STATE OF WASHINGTON March 2007

2006 Warmwater Fisheries Survey of Whitestone Lake, Okanogan County, Washington

Warmwater Fish Enhancement

by Marc R. Petersen and Michael R. Schmuck

Washington Department of
FISH AND WILDLIFE
Fish Program
Fish Management Division

FPT 07-06

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Abstract

A three-person team surveyed Whitestone Lake September 18-21, 2006. A total of 7 fish species were collected during the survey, of which bluegill *Lepomis macrochirus* and largemouth bass *Micropterus salmoides* were the most abundant, respectively. The largemouth bass fishery in Whitestone Lake is similar to the outcome sought under a big bass management option (Willis et al. 1993). Under the big bass option, largemouth bass Proportional Stock Density (PSD) should be 50 to 80 and bluegill PSD should be 10 to 50. During 2006, largemouth bass were above and bluegill were below the big bass standard for stock density. The number of largemouth bass collected in 2006 greater than 300 mm in length increased from findings of the 2000 warmwater survey (Osborne and Petersen 2001), raising the PSD value. Bluegill density was high, and growth and condition were below average. Overall, largemouth bass in Whitestone Lake were numerous at larger sizes, sparse at smaller sizes, and bluegill displayed characteristics of a stunted population.

Yellow perch *Perca flavescens*, pumpkinseed sunfish *L. gibbosus*, black crappie *Pomoxis nigromaculatus*, and carp *Cyprinus carpio* were collected in lower numbers, but similar abundance wise to the 2000 survey. The abundance of channel catfish collected during 2006 increase significantly since the 2000 survey, their first observation since stocking began in 1997. Channel catfish have been successful in adapting to Whitestone Lake and should provide anglers with an excellent opportunity to harvest large fish.

We recommend the stocking of additional largemouth bass, mechanical removal of bluegill, continued stocking of channel catfish, and removal of carp while performing future management actions.

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Introduction and Background

Whitestone Lake is located in the Okanogan River drainage approximately 5.7 miles northwest of Tonasket, Washington in Okanogan County (Figure 1). The lake, which is used primarily for irrigation, has a surface area of 70 hectares (ha)(173 acres) and a maximum depth of approximately 7.6 meters (m)(25 feet). The basin (Whitestone Flats) lies about 4 kilometers (km)(2.5 miles) southeast and approximately 34 m (113 feet) below (elevation) Spectacle Lake, which supports Whitestone Lake through underground seepage (Heather Bartlett, Washington Department of Fish and Wildlife (WDFW), personal communication). Whitestone Lake originates from springs located in a 32 ha (80 acre) cattail *Typha spp.* marsh at the northwest end which contributes an estimated 1.5 cubic feet per second (cfs) of accumulated inflow.

Whitestone Lake is a natural lake, although a small outlet dam was constructed in the 1920's by the Whitestone Reclamation District (WRD) as part of the Whitestone Project (Jerry Barnes, WRD, personal communication) which increased the lake's volume by approximately 20%. Although the current volume of water (2,144 acre-feet) is the maximum amount that can be impounded by the dam, the WRD possesses a storage right of 3,144 acre-feet. To utilize its full storage right, WRD would have to construct a new outlet dam and dikes and address problems associated with inundating a county road (Loomis-Oroville Road), portions of orchards, and a few residences (Heather Bartlett, WDFW, personal communication). In 1986, WRD installed a spillway on the outlet dam to prevent hydraulic erosion. In addition, a concrete drop structure was installed about 1 km downstream from the dam to prevent upstream migration of non-game fish species.

Until the mid-1960's, Whitestone Lake was managed as a rainbow trout *Oncorhynchus mykiss* fishery. Due to the lake's shallow depth, summer fish kills were common and most trout were harvested during the winter. WDFW rehabilitated Whitestone Lake in 1954, 1959, and 1965 to alleviate warmwater fish populations. Although most of the rehabilitation efforts were successful, repeated unauthorized introductions of warmwater fish species influenced the decision to manage the lake as a warmwater fishery (Williams 1979). WDFW introduced smallmouth bass *Micropterus dolomieu* to the lake in 1972 and largemouth bass *M. salmoides* in 1973 (Table 1) in an attempt to selectively control the black crappie *Pomoxis nigromaculatus* population. The smallmouth bass were collected from the Columbia River near Hanford and the largemouth bass were collected from Big Goose Lake on the Colville Indian Reservation (Heather Bartlett, WDFW, personal communication). Although their origin is unknown, black crappie and brown bullhead *Ictalurus nebulosus* existed many years prior to the bass introductions. In 1978, angler creel surveys indicated that black crappie size were increasing and that a substantial bass fishery had yet to materialize, although bass ranging from 7 to 9 inches were abundant. In 1979, increased size of black crappie was apparent and larger size bass began to enter the fishery (Williams 1979). Bluegill *Lepomis macrochirus* were introduced to the lake in 1988 (Table 1).

Currently, anglers are allowed to fish the lake year round. Bass are protected by a slot-length limit regulation which allows anglers to harvest five bass per day less than 12 inches to include no more than one bass over 17 inches in length. Anglers are also allowed to harvest 5 channel catfish *I. punctatus* per day. Other gamefish fall under statewide regulations, no minimum size or daily bag limit (yellow perch *Perca flavescens*, pumpkinseed *L. gibbosus*, black crappie, and brown bullhead).

Most of the land surrounding Whitestone Lake is owned by Ellis-Barnes Livestock Company, Jim Atwood, and Whitestone Mountain Orchards and consists of fruit orchards and cattle range land. Residential development is limited to a few houses and cabins associated with the orchard farms (Heather Bartlett, WDFW, personal communication). WDFW operates a well-developed access area on the lake that provides parking, boat launch and dock, and toilet facilities.

The floor of Whitestone Lake supports voluminous mats of chara (macro-algae) and watermilfoil *Myriophyllum spp.* Various sub-aquatic (cattail *Typha latifolia*, bulrush *Scirpus spp.*) and terrestrial (Russian olive *Elaeagnus angustifolia*, sagebrush *Artemisia tridentata*, willow *Salix spp.*) vegetation are also common in the area. The riparian area of the lake hosts various mammals including coyote *Canis latrans* and muskrat *Ondatra zibethicus*. In addition, numerous species of waterfowl, including mallard ducks *Anas platyrhynchos* and Canada geese *Branta canadensis*, utilize the lake during the spring and fall.

