203.0	
1995	1	30.3	91.0	162.9	200.0
		60.0	110.1	169.4	200.0
Overall mean		59.2	133.2	183.0	200.0
		83.1	142.7	186.2	200.0
E. Washington Average		46	111.2	156.7	183.4

Total lengths of black crappie in Alkali Lake ranged from 127 to 205 mm (Table 3, Figure 8). Fyke nets were the most effective method for sampling black crappie, collecting 73 percent (n = 11) of the sample. The remaining 27 percent (n = 4) were captured by electrofishing. Black crappie from Alkali Lake were in above average condition indicating these fish are not limited by food or density. Only one fish had a relative weight less than 100 (Figure 9). As mentioned previously with other fish species, our sample size for black crappie was low, thus analyses such as age and growth, stock density, and relative weight indices may be unreliable.

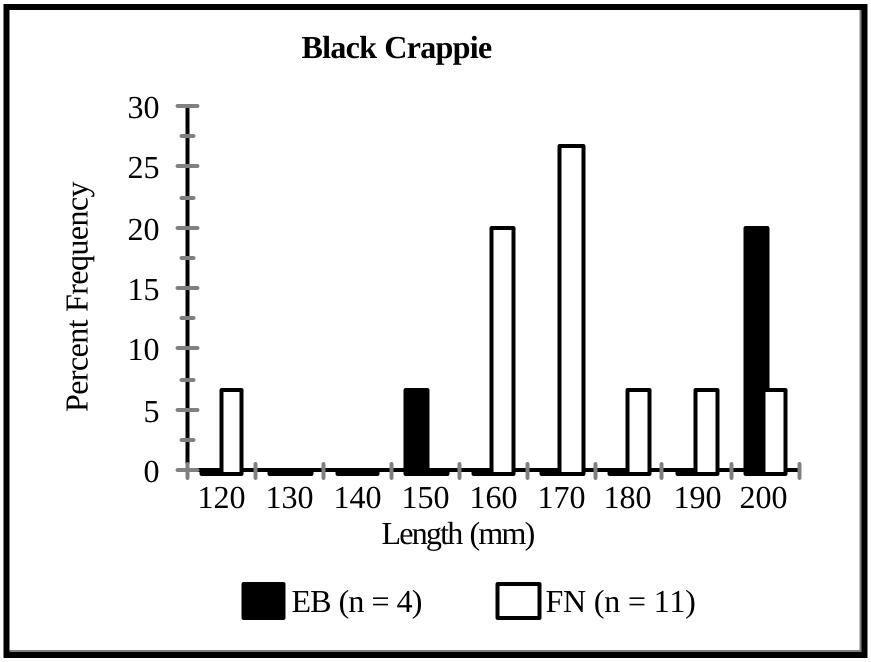

Figure 8. Length frequency distribution of black crappie sampled by electrofishing (EB) and fyke netting (FN) in Alkali Lake during May, 1999.

