STATE OF WASHINGTON March 2007

The Warmwater Fish Communities of Four Lakes Surveyed in Fall, 2003:

McIntosh Lake, Munn Lake, and Offut Lake in Thurston County, and Ohop Lake in Pierce County

by Adam Couto and Stephen J. Caromile

Washington Department of
FISH AND WILDLIFE
Fish Program
Fish Management Division

FPT 07-03

The Warmwater Fish Communities of Four Lakes Surveyed in Fall, 2003: McIntosh Lake, Munn Lake, and Offut Lake in Thurston County, and Ohop Lake in Pierce County

By

By Adam Couto and Stephen J. Caromile

March 2007

Acknowledgements

We would like to thank Sandy Schexnader for her dedicated assistance collected data in the field. We would also like to thank Ben Power, Larry Philips, and Steve Jackson for their help in the field, and Lucinda Morrow and John Sneva for calculating fish ages and length-at-age data. These surveys were funded by the Warmwater Enhancement Program, which is providing greater opportunity to fish for warmwater fish species in Washington.

Abstract

Four lakes were surveyed in the fall of 2003: Munn Lake in Thurston County, Ohop Lake in Pierce County, McIntosh Lake in Thurston County, and Offut Lake, also in Thurston County. Each survey was conducted by a three-person crew using multiple gear types: electrofishing, gillnetting, and fyke-netting. The Munn Lake sample was the smallest numerically and least diverse, with only five species represented. The sample from Ohop Lake was the most diverse, with 11 fish taxa. The McIntosh and Offut samples had seven and nine taxa, respectively. Largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) were the only two species common to all five lakes. The data show a possible link between increased harvest opportunity and reduced condition of the warmwater fish community.

Table of Contents

List of Tables

List of Figures

Introduction and Background

In the fall of 2003 the Warmwater Fisheries Enhancement Team 3 surveyed four lakes using methods described in the "Standard Fish Sampling Guidelines for Washington State Ponds and Lakes" (Bonar et al. 2000). Those lakes were, in chronological order of survey, Munn Lake in Thurston County, Ohop Lake in Pierce County, McIntosh Lake and Offut Lake, both in Thurston County.

Munn Lake is a small (13.75 hectare), shallow (max depth 5.8 m) water body located in the City of Tumwater's Urban Growth Area and close to the Deschutes River. The lake has a single, small public access that is open from the last Saturday in April through October. Residential development currently occupies 60 percent of the shoreline, with future development planned on much of the remaining shoreline. Despite its proximity to the Deschutes River, there is neither an inflow or outflow channel.

Ohop Lake is a 95 hectare, shallow lake (max depth 5.9 m) located just north of Eatonville. It is a long, narrow lake, 3.6 km long, but no more than 400 m at its widest point. The lake was formed by a natural dam on Ohop Creek, which enters at the north end and exits from the south. (Bortleson et al. 1976) The creek drains to the Nisqually River about 5 miles from the lake outlet. There is a public access open from the last Saturday in April through October. Approximately 85% of the lake is currently developed with single family homes. Ohop Lake was surveyed in the spring of 2000 (Caromile and Jackson 2002), at the same time the lake transitioned from year-round access to being an opening day lake.

McIntosh Lake is located in south-central Thurston County, 2 miles east of Tenino. It is a small (37.6 hectare), shallow (max depth 3.4 m) lake with a single public access open from the last Saturday in April through October. Approximately half the shoreline has residential development. The lake lacks a defined inflow channel, although several intermittent streams feed the lake; an intermittent outflow channel connects the lake to the Deschutes River.

Offut Lake is located four miles northwest of McIntosh. It is a 81 hectare, shallow (max depth 7.6 m) lake with one year-round public access and one private access. It has one small inlet stream and an outlet stream that flows in the Deschutes River. Several springs also feed the lake. (Bortleson et al. 1976) Two thirds of the shoreline has residential development.

Methods and Materials

Data Collection

All four lakes were surveyed by a three-person team over several days. Munn Lake was surveyed on September 10th and 11th, Ohop Lake was surveyed September 23rd through 25th, McIntosh was surveyed from September 29th to October 1st, and the Offut Lake survey occurred October 27th and 28th. Fish were captured using 3 sampling techniques: electrofishing, gillnetting, and fyke-netting. The electrofishing unit consisted of a Smith-Root SR-16s electrofishing boat, with a 5.0GPP pulsator unit. Peak efficiency of the electrofishing unit is defined as producing a ¼ sine wave. The boat was fished using a pulsed DC current of 60 Hz at 2-4 amps power, as close to peak efficiency as possible. Experimental gill nets, 45.7 meters (m) long x 2.4 m deep, were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable-size (1.3, 1.9, 2.5, and 5.1 cm stretch) monofilament mesh. Fyke (modified hoop) nets were constructed of five 1.2 m diameter hoops with two funnels, and a 2.4 m cod end (6 mm nylon delta mesh). Attached to the mouth of the net were two 7.6 m wings, and a 30.5 m lead.