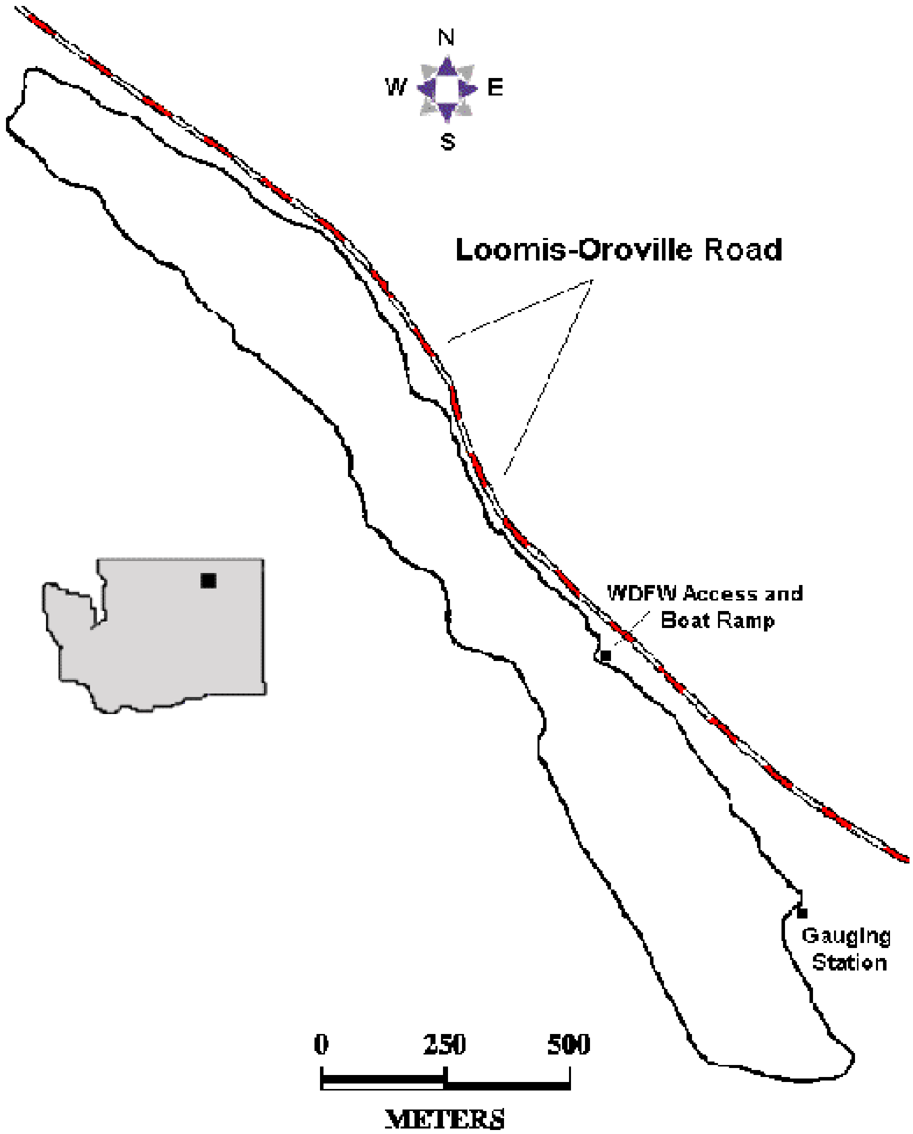

Figure 1. Map of Whitestone Lake, Okanogan County, Washington.

Table 1. Fish stocked in Whitestone Lake, Okanogan County, Washington since 1972.

Year	Species	Size	No. Stocked
2006	Largemouth bass	Juveniles (2.4/lb)	717
2005	Channel catfish	Sub-adults	670
	Black crappie	Fry	5,800
	Largemouth bass	Adults/juveniles	250
2004	Channel catfish	Sub-adults	700
2000	Black crappie	adults	1,000
	Black crappie	fry	733
	Channel catfish	adults	120
	Channel catfish	sub-adults	3,000
1999	Black crappie	fry	10,132
	Channel catfish	fingerlings	2,500
1997	Channel catfish	fingerlings	2,500
1988	Bluegill	adults	900
1974	Rainbow trout	fingerlings	19,600
1973	Rainbow trout	fingerlings	40,600
	Largemouth bass	adults	40
1972	Smallmouth bass	adults	20

Methods and Materials

A three-person team surveyed Whitestone Lake September 18-21, 2006. All fish were collected using a boat electrofisher, gill nets, and fyke nets. The electrofisher unit consisted of a 5.5 m Smith-Root GPP electrofisher boat with a DC current of 60 cycles/sec at 3 to 4 amps power (Bonar et al. 2000). Experimental gill nets (45.7 m x 2.4 m) were constructed 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. Fyke net material was constructed of 13 mm nylon mesh.

Sampling locations were selected prior to sampling by dividing the shoreline into 400 m sections for a total of 14 sections. All 14 sites were sampled by electrofisher, and eight sites each were randomly selected for sampling with gill nets and fyke nets. 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 70° 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 nighttime hours when fish were most numerous along the shoreline thus maximizing the efficiency of each gear type.

Once collected, fish were identified to species, measured (total length [TL]) and weighed (g). Total length data were used to construct length-frequency histograms and to evaluate the size structure of the warmwater gamefish populations in the lake. Warmwater gamefish 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).

Species composition, by weight (kg) and number, was determined from fish captured. Fish less than one year old were excluded from all analyses. Eliminating fish less than one year of age, i.e., young-of-the-year (YOY), prevents distortions in species composition that fluctuate between sampling locations, sampling method, and specific timing of hatches (Fletcher et al. 1993).

Catch per unit effort (CPUE, fish/hour or fish/net night) of each sampling gear was determined for each warmwater fish species collected. Electrofisher CPUE was determined by dividing the number of fish captured by the total amount of time that was electrofished. Similarly, CPUE of gill netting and fyke netting was determined by dividing the number of fish captured by the total time the nets were deployed.

A relative weight (W_r) index was used to evaluate the condition of fish in Whitestone Lake. Relative weight of a fish is the relationship between the actual weight of a fish at a given length to the national standard weight (standard weight W_s) of a fish of the same species and length. A W_r of 100 generally indicates that the fish is in a condition similar to the national standard for that species and length (Anderson and Neumann 1996). 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). The W_s was derived from a standard weight-length ($\log_{10}$) relationship, which was defined for each species of interest (Anderson and Neumann 1996). Only fish age one and older were used for calculations of W_r, as the variability can be significant for YOY. Relative weights less than (W_r = 50) were also excluded from our analysis as we suspected unreliable weight measurements.

Age and growth of warmwater gamefish 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/or 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 statewide, eastern Washington and/or Region Two averages.

The proportional stock density (PSD) of each warmwater gamefish species was determined following procedures outlined in Anderson and Neumann (1996). PSD used two measurements, stock length and quality length, to provide useful information about the proportion of various size fish in a population. Stock length was defined as the minimum size of a fish, which provides recreational value or the approximate length when fish reach maturity (Table 1). Quality length was defined as the minimum size of a fish that most anglers liked to catch and begin keeping. PSD was calculated using the number of quality size fish, divided by the number of stock size fish, multiplied by 100. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Stock length was 20-26 percent of world record length, whereas quality length was 36-41 percent of world record length. Gustafson (1988) reported that at least 55 stock length fish are needed in order to calculate statistically valid PSD estimates. Electrofishing is a useful tool for collecting large samples of centrarchids (bass, panfish) and gill nets are effective for collecting large samples of percids (perch, walleye). Based on these trends, and in order to maintain consistency, we report electrofishing PSDs for centrarchids and gill net PSDs for percids.

Relative stock density (RSD) of each warmwater gamefish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality lengths, preferred, memorable, and trophy categories were added (Table 1). Preferred length (RSD-P) was defined as the minimum size of fish anglers preferred to catch. Memorable length (RSD-M) referred to the minimum size fish anglers remembered catching and trophy length (RSD-T) referred to the minimum size fish worthy of acknowledgment. Preferred, memorable, and trophy length fish were also based on percentages of world record lengths. Preferred length was 45-55 percent of world record length, memorable length was 59-64 percent of world record length, and trophy length was 74-80 percent of world record length. RSD differs from PSD in that it is more sensitive to changes in year class strength. RSD was 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 were selected from tables in Gustafson (1988).

Certain analyses were compared to information collected from Whitestone Lake in 1979 (Williams 1979), 1986 (Walton and Wirt 1989), 1998 (Jackson 1998 - unpublished), and 2000 (Osborne and Petersen 2001). Sampling protocols used by these researchers prior to 2000 were different than those used after, and the 2000 survey was conducted in the spring rather than fall as done in 2006. Regardless, the information collected in 1979, 1986, 1998, and 2000 may be used to identify trends in certain dynamics of the warmwater gamefish populations in Whitestone Lake.

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

	Length Category				
Species	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 and Discussion

Species Composition

A total of 7 fish species were collected during the September 2006 survey (Table 3). Warmwater gamefish comprised 98.9 percent of the total fish captured. Bluegill was the most abundant species (84.9%) encountered, but only accounted for 13.3 percent of the total fish biomass collected. Largemouth bass were second in abundance during 2006, and produced the highest fish biomass (41.9%) of this survey. Other fish species collected were in lower numbers (ranging from 42 – 99) and black crappie were collected in lowest number (11).

As expected, bluegill were collected in large numbers (3,373) during 2006, but 1,074 fewer were collected than in 2000 (Osborne and Petersen 2001)(Table 4). Other notable differences in species composition in 2006 from previous years (Table 4) include a decrease in numbers of yellow perch and pumpkinseed, and increases in channel catfish, largemouth bass, and carp *Cyprinus carpio*. While numbers of fish collected during 2006 varied from 2000 samples, the order of abundance by species changed little.

Table 3. Species composition by weight, number, and size range of fish captured at Whitestone Lake during a warmwater survey in September 2006.