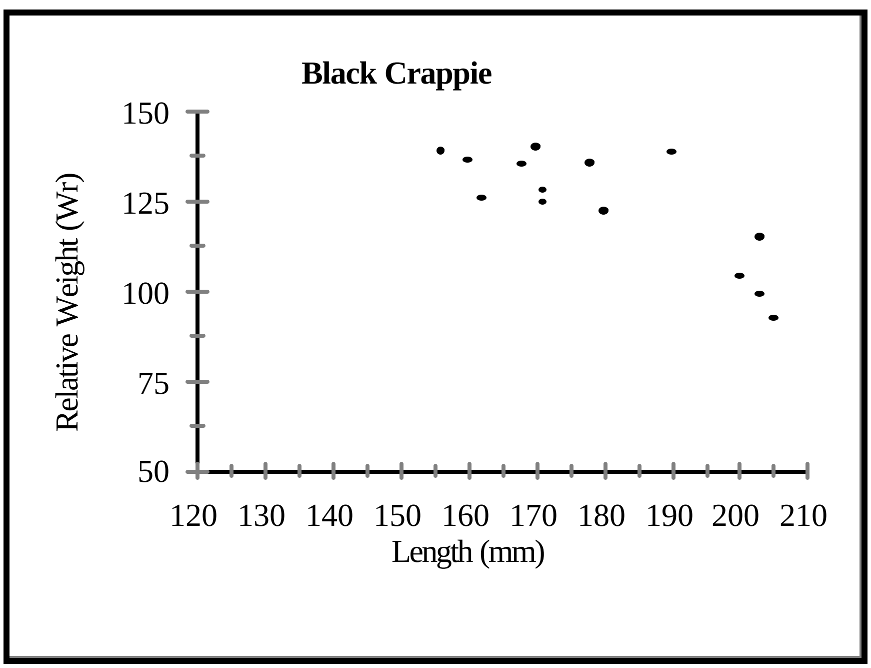

Figure 9. Relative weights of black crappie sampled (n = 14) at Alkali Lake during May 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Channel Catfish

Of the 4,510 channel catfish stocked into Alkali Lake as fingerlings in 1997 and 1998 (Table 1), a total of 10 were sampled in 1999 (Table 3). All channel catfish were collected by electrofishing. This might be expected given that smaller fish, inhabiting deeper water, might not be susceptible to the larger mesh of experimental gill nets. The majority of channel catfish were sampled along steep, rocky shoreline in approximately 6 feet of water. Since less than 25 percent of Alkali Lake's shoreline is of this type, and only 6 gill net-nights of effort were expended, areas preferred by channel catfish may not have been sampled by gill netting. Additionally, channel catfish were stocked into Alkali Lake as fingerlings which might explain the low number observed. Channel catfish less than 200 mm are vulnerable to predation (Heidinger 1999) and might have been preyed heavily upon by the largemouth and smallmouth bass in the lake. Total lengths of channel catfish ranged from 134 to 335 mm, but only one was greater than 166 mm in length. Although we did not analyze age and growth, the channel catfish were most likely stocked in Alkali Lake as fingerlings in 1997 and 1998 following the rehabilitation in 1996. Channel catfish comprised 4.8 percent of the total number of fish sampled and 1.5 percent of the total biomass.

Lahontan Cutthroat and Rainbow Trout

Lahontan cutthroat trout were stocked in Alkali Lake as fry (n = 5,040) in 1997 and as fingerlings (n = 5,016) in 1998 (Table 1). A total of 42 Lahontan cutthroat trout, ranging from 178 to 420 mm, were collected in the 1999 survey. Rainbow trout were stocked in Alkali Lake as fingerlings (n= 5,180) in 1997, and as advanced fingerlings (n= 5,007) in 1998. Rainbow trout were not observed in the 1999 survey. Natural reproduction of Lahontan cutthroat or rainbow trout in Alkali Lake is not expected. These species are frequently stocked in recently rehabilitated warmwater lakes to provided angling opportunities until warmwater fish populations become established.

Pumpkinseed Sunfish and Yellow Perch

A total of 19 pumpkinseed and 1 yellow perch were collected at Alkali Lake in 1999 (Table 3). Scale samples were not collected for either species and age and growth information were not investigated. Total lengths of pumpkinseed ranged from 67 to 136 mm (Table 3). Pumpkinseed comprised 9.1 percent (n = 19) of the total number of fish sampled and 2.0 percent of the total biomass (Table 3). Pumpkinseed sunfish were not stocked in Alkali Lake and most likely survived the rehabilitation effort.

Based on low numbers of these species in our samples, the fall 1996 rehabilitation appears to have been successful initially. The presence of pumpkinseed and yellow perch indicate that future benefits of the rehabilitation will depend upon how long their populations remain low.

Additional Fish Stocking

The information presented thus far in this report is based on the warmwater fish survey conducted between May 10-12, 1999, and focuses, primarily, on populations of fish stocked in Alkali Lake since the fall 1996 rehabilitation. Additional fish stocking has occurred since the spring 1999 survey (Table 11) and must be considered in order to develop viable management strategies (discussed later in this report). However, the following discussions of growth, reproduction, and other dynamics of fish populations stocked since the spring 1999 survey are inferences only, and verification of these statements awaits further investigation.

Table 11. Fish stocked in Alkali Lake between spring 1999 (following warmwater fish survey, May 10-12) and fall 2000.