In order to reduce the gear induced bias in the data, the sampling time for each gear was standardized so that the ratio of electrofishing to gillnetting to fyke-netting was 3:2:2. The standardized sample is 1800 sec of electrofishing (3 sections), 2 gill-net nights, and 2 fyke-net nights. Sampling occurred during the evening hours to maximize the type and number of fish captured. Sampling locations were selected from a map by dividing the entire shoreline into 400 m sections, numbering them consecutively and randomly choosing them without replication. While electrofishing, the boat was maneuvered slowly through the shallows for a total of 600 seconds of "pedal-down" time. Gill nets were fished perpendicular to the shoreline; the small-mesh end was tied off to shore, and the large- mesh end was anchored off shore. Fyke nets were fished perpendicular to the shoreline as well. The lead was tied on shore, and the cod-end was anchored off shore, with the wings anchored at approximately a 45° angle from the net lead. Fyke nets are fished with the hoops 0.3 - 0.5 m below the water surface, this sometimes requires shortening the lead. Twelve (12) 400 m sections were electrofished; gill nets and fyke nets were each set overnight at eight (8) locations around the lake.

With the exception of sculpin (family Cottidae), all fish captured were identified to the species level. Most fish were measured to the nearest millimeter (mm) and weighed to the nearest gram (g). Fish less than 70 mm were not weighed due to inadequate scale precision. In order to reduce handling stress on fish, where large numbers (>200) of obviously similar-sized fish were collected simultaneously, a subsample was measured to the nearest millimeter and weighed to the nearest gram. The remaining fish were counted and the subsampled data expanded. Weights were then assigned using a length-weight regression formula.

For aging purposes, scales were taken from five individuals of each warmwater game species per centimeter size class (greater than 70 mm). All fish providing scales were measured to the nearest millimeter and weighed to the nearest gram individually.

Water quality data was collected during midday from the deepest section of each lake on the last day of the survey. Using a Hydrolab® probe and digital recorder, dissolved oxygen (mg/l), temperature (C°), pH, turbidity (NTU), and conductivity (μsiemens/cm) data was gathered in the deepest section of the lake at 1 m intervals through the water column. Secchi disk readings, used to measure transparency, were taken by the methods outlined by Wetzel (1983).

Data Analysis

Species Composition

The species composition by number of fish captured was determined using procedures outlined by Fletcher et al.(1993). Species composition by weight (kg) of fish captured, was determined using procedures adapted from Swingle (1950). All fish, including young of the year, are used to determine biomass and species composition.

Catch Per of Unit Effort

The catch per unit of effort (CPUE) of electrofishing for each species was determined by dividing the total number in all size classes equal or greater than stock size (defined in Appendix A), by the total electrofishing time (sec). The CPUE for gill nets and fyke nets was determined similarly, except the number equal or greater than stock size was divided by the number of net-nights for each net (usually one). An average CPUE (across sample sections) with 80% confidence interval was calculated for each species and gear type.

For fishes in which there is no published stock size (i.e., sculpins, suckers, etc.), CPUE is calculated using all individuals captured. Because it is a standardized index, CPUE is useful for comparing stocks between lakes.

Length-Frequency

A length-frequency histogram was calculated for warmwater gamefish species by calculating the number of individuals of a species in a given size class divided by the total individuals of that species sampled, creating a percentage graph. Typically these graphs are constructed for each gear type and are limited to either age-1 fish and above, as determined by the aging process. For this survey all gear types are combined on a single graph and all stock size fish collected were included. Plotting the histogram by percentages tends to flatten out large peaks created by an

abundant size class, and makes the graph easier to read. These length-frequency histograms are helpful when trying to evaluate the size and age structure of the fish community, and their relative abundance in the lake.

Stock-Density Indices

To assess the size structure of fish populations, stock density indices were calculated as described by Gablehouse (1984). Proportional stock density (PSD and relative stock density RSD) are calculated as proportions of various size-classes of fish in a sample. The size classes are referred to as minimum stock (S), quality (Q), preferred (P), memorable (M), and trophy (T). Lengths have been published to represent these size classes for each species, and were developed to represent a percentage of world-record lengths as listed by the International Game Fish Association (Gablehouse 1984). These lengths are presented in Appendix A.

Stock-density indices are accompanied by a 80% confidence interval (Gustafson 1988) to provide an estimate of statistical precision.