	Species Composition					
	Weight		Number		Size Range (mm TL)	
Species	kg	%	No.	%	Min	Max
Black crappie	0.7	0.1	11	0.3	130	259
Bluegill	67.8	13.3	3373	84.9	55	240
Channel catfish	94.0	18.4	76	1.9	204	640
Carp	129.2	25.3	42	1.1	515	720
Largemouth bass	213.6	41.9	322	8.1	82	534
Pumpkinseed sunfish	2.3	0.4	99	2.5	63	135
Yellow perch	2.1	0.4	48	1.2	81	234

Table 4. Species composition by number and percent of fish sampled at Whitestone Lake from surveys in 1979 (Williams 1979), 1986 (Walton and Wirt 1989), 1998 (Jackson 1998 - unpublished), and 2000 (Osborne and Petersen 2001).

	Species Composition							
	1979		1986		1998		2000	
Species	No.	%	No.	%	No.	%	No.	%
Brown bullhead	122	29.6	134	41.7	1	0.2	2	0.1
Black crappie	29	7.0	169	52.6	0	0	0	0
Bluegill	0	0	0	0	179	44.4	4,447	87.3
Channel catfish	0	0	0	0	0	0	11	0.2
Carp	0	0	0	0	9	2.2	7	0.1
Largemouth bass	258	62.6	15	4.7	137	34.0	206	4.0
Pumpkinseed	0	0	3	0.9	74	18.3	326	6.4
Smallmouth bass	2	0.56	0	0	0	0	1	0.1
Suckers (spp.)	1	0.24	0	0	0	0	0	0
Yellow perch	0	0	0	0	4	0.9	96	1.9

Catch per Unit Effort (CPUE)

When using either active (electrofishing) or passive (gill or fyke nets) sampling techniques, CPUE can be used as an index to monitor size structure and relative abundance of fish species in a lake or reservoir (Hubert 1996). Electrofishing was the most effective technique at capturing fish species at Whitestone Lake in 2006. Catch rates by electrofisher was highest for bluegill followed by largemouth bass and pumpkinseed (Table 5). Gill net catch rates were highest for channel catfish and yellow perch, and fyke net catch rates were highest for bluegill. Each of the 7 fish species collected during the 2006 survey were captured by both electrofisher and gill nets, and only carp and channel catfish were not captured by fyke nets.

In most cases, the boat electrofisher captured the same size fish as did gill nets and fyke nets (refer to length-frequency histograms under species sections). Yellow perch is the one exception, and as expected, gill nets captured larger yellow perch than the electrofisher or fyke nets. Adult yellow perch inhabit pelagic water and are, under most circumstances, sampled more effectively using gill nets.

Table 5. Mean catch per unit effort by sampling method (excluding YOY), including 80 percent confidence intervals, for fish collected from Whitestone Lake in September 2006.

	Gear Type								
	Electrofisher			Gill Nets			Fyke Nets		
Species	No. Hour	CI (+/-)	No. Sites	No. Per Night	CI (+/-)	Net Nights	No. Per Night	CI (+/-)	Net Nights
Black crappie	2.6	1.6	14	0.3	0.2	8	0.4	0.3	8
Bluegill	1303.7	279.5	14	1.1	0.4	8	40.3	17.2	8
Channel catfish	11.1	4.3	14	6.0	3.0	8	0.0	0.0	8
Carp	17.6	10.8	14	0.1	0.2	8	0.0	0.0	8
Largemouth bass	125.1	35.2	14	0.9	0.4	8	2.9	1.8	8
Pumpkinseed sunfish	35.1	12.2	14	0.3	0.2	8	1.9	0.9	8
Yellow perch	2.6	1.1	14	3.3	2.1	8	1.9	1.1	8

Stock Density Indices

Bluegill, pumpkinseed, and largemouth bass were the only fish species collected in high enough numbers at stock size to develop valid PSD estimates. The PSD of largemouth bass captured by boat electrofisher was (89 ± 3)(Table 6). This indicates approximately 89 percent of the largemouth bass collected greater than 200 mm in length were of quality size. Of the 220 stock length largemouth bass collected by electrofisher, approximately 49 percent were of preferred size and 3 percent were categorized as memorable. Bluegill PSD by electrofisher and fyke nets was low, and no fish in the preferred or larger sizes were collected.

Table 6. Stock density indices (± 80 percent confidence interval) for warmwater fishes collected using boat electrofisher, gill nets, and fyke nets in Whitestone Lake during September 2006. 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	No. Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofisher			
Black crappie	6	0	0	0	0
Bluegill	2923	2 (±.3)	0	0	0
Channel catfish	26	92 (± 7)	4 (± 5)	0	0
Carp	41	100	90 (± 6)	10 (± 6)	0
Largemouth bass	220	89 (± 3)	49 (± 4)	3 (± 1)	0
Pumpkinseed sunfish	75	0	0	0	0
Yellow perch	6	0	0	0	0
		Gill Nets			
Black crappie	2	50 (+ 45)	0	0	0
Bluegill	7	14 (+ 17)	0	0	0
Channel catfish	48	100	0	0	0
Largemouth bass	6	100	67 (+ 25)	17 (+ 19)	0
Pumpkinseed sunfish	2	0	0	0	0
Yellow perch	26	4 (+ 5)	0	0	0
		Fyke Nets			
Black crappie	3	33 (+ 35)	33 (+ 35)	0	0
Bluegill	270	1 (+ 1)	0	0	0
Pumpkinseed sunfish	15	0	0	0	0
Yellow perch	14	0	0	0	0

Water Chemistry

Whitestone Lake was relatively homogeneous in terms of temperature, dissolved oxygen, pH, and conductivity throughout the entire water column (Table 7). This is probably due to the time of sampling. Due to the shallow depth of the basin and the high quantity of aquatic vegetation present in the lake, Whitestone Lake has a history of dissolved oxygen depletion and frequent partial fish kills (Williams 1979). However, water chemistry parameters measured in September 2006 were within acceptable ranges for healthy warmwater fish populations. Water temperatures ranged from 15.9 to 16.1°C. Dissolved oxygen ranged from 7.2 to 8.9 mg/l. The pH levels within the top 3 meters of Whitestone Lake were only slightly lower than the range (6.5 - 9) desirable for warmwater fish as reported by Swingle (1969).

Table 7. Water Chemistry data collected from Whitestone Lake during September 2006.

Location	Depth (m)	Temp (°C)	pH	Dissolved O_2 (mg/l)	Conductivity (μS/cm)
Center Lake	Surface	16.1	6.2	8.1	551
	1	16.1	6.4	8.7	551
	2	16.1	6.4	8.7	551
	3	16.0	6.4	8.9	553
	4	15.9	6.5	7.9	543
	Bottom	15.9	6.6	7.2	551

Largemouth Bass

Largemouth bass ranged in age from 1 to 13 years with age 5 fish being the most abundant of those analyzed for age and growth (Table 8). Age 12 largemouth bass were absent from samples. Most age classes found were below average for growth; only age 9 and 13 were above average. Additionally, few age 10 and older largemouth bass were evaluated and below average growth of these fish may be a result of low sample sizes.

Total lengths of largemouth bass collected at Whitestone Lake during 2006 ranged from 82 to 534 mm (Figure 2). Length frequencies were similar when compared to the 2000 survey, as was the distribution of age classes in which ages 1 to 5 comprised the majority of fish (Osborne and Petersen 2001). Relative weights of largemouth bass collected during 2006 were below the national standard for the majority of fish less than 300 mm, and above average for most fish larger than 300 mm in length (Figure 3). These findings were similar to our growth analysis of largemouth bass in this size range. Relative weights were similar in comparison with 2000 survey data.