Year	Species	Size	Number
1999	largemouth bass	adults	5
		juveniles	434
	black crappie	adults	1,692
		juveniles	5
	bluegill	adults	43
		juveniles	628
		fry	19,440
	white crappie	adults	49
		juveniles	5
2000	largemouth bass	adults	600
		juveniles	510
	bluegill	adults	728
		fry	54,629
	rainbow trout	fry	49,720

From the largemouth bass stocked as adults since the 1999 survey in Alkali Lake, those previously stocked as adults, or those which matured after being stocked, natural reproduction likely occurred in 1999 and 2000. Since Alkali Lake has been recently rehabilitated, contains a relatively low density of largemouth bass, and has been stocked with reasonable numbers of panfish, the largemouth bass stocked in 1999 and 2000 should exhibit above average growth rates.

A total of 771 adult bluegill were stocked in Alkali Lake since the 1999 survey (Table 11). These fish, combined with those stocked as juveniles (431) and fry (25,468) since the 1996 rehabilitation, should contribute to reproduction in 2001. Although the current density of bluegill is likely higher than what was found in the 1999 survey, we expect growth of those stocked in 1999 and 2000 to be above average because fish densities are still low.

Although adult black crappie (n = 230) were stocked prior to the 1999 survey, natural reproduction was not observed. However, the 1,692 adult crappie stocked in Alkali Lake later in 1999 should contribute significantly to the spawning population. As with the largemouth bass and bluegill, growth rates of juvenile crappie stocked since the 1999 survey are expected to be above average due to the recent rehabilitation and low density of black crappie in the lake.

A total of 49,720 rainbow trout fry were stocked in Alkali Lake in March 2000. Although Alkali lake is not currently managed as a trout fishery, these fish were available for stocking due to a hatchery surplus and were intended to provide additional angling opportunity in fall 2000. Because of the additional stocking of warmwater fish in Alkali Lake in 1999 and 2000, low survival of these fish was expected due to predation. However, angler correspondence indicated that these fish produced an above average trout fishery during the winter of 2000 and spring 2001.

To date (including 1999 and 2000), a total of 12,766 bass (smallmouth and largemouth) and 77,653 panfish (bluegill, white and black crappie) have been stocked into Alkali Lake since the fall 1996 rehabilitation. The overall ratio of panfish to bass stocked in Alkali Lake since the fall 1996 rehabilitation was 9 to 1 and includes fish stocked as adults, fingerlings, and fry. Swingle (1951) obtained the highest average standing crop of harvestable size bass when bluegill fingerlings and largemouth bass fingerlings were stocked in fertilized ponds at a ratio of 10 to 1. Since proportions of panfish and bass stocked in Alkali Lake were similar to those used by Swingle (1951), Alkali Lake might produce a high standing crop of harvestable size bass which may result in fewer, but larger, panfish. Proportions of largemouth bass and panfish should play a relevant role in determining future management and stocking objectives for Alkali Lake.

Conclusions and Management Options

Largemouth bass were the most abundant species collected and the only fish species stocked in Alkali Lake found to be naturally reproducing. Several largemouth bass nests were observed during sampling efforts indicating that spawning should have occurred in 1999. With an additional 605 adults stocked in 1999 and 2000, reproduction most likely occurred at higher rates than prior to our 1999 survey. All other fish species found, with the exception of pumpkinseed and yellow perch, were those believed to be stocked following the 1996 rehabilitation. Pumpkinseed and yellow perch were found in low numbers indicating the 1996 rehabilitation was successful. Besides pumpkinseed and yellow perch, no other unwanted fish species were observed in Alkali Lake. Because most species were found in low abundance, angler exploitation was not likely a factor. Growth and condition of all fish species sampled appeared to be above average, including those stocked as fry and fingerlings in 1997 and 1998.

As with largemouth bass, smallmouth bass were observed near nests and were expected to spawn in 1999. Wydoski and Whitney (1979) reported that smallmouth bass usually mature at 3 to 4 years of age. Age and growth data indicate that smallmouth bass in Alkali Lake were mature enough to spawn in 1998, however, evidence of juvenile survival was not observed. Smallmouth bass were not stocked since the 1999 survey, and their numbers are expected to remain low compared to largemouth bass.

Bluegill generally reach maturity at 2 to 3 years of age (Wydoski and Whitney, 1979). Based on age and growth data and physical observation of bluegill sampled, bluegill could begin spawning in 1999. A combined 771 adults and 628 juveniles were stocked in 1999 and 2000. These fish should contribute to higher levels of natural reproduction than which might have occurred in 1999.