Relative Weight

A relative weight index (W*r*) was used to evaluate the relative condition of fish in the lake. A W*r* value of 100 generally indicates a fish in good condition when compared to the national average for that species and size. Furthermore, relative weights are useful for comparing the condition of different size groups within a single population to determine if all sizes are finding adequate forage or food. Relative weights were calculated following Murphy and Willis (1991). The parameters for the standard weight (W_s) equations of many fish species, including the minimum length recommendations for their application, are listed in Anderson and Neumann (1996).

Age and Growth

Age determination and annuli measurements from scales or other structures were determined by the Department of Fish and Wildlife Aging Unit. Total length at annulus formation was back-calculated using the Fraser-Lee method with *y*-axis intercepts specified by Carlander (1982). Mean back-calculated lengths at each age for each species were presented in tabular form for easy comparison between year classes. Results for each survey were compared to regional averages using the Student's *t*-test, one-tailed. Regional averages were developed from age data collected on other western Washington lakes in this same manner then calculated as a mean of means.

Results

Water Quality and Habitat

Water quality data can be found in Table 1. Water temperatures for all four lakes are typical for shallow lakes in western Washington in late summer and fall. None of the lakes exhibited thermal stratification. All other data are also typical except in Munn Lake, which has atypically low dissolved oxygen and pH.

Table 1. Water quality measurements taken at each lake surveyed in fall, 2003. Measurements taken at midday on date indicated.

	Depth (m)	Temp (°C)	pH	Oxygen (mg/l)	Conductivity (ms/cm)
Munn Lake	0	18.18	5.70	6.26	24.3
09/16/2003	1	18.13	5.72	6.18	24.3
	2	18.06	5.67	6.12	24.3
Secchi 1.6m	3	17.98	5.61	5.75	25.5
	4	16.72	5.60	0.26	100.3
	4.6	16.59	5.62	0.35	99.3
Ohop Lake	0	19.40	6.38	10.33	66.2
09/25/2003	1	19.10	7.11	9.44	66.4
	2	17.37	6.89	4.50	67.1
Secchi 0.8m	3	16.95	6.75	4.70	67.3
	4	16.68	6.61	2.90	69.2
	5	15.56	6.30	0.27	101.0
McIntosh Lake	0	18.07	6.80	8.09	54.2
10/02/2003	1	17.86	6.82	7.49	54.2
Secchi 0.65m	2	17.66	6.54	3.81	56.1
Offut Lake	0	14.10	8.00	8.10	52.0
10/29/2003	1	13.90	7.90	7.70	52.0
	2	13.80	8.00	7.50	52.0
Secchi 2.0m	3	13.70	8.00	7.30	51.0
	4	13.70	8.10	7.20	52.0
	5	13.70	8.10	7.10	52.0
	6	13.70	8.10	6.10	61.0

Species Composition and Relative Abundance

Table 2 shows species composition data by number and biomass. Five species of fish were collected in Munn Lake: largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and brown bullhead (*Ameiurus nebulosus*). Bluegill and yellow perch together comprised over 80% of the catch numerically, while largemouth bass and yellow perch together accounted for nearly 90% of the biomass.

Ohop Lake had the most diverse sample with eleven taxa (ten species and one family) represented: largescale sucker (*Catostomus macrocheilus*), yellow perch, largemouth bass, black crappie, brown bullhead, rainbow trout (*Oncorhynchus mykiss*), pumpkinseed (*L. gibbosus*), bluegill, sculpin (Cottidae), rock bass (*Ambloplites rupestris*), and lake whitefish (*Coregonus clupeaformis*). Largescale suckers represented over 60% of the biomass, while yellow perch were the dominant species numerically.

McIntosh Lake had seven taxa (six species and one family): largemouth bass, rainbow trout, yellow perch, brown trout (*Salmo trutta*), bluegill, brown bullhead, and sculpin. Largemouth bass were the primary fish in this sample both by number and weight.

Nine taxa (eight species and one family) were collected in Offut Lake: largemouth bass, rainbow trout, largescale sucker, yellow perch, brown bullhead, pumpkinseed, coho salmon (*O. kisutch*), redside shiner (*Richardsonius balteatus*), and sculpin. Largemouth bass were again the dominant species in both weight and number.

Table 3 shows stock density indices for games species sampled in each of the fall, 2003 surveys. At Munn Lake, samples sizes were too small to draw inferences for any species except yellow perch, which lacked quality size fish. The fish community in Ohop Lake seems to be the strongest of the four lakes, judging from the stock density data. Data for black crappie, largemouth bass, and yellow perch all indicate that sufficient numbers of quality size fish are available. The McIntosh Lake sample indicated some opportunities for yellow perch and possibly largemouth bass. Offut Lake anglers would probably do best to target brown bullhead or yellow perch.