Table 8. Length at age of largemouth bass sampled at Whitestone Lake during September 2006. Values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age												
Year class	No. Fish	1	2	3	4	5	6	7	8	9	10	11	12	13
2005	14	66.9												
2004	8	88.1	167.8											
2003	21	73.3	141.4	199.4										
2002	31	77.0	137.5	203.2	271.0									
2001	35	73.0	122.5	184.8	259.7	338.4								
2000	5	94.3	155.0	219.1	314.2	384.9	421.4							
1999	4	104.5	170.8	218.6	285.0	367.9	423.7	452.9						
1998	9	80.9	126.4	177.7	247.0	334.5	389.8	421.3	449.2					
1997	12	76.3	122.2	167.1	230.1	315.3	369.6	403.9	430.5	370.4				
1996	1	90.7	141.3	190.7	225.3	309.3	374.7	408.0	432.0	433.3	0			
1995	1	70.7	124.1	161.5	247.0	357.8	408.5	444.6	465.9	486.0	498.0	506.0		
1994	0													
1993	1	76.5	125.7	180.7	254.6	328.4	390.7	412.4	441.3	465.9	486.2	505.0	519.5	528.2
Lee's Average		77.8	135.3	192.2	261.7	338.7	391.5	418.4	439.5	455.0	485.0	505.5	519.5	528.2
Region 2 Avg.		89.0	175.5	256.4	318.1	359.7	394.1	427.4	444.9	454.8	497.9	515.4	529.1	527.4

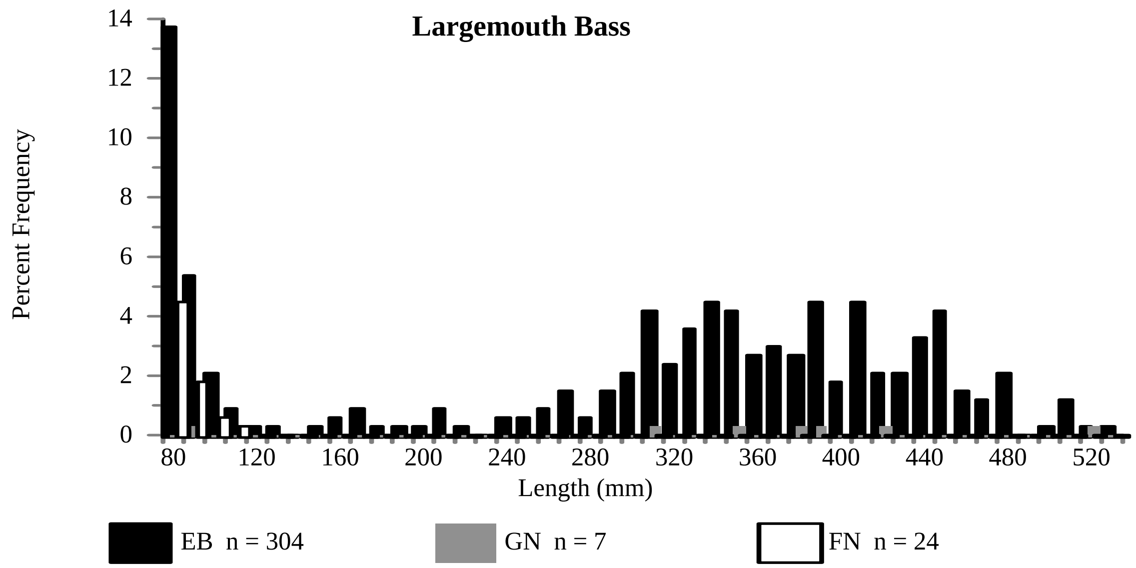

Figure 2. Length frequency of largemouth bass captured while using a boat electrofisher (EB) and gill nets (GN) on Whitestone Lake during September 2006.

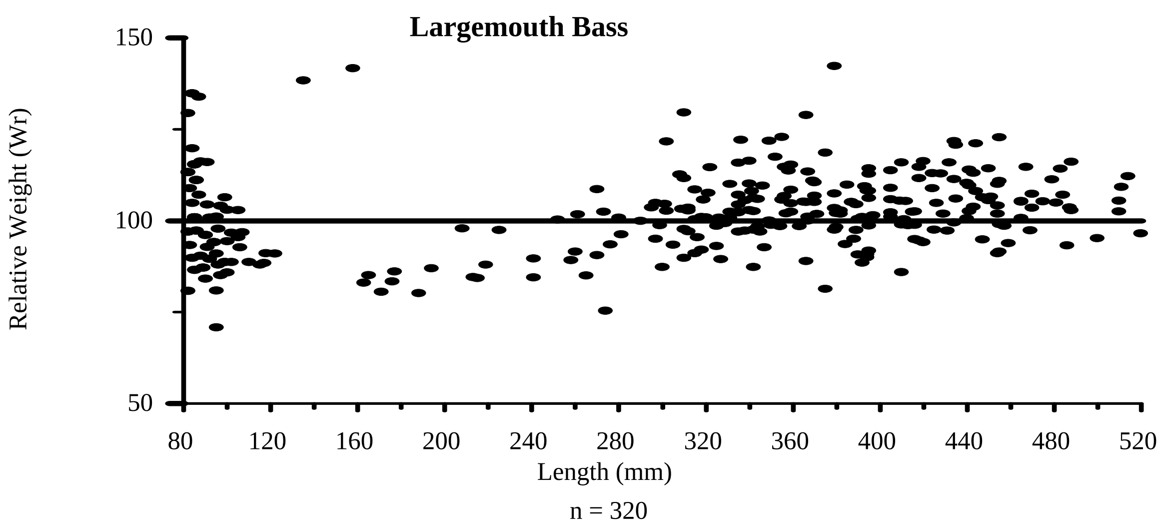

Figure 3. Relative weights for largemouth bass sampled at Whitestone Lake during September 2006, compared to the national standard W_r = 100 (Anderson and Neumann 1996).

Bluegill

A total of 3,373 bluegill were sampled at Whitestone Lake in September 2006 (Table 3), approximately 1,100 less than observed in 2000 (Osborne and Petersen 2001). Bluegill ranged in age from 1 to 7 years with age 4 being the most abundant of those fish analyzed for age and growth (Table 9). Growth of Whitestone Lake bluegill was below the statewide average at all ages, similar to the 2000 findings.

Total lengths of bluegill sampled at Whitestone Lake ranged from 55 to 240 mm in 2006 (Table 3, Figure 4) and from approximately 40 to 224 mm in 2000. Bluegill 70 to 140 mm dominated the 2006 samples. Overlap of ages and size was significant and individual age classes could not be identified using length frequencies. Relative weights of bluegill were below average overall, and highest condition was displayed by bluegill less than 80 mm in length (Figure 5).

Table 9. Length at age of bluegill sampled at Whitestone Lake during September 2006. Shaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Unshaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age						
Year class	No. Fish	1	2	3	4	5	6	7
2005	3	29.5						
		40.0						
2004	9	21.8	53.3					
		36.1	59.5					
2003	7	19.2	52.9	83.5				
		35.5	62.7	87.3				
2002	14	20.8	52.2	81.1	103.1			
		37.4	63.5	87.5	105.8			
2001	5	15.6	43.1	72.5	98.1	121.8		
		33.2	56.6	81.6	103.3	123.5		
2000	11	19.9	48.3	74.9	96.0	121.8	141.7	
		37.3	62.1	85.2	103.6	126.1	143.4	
1999	5	20.5	45.8	75.1	93.3	124.7	149.7	167.7
		38.2	60.7	86.8	102.9	130.9	153.1	169.1
Direct P. Average		21.0	49.3	77.4	97.6	122.8	145.7	167.7
Lee's Average		36.8	61.4	86.1	104.4	126.6	146.5	169.1
State Average		37.3	96.8	132.1	148.3	169.9	200.9	195.8