Although previous rehabilitations have been successful in reducing numbers of unwanted species, yellow perch and pumpkinseed are again present in Alkali Lake. Overpopulation of unwanted species often occurs in lakes having low predator abundance or improper predator size structure. Funding priority should be elevated for restocking rehabilitated lakes. At present levels, replacement are seldom acquired in sufficient numbers and/or sizes to facilitate balance of the fish communities in the lakes. If replacement fish were available in the size and quantity requested, populations of unwanted species could be held at manageable levels and anglers could witness immediate benefits.

Management strategies should be developed in response to the Warmwater Gamefish Enhancement Program's goal of increasing opportunities to fish for and catch warmwater gamefish. Current management objectives for Alkali Lake include managing the lake for bluegill and largemouth bass (WDFW 1996b). The following options address the objectives and provide detail for managing Alkali Lake for either panfish or both panfish and largemouth bass.

Option 1: Panfish option

This option requires the protection of all largemouth bass 15 inches in length and smaller, with a daily harvest limit of no more than 1 largemouth bass greater than 15 inches in length. Additionally, current panfish regulations for Alkali Lake would be maintained; no daily limit but no more than 5 black crappie exceeding 8 inches in length, and no more than 5 bluegill exceeding 6 inches in length could be retained per day. Regular warmwater surveys will be required to monitor the balance of panfish and largemouth bass for this option to be successful.

As with many of the lakes in the Columbia Basin, over-population of pumpkinseed and yellow perch in Alkali Lake is common. Overpopulation of these species often results in stunted panfish populations and can limit recruitment of largemouth bass. Although most previous rehabilitations have been successful, eventual overpopulation of both desirable and undesirable panfish have forced further treatments. The panfish option is designed to prevent over-population of panfish by maintaining a high density of largemouth bass less than 15 inches (Flickinger et al. 1999) thus allowing increased panfish growth. Although minimum length limits have been found to increase catch rates (Wilde 1996), angler satisfaction may sometimes be sacrificed due to the increased number of smaller bass in the lake (Flickinger et al. 1999).

The success of this option is governed by the adherence by anglers to the largemouth bass minimum size harvest restriction. Stocking should be suspended until population monitoring warrants the addition of largemouth bass or panfish in the future. In-lake production may produce the preferred size structure of largemouth bass and panfish and supplementation may not be necessary.

Option 2: Largemouth bass and panfish option

This option continues with the current slot-length limit regulation on largemouth bass of a daily limit of 5 bass less than 12 inches or greater than 17 inches in length, with no more than 1 over 17 inches in length being retained. Current panfish regulations, as defined in Option 1, would remain in effect. As with Option 1, regular warmwater surveys will be required to monitor the balance of panfish and largemouth bass in Alkali Lake.

Option 2 is similar to Option 1 in that both attempt to prevent overpopulation of panfish. However, the largemouth bass and panfish option allows anglers to harvest bass under 12 inches in length which would not be allowed under the panfish option. Managing a lake under a slot-length limit would protect sizes of largemouth bass that are highly predacious on panfish. It has been found that, in some cases, slot-length limits have failed to restructure largemouth bass populations due to lack of harvest of bass below the lower limit of the protected size range (Wilde 1996). In these cases, the slot-length limit acts as a minimum-length limit described in Option 1. Wilde

(1996) reported that slot-length limits are useful in restructuring largemouth bass populations but often fail to increase angler catch rates. As with Option 1, no additional stocking of largemouth bass and panfish should occur until future monitoring warrants such.

In conclusion, Option 1 and 2 could both be used in an attempt to reduce panfish density, although each have their limitations. Option 1 (panfish) emphasizes larger panfish size structure and increases catch rates of largemouth bass, while allowing harvest of some larger size bass. Option 2 (largemouth bass and panfish) is similar to Option 1 in that it would enable panfish to grow to larger sizes but would also allow anglers to harvest small bass from the lake. Although fishery managers would prefer to increase angler catch rates and restructure largemouth bass populations, minimum-length (Option 1) and slot-length (Option 2) limits seldom accomplish both (Wilde 1996).

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Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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