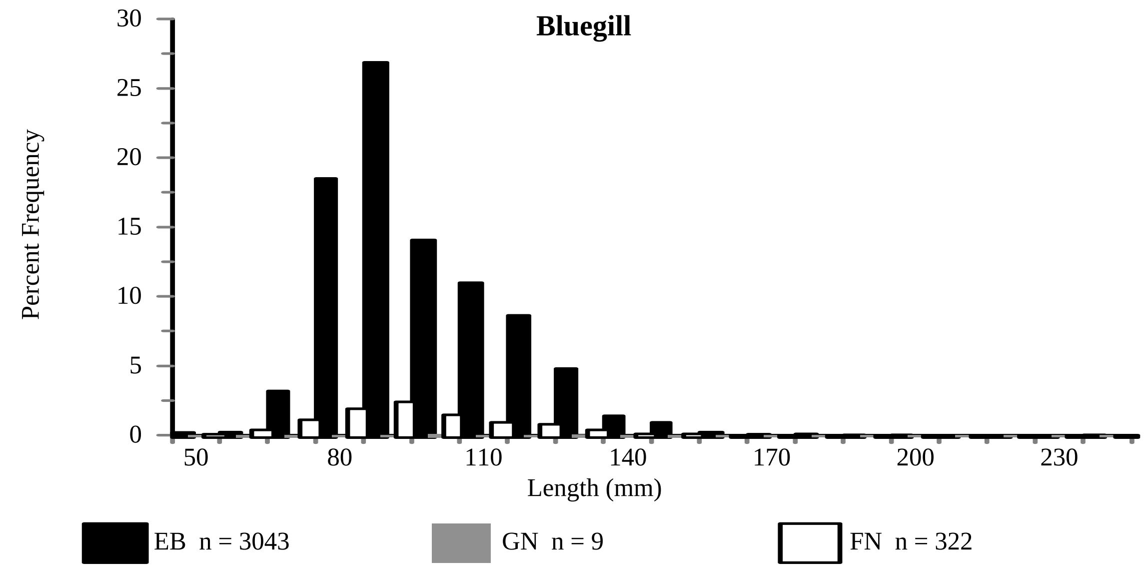

Figure 4. **Length frequency of bluegill captured while using a boat electrofisher (EB) and gill nets (GN) and fyke nets (FN) on Whitestone Lake during September 2006.**

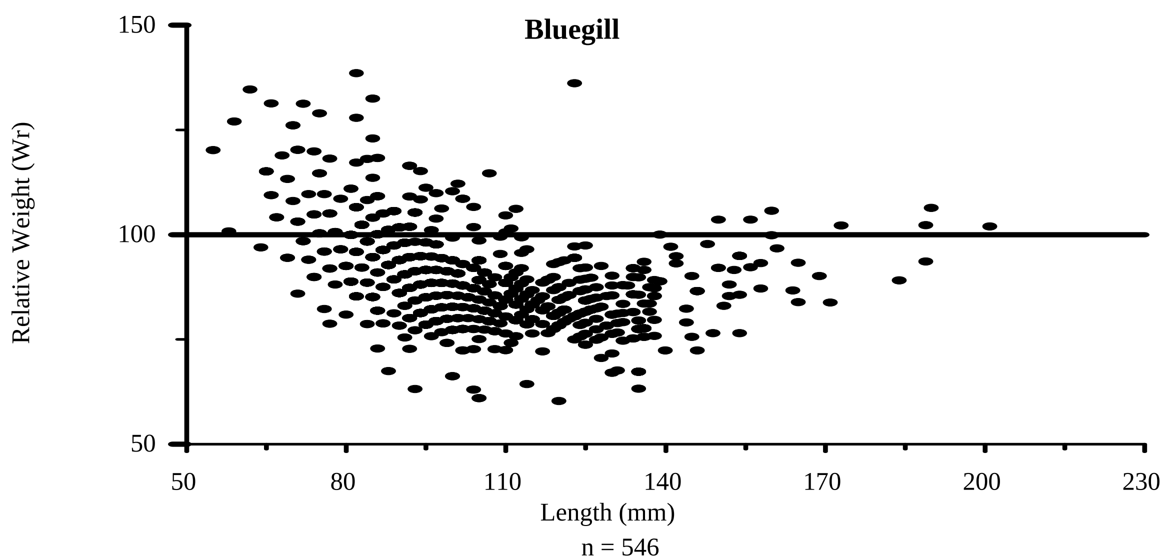

Figure 5. **Relative weights for bluegill sampled at Whitestone Lake during September 2006, compared to the national standard W_r = 100 (Anderson and Neumann 1996).**

Black Crappie

A total of 11 black crappie were collected during the 2006 warmwater survey (Table 3). Ages of black crappie ranged from 2 to 3 with age 2 being the most abundant age class evaluated (Table 10). No age 1 black crappie were collected. Growth was above average at both ages when compared the state average. Lengths ranged from 130 to 259 mm with the majority of fish found at sizes less than 160 mm (Figure 6). Relative weights of all black crappie were below average when compared to the national standard (Figure 7). Black crappie were last stocked in 1999, given the ages of black crappie collected, these fish were likely offspring of those stocked in 1999.

Table 10. Length at age of black crappie captured at Whitestone Lake during September 2006. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993). Unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age		
Year class	No. Fish	1	2	3
2005	0			
2004	9	55.9	103.3	
		77.3	113.1	
2003	2	49.6	140.5	190.8
		76.9	153.8	196.6
Direct P. Average		52.7	121.9	190.8
Lee's Average		77.2	120.5	196.6
State Average		46.0	111.2	156.7

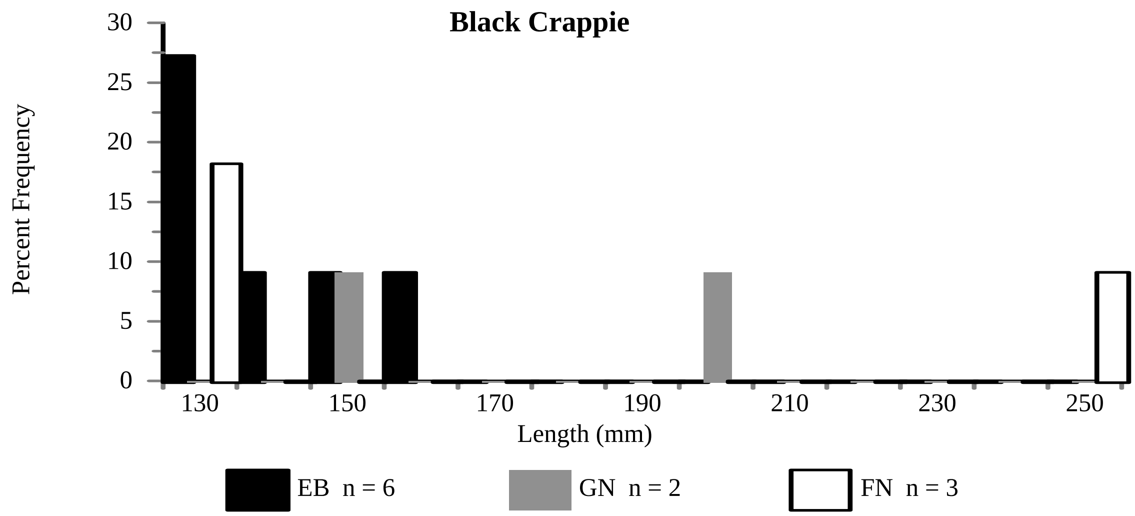

Figure 6. Length frequency of black crappie captured while using a boat electrofisher (EB) and gill nets (GN) and fyke nets (FN) on Whitestone Lake during September 2006.

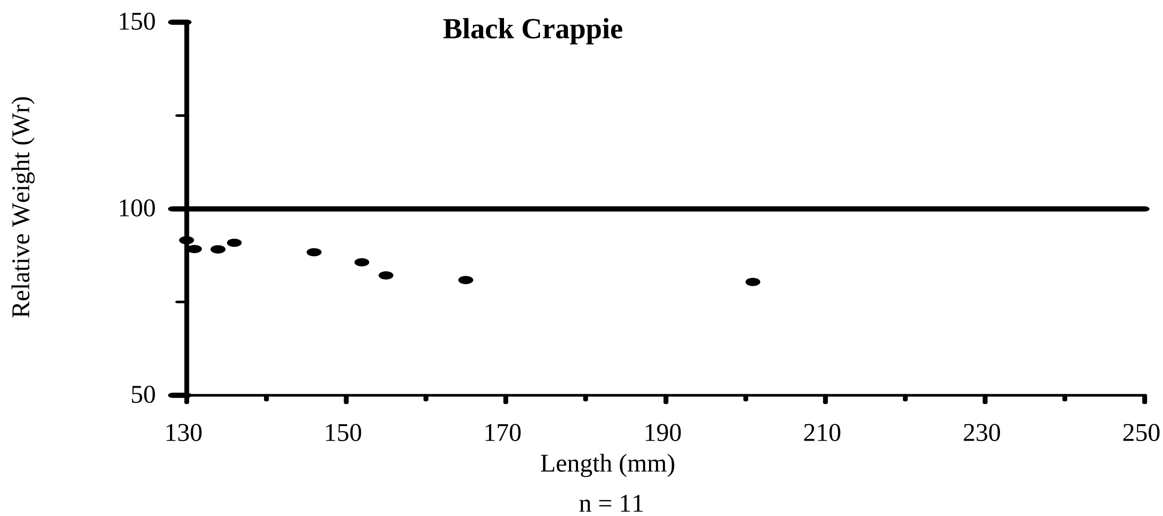

Figure 7. Relative weights for black crappie sampled at Whitestone Lake during September 2006, compared to the national standard W_r = 100 (Anderson and Neumann 1996).

Pumpkinseed Sunfish

A total of 99 pumpkinseed sunfish were collected during the 2006 survey (Table 3). Pumpkinseed ranged in age from 1 to 3 with age 2 being the most abundant age class evaluated (Table 11). When compared to the state average, growth of pumpkinseed was found above average at age 1 and below average for ages 2 and 3. Lengths ranged from 81 to 234 mm with the majority found at sizes between 80 and 110 mm (Figure 8). Pumpkinseed relative weights were found above average for most fish less than 100 mm in length, and below average for most greater than 100 mm (Figure 9).

Table 11. Length at age of pumpkinseed captured at Whitestone Lake during September 2006. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993). Unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age		
Year class	No. Fish	1	2	3
2005	5	29.4		
		43.5		
2004	14	27.6	63.7	
		45.0	71.2	
2003	10	23.2	67.4	107.3
		43.6	78.9	110.8
Direct P. Average		26.7	65.6	107.3
Lee's Average		44.3	74.4	110.8
State Average		23.6	72.1	101.6

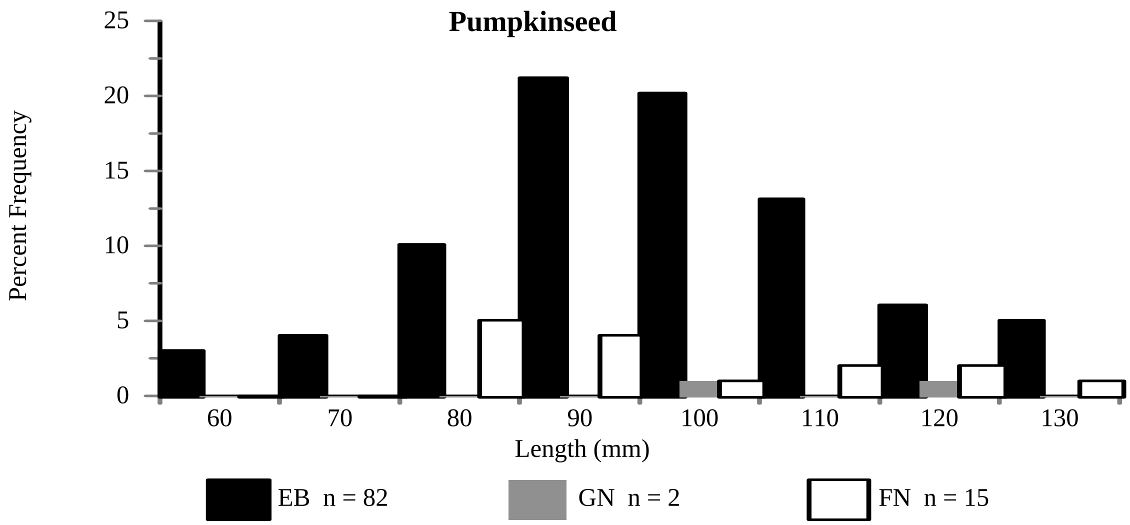

Figure 8. **Length frequency of pumpkinseed captured while using a boat electrofisher (EB) and gill nets (GN) and fyke nets (FN) on Whitestone Lake during September 2006.**

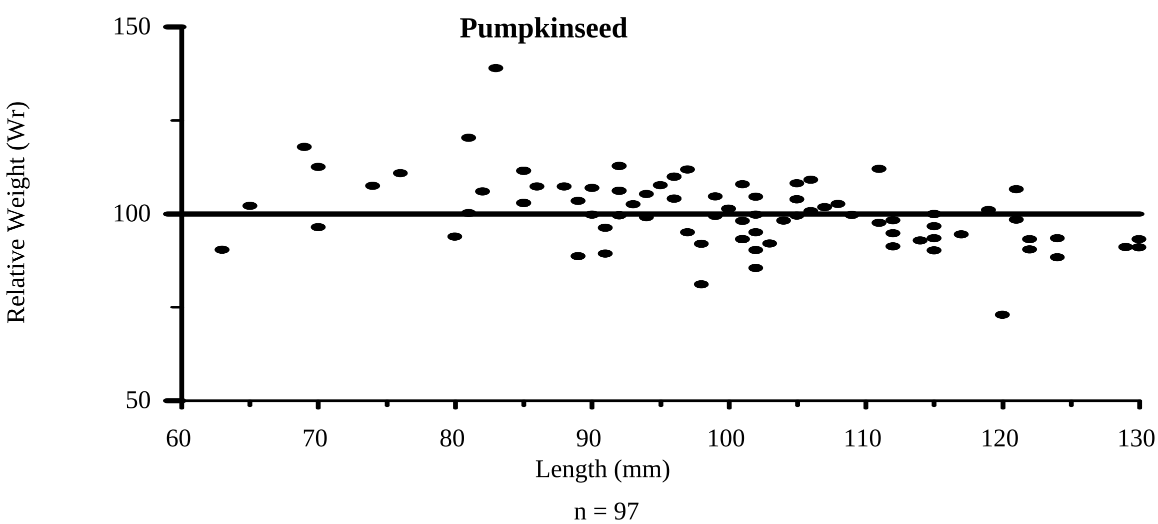

Figure 9. **Relative weights for pumpkinseed sampled at Whitestone Lake during September 2006, compared to the national standard W_r = 100 (Anderson and Neumann 1996).**

Yellow Perch

A total of 48 yellow perch were observed during the 2006 survey (Table 3) which was less than observed in 2000 (Osborne and Petersen 2001)(Table 4). Yellow perch ranged in age from 1 to 4 years with age 2 being the most abundant of those fish analyzed for age and growth (Table 12). Yellow perch were found above the statewide average for growth at all ages. Total lengths of yellow perch collected at Whitestone Lake during 2006 ranged from 81 to 234 mm with most fish found in the range of 130 to 180 mm in length (Figure 10). Relative weights were below average for all yellow perch evaluated when compared to the national standard (Figure11).

Table 12. Length at age of yellow perch captured at Whitestone Lake during September 2006. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993). Unshaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age			
Year class	No. Fish	1	2	3	4
2005	1	84.1			
		93.8			
2004	19	82.4	135.4		
		96.2	138.9		
2003	7	74.3	134.4	164.5	
		91.7	141.7	166.8	
2002	1	73.6	131.0	185.4	219.3
		94.2	144.2	191.7	221.2
Direct P. Average		78.6	133.6	175.0	219.3
Lee's Average		94.9	139.8	169.9	221.2
State Average		59.7	119.9	152.1	192.5

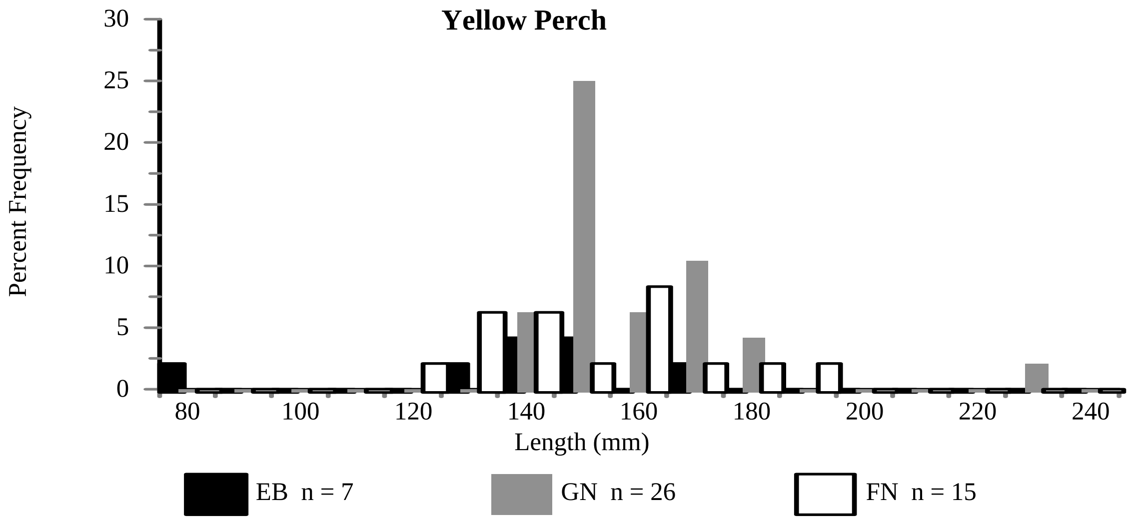

Figure 10. **Length frequency of yellow perch captured while using a boat electrofisher (EB) and gill nets (GN) and fyke nets (FN) on Whitestone Lake during September 2006.**

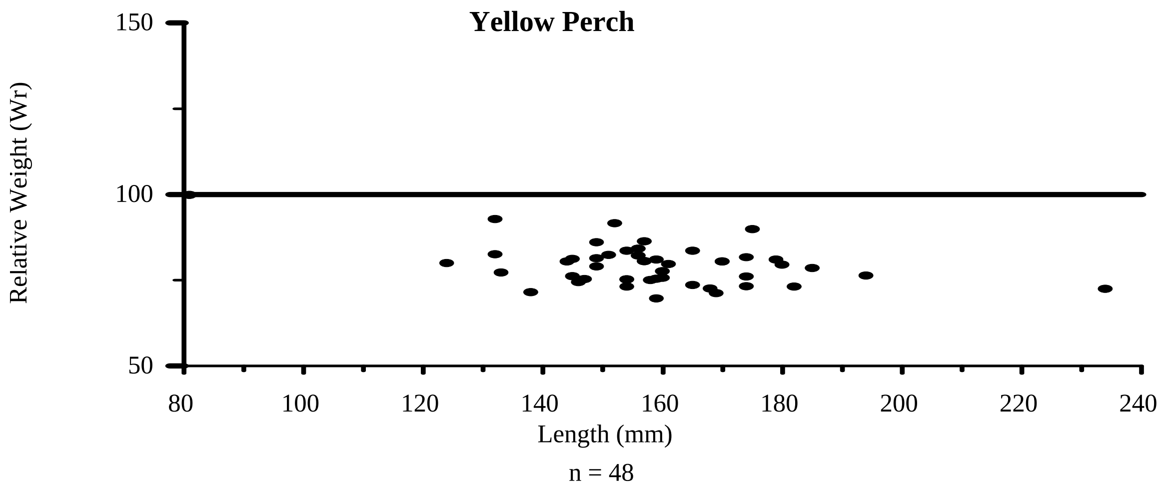

Figure 11. **Relative weights for yellow perch sampled at Whitestone Lake during September 2006, compared to the national standard W_r = 100 (Anderson and Neumann 1996).**

Channel Catfish

A total of 74 channel catfish were collected during the September 2006 warmwater survey (Table 3). Age and growth was not evaluated on channel catfish as most techniques require injury or are lethal to the fish. The stocking of channel catfish (fingerlings) in Whitestone Lake began in 1997 (Table 1), but has not occurred since 2005. Based on stocking records, channel catfish ranged in age from 1 to 9. Lengths of channel catfish ranged from 204 to 640 mm, and relative weights varied but were slightly above (W_r = 101) the national standard overall.

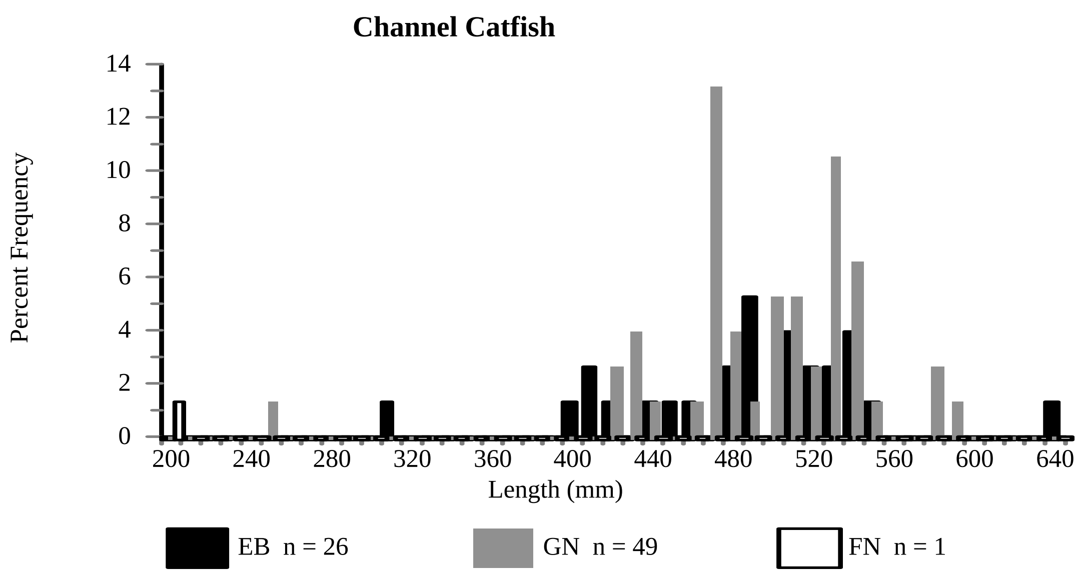

Figure 12. Length frequency of channel catfish captured while using a boat electrofisher (EB) and gill nets (GN) and fyke nets (FN) on Whitestone Lake during September 2006.

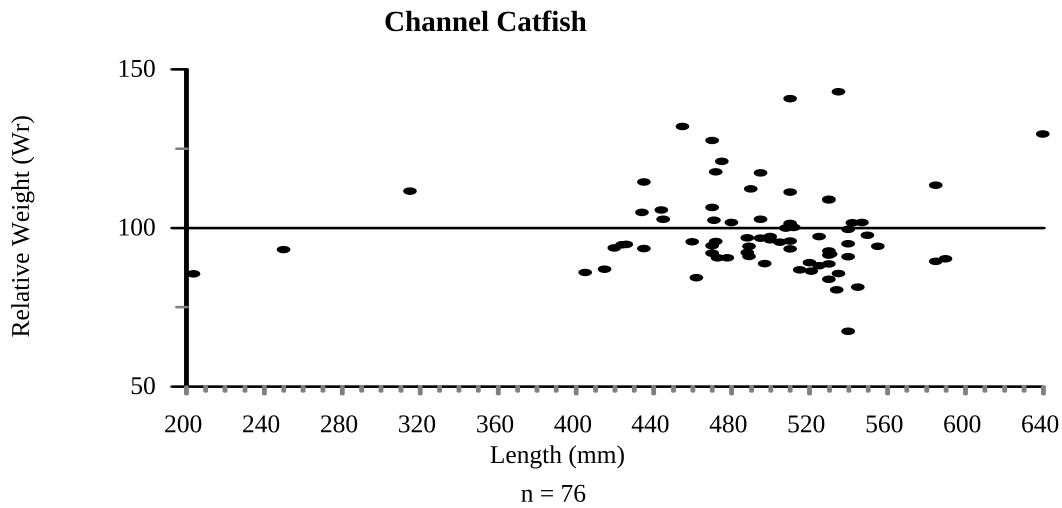

Figure 13. Relative weights for channel catfish sampled at Whitestone Lake during September 2006, compared to the national standard W_r = 100 (Anderson and Neumann 1996).

Discussion and Management Strategies

Although Whitestone Lake was sampled in 1998 (Jackson 1998), electrofishing was the sole sampling technique and was conducted only during daylight hours. Regardless, CPUE from previous surveys provide information that allows fishery managers to monitor the effectiveness of management techniques on the lake. The most notable differences in CPUE between 1998, 2000, and 2006 occurred with largemouth bass, bluegill, and pumpkinseed sunfish. In 1998, CPUE by electrofisher of largemouth bass was 99 fish per hour (Jackson 1998) whereas in 2000 was approximately 43 fish/hr (Osborne and Petersen 2001). The number of largemouth bass caught per hour by electrofisher during 2006 was 125 fish/hr, nearly three times the catch rate found in 2000. The CPUE of bluegill sampled by electrofisher in 1998 was 130 fish/hr whereas in 2000 was 1,334 fish/hr, and in 2006 was 1,303 fish/hr. Very little change occurred in bluegill catch rates by electrofisher between 2000 and 2006; however, catch rates of both years were nearly 10 times higher than observed in 1998, potentially a result of daytime electrofishing in 1998. Electrofisher catch rates of pumpkinseed increased slightly from 1998 (74 fish/hr) to 2000 (96.5 fish/hr), but declined approximately 36 percent in 2006 from rates observed in 2000.

When compared to the 2000 warmwater survey, 2006 bluegill PSD declined while the overall number of stock length fish collected increased (Osborne and Petersen 2001). While the PSD indicates fewer larger size bluegill were collected in 2006 samples, more bluegill have recruited to stock size and may grow to larger sizes if allowed. However, overcrowding can cause food competition, leading to slow growth and small sizes at older ages, hindering growth of bluegill to quality and larger sizes. The number of stock length largemouth bass increased in 2006 from 2000 samples, as did PSD and the RSD of preferred sizes. This increase in proportion of larger fish may be indicative of slightly better recruitment, lower angler harvest, or anglers strictly adhering to regulations.

The largemouth bass fishery in Whitestone Lake is similar to the outcome sought under the big bass management option (Willis et al. 1993). Under the big bass option, largemouth bass PSD should be 50 to 80 (RSD-P of 30 to 60) and bluegill PSD should be 10 to 50 (RSD-P of 0 to 10). During 2006, largemouth bass were above and bluegill were below the big bass standard. The PSD of largemouth bass sampled by electrofishing was 89 $\pm$ 3 and the RSD-P was 49 $\pm$ 4 (Table 6). Bluegill PSD was 2 $\pm$ 0.3 and the RSD-P was 0. The strategy of the big bass option is to produce fewer, larger bass and a smaller size structure of bluegill. Dense populations of bluegill may limit largemouth bass spawning success by invading nests and consuming the eggs. Since both largemouth bass and bluegill PSDs were outside the big bass management range, removing bluegill and/or stocking more largemouth bass may help bring these populations back into balance. Below average growth of Whitestone Lake largemouth bass was unexpected given the abundance of bluegill available as prey. Largemouth bass less than 300 mm (12 inches) experienced slower growth than larger fish, likely a result of competing with bluegill for smaller forage. It is surprising; however, that these smaller size largemouth bass do not appear to be optimally utilizing the abundant young-of-the-year bluegill resource expected to be available. Low relative weights of the smaller size largemouth bass were also an indication of competition with the bluegill and pumpkinseed in the lake. Although natural reproduction of largemouth bass is evident with the presence of age 1 fish, competition for food and space not only results in poor condition, but may also limit juvenile survival. High competition and low reproductive success may lead to low recruitment of largemouth bass to larger sizes as well, though currently, enough recruitment has occurred to improve the number of larger bass since the 2000 survey.

Bluegill density in Whitestone Lake was high during 2006; slow growth and below average condition of these fish is consistent with other dense populations. Additionally, a convergence of age classes to similar sizes and lower numbers of age classes are known characteristics of stunted populations. Length frequency and age analysis of bluegill collected during 2006 identified a high degree of overlap in sizes at age. Moreover, older age bluegill (ages 8 to 10) observed during the 2000 warmwater survey were absent in 2006 samples, indicating this population is comprised of younger fish (Osborne and Petersen 2001). Stock density indices showed bluegill PSD was low during 2006, an indication of few large fish in the community relative to the number of smaller fish. While bluegill are the most important prey species for largemouth bass in Whitestone Lake, mechanical removal of bluegill may benefit the bluegill population and provide anglers more desired size fish. Additionally, recruitment of largemouth bass should improve with bluegill removal, as egg robbing and fry mortality may decrease as these species become more balanced.

Growth of Whitestone Lake yellow perch was above the statewide average at all ages; however, only 4 age classes were observed and all ages except age 2 fish were in low abundance. Similar to bluegill, size ranges from these age classes overlapped significantly and proportions of fish from each age class could not be determined in the length frequency histogram. Although yellow perch sampled in 2006 exhibited above average growth, their condition was poor; no fish had relative weights exceeding the national standard (W_r = 100). These results were also found during the 2000 warmwater survey (Osborne and Petersen 2001). Above average growth with poor condition may indicate food resources were allocated more to fish length rather than roundness, possibly in response to intense predation. Post and Prankevicius (1987) found that slow growing yellow perch remain vulnerable to predation longer than faster growing populations. Since yellow perch in Whitestone Lake were found most numerous at sizes between 130 and 180 mm, above average growth doesn't appear sufficient to recruit these fish to larger, more desirable sizes. The number of yellow perch collected during surveys declined from 96 fish in 2000 to 48 fish in 2006. This decline in abundance is not concerning since yellow perch are not a desired species in Whitestone Lake, and bluegill are the predominant forage for largemouth bass.

Channel catfish were observed in much higher numbers (76) in 2006 than in 2000 (11). Channel catfish exhibited good growth and condition at the time of this survey, an indication that this population is well suited to conditions within the lake. Survival of these stocked catfish appears good, given the increased numbers collected, and currently provides anglers with an excellent opportunity to harvest very nice size fish. As with most lake-stocked populations of channel catfish, natural reproduction doesn't occur, so yearly stocking is needed to maintain populations. Stocking did not occur in 2006, as the out-of-state supplier closed his business. Currently, efforts are being made to secure another supplier, and if successful, stocking of channel catfish in Whitestone Lake should continue at previous levels to insure this successful program is maintained.

Common carp have been observed in Whitestone Lake since 1998. Low numbers were observed during 1998 (Jackson 1998) and 2000 (Osborne and Petersen 2001), but were observed in higher numbers (n = 42) during 2006. Since carp are an undesirable fish species that can harm fish communities, effort should be made to remove any carp collected during future warmwater surveys or improvement measures.

Strategy 1. Improvement measures may be taken to bring largemouth bass and bluegill in to balance with the "big bass" option discussed earlier in this document. Mechanical removal of bluegill as well as stocking of largemouth bass at least 200 mm in length should achieve a more desired balance. We recommend bluegill be removed at a rate of 3,000 per year and largemouth bass be stocked at levels at or near 400 per year. Also, continued monitoring should be conducted to identify when these fish population respond to management actions so stocking and removal can be suspended.

Strategy 2. Whether implementing new or monitoring existing management strategies, we recommend conducting a creel survey to evaluate current angler harvest and to monitor changes in harvest that may occur as a result of new strategies. A creel survey will also be useful in determining effort, changes in size structure of bluegill, and catch rates. We recommend beginning a creel survey in May, and making periodic checks throughout the summer and fall.

Strategy 3. Whitestone Lake is a very important warmwater fishery in Okanogan County. Since common carp are known to exist in the lake, measures should be taken to remove carp whenever the opportunity exists. Carp are known to uproot aquatic vegetation in the search for food, resulting in turbid water which often reduces the ability for sight dependent feeders to find prey. Often times, too many carp can destroy a fishery or prevent desired fish species from reestablishing themselves, ultimately leading to a costly rehabilitation. We suggest additional actions (such as large mesh gill nets or electrofishing) be taken to remove them from the lake.

Strategy 4. Channel catfish have adapted well to Whitestone Lake, and numerous large catfish are currently available for angler harvest. Since stocking of these fish has proven successful, we recommend the continued stocking as soon as a new supplier can be identified.

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Glossary

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

Confidence Interval (CI): Is defined as an estimated range of values that 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, and 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 (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, and 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, and 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, and multiplied by 100.

Relative Weight (W_r): The comparison of the weight of a fish at a given size to the national standard 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): Length measurement from the anterior most part of the fish to the tip of the longest caudal (tail) fin ray (compressed).

Trophy Size: Minimum size fish worthy of acknowledgment, and identified as 74-80 percent of world record length. Trophy length varies by species.

Acknowledgements

We thank Tammy Gish for his assistance with data collection. We would also like to thank Robert Jateff for his technical review, and David Bramwell for his tireless effort in compiling and preparing this report for publication. Appreciation is also extended to Lucinda Morrow for aging scales collected during this survey. The WDFW Warmwater Gamefish Enhancement Program funded this survey.