Table 2. Species composition by weight and number for all fish sampled, fall 2003.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
	(kg)	(%w)	(#)	(%n)	Min	Max
Munn Lake						
Largemouth bass	6.25	46.19	51	13.49	48	440
Yellow perch	5.54	41.00	139	36.77	119	230
Black crappie	1.13	8.36	12	3.17	59	261
Bluegill	0.42	3.13	175	46.30	25	229
Brown bullhead	0.18	1.33	1	0.26	235	235
Ohop Lake						
Largescale sucker	261.03	63.61	269	15.00	100	567
Yellow perch	58.46	14.25	692	38.59	71	245
Largemouth bass	51.96	12.66	473	26.38	50	545
Black crappie	24.80	6.04	267	14.89	125	271
Brown bullhead	7.97	1.94	26	1.45	131	432
Rainbow trout	3.27	0.80	9	0.50	236	401
Pumpkinseed	1.68	0.41	25	1.39	112	185
Bluegill	0.63	0.15	21	1.17	33	145
Sculpin	0.19	0.05	8	0.45	84	148
Rock bass	0.18	0.04	2	0.11	142	177
Lake whitefish	0.17	0.04	1	0.06	268	268
McIntosh Lake						
Largemouth bass	37.90	41.98	862	48.16	58	516
Rainbow trout	27.63	30.61	332	18.55	152	490
Yellow perch	13.73	15.21	461	25.75	98	252
Brown trout	5.55	6.15	4	0.22	508	545
Bluegill	5.11	5.66	129	7.21	27	244
Brown bullhead	0.34	0.38	1	0.06	290	290
Sculpin	0.00	0.00	1	0.06	64	64
Offut Lake						
Largemouth bass	36.07	31.28	1964	72.37	57	350
Rainbow trout	21.87	18.97	253	9.32	171	368
Largescale sucker	20.80	18.04	15	0.55	163	542
Yellow perch	18.17	15.75	150	5.53	108	299
Brown bullhead	12.03	10.43	144	5.31	94	263
Pumpkinseed	4.29	3.72	138	5.08	46	141
Coho	1.78	1.55	4	0.15	338	440
Redside shiner	0.21	0.18	8	0.29	112	157
Sculpin	0.09	0.08	38	1.40	42	103

Table 3. Stock density indices, by gear type and lake, for fish sampled in fall, 2003.

		# Stock	Quality		Preferred		Memorable		Trophy	
		Length	PSD	CI (.08)	RSD-P	CI (.08)	RSD-M	CI (.08)	RSD-T	CI (.08)
Munn Lake										
EB	Black crappie	2	100	0	0	0	0	0	0	0
	Largemouth bass	11	45	19	27	17	0	0	0	0
	Yellow perch	81	0	0	0	0	0	0	0	0
GN	Black crappie	3	33	35	33	35	0	0	0	0
	Yellow perch	32	13	7	0	0	0	0	0	0
Ohop Lake										
EB	Black crappie	162	27	4	0	0	0	0	0	0
	Bluegill	8	0	0	0	0	0	0	0	0
	Brown bullhead	7	86	17	57	24	14	17	14	17
	Largemouth bass	56	23	7	16	6	7	4	0	0
	Pumpkinseed	16	31	15	0	0	0	0	0	0
	Rainbow trout	6	17	19	0	0	0	0	0	0
	Yellow perch	241	13	3	0	0	0	0	0	0
GN	Black crappie	59	7	4	0	0	0	0	0	0
	Bluegill	4	0	0	0	0	0	0	0	0
	Brown bullhead	6	67	25	33	25	0	0	0	0
	Largemouth bass	5	0	0	0	0	0	0	0	0
	Pumpkinseed	5	0	0	0	0	0	0	0	0
	Rainbow trout	2	0	0	0	0	0	0	0	0
	Rock bass	2	0	0	0	0	0	0	0	0
	Yellow perch	448	36	3	0	0	0	0	0	0
FN	Black crappie	44	82	7	2	3	0	0	0	0
	Brown bullhead	13	100	0	23	15	0	0	0	0
	Pumpkinseed	4	50	32	0	0	0	0	0	0
McIntosh Lake										
EB	Bluegill	72	11	5	0	0	0	0	0	0
	Largemouth bass	25	28	12	20	10	4	5	0	0
	Rainbow trout	16	0	0	0	0	0	0	0	0
	Yellow perch	48	21	8	2	3	0	0	0	0
GN	Bluegill	43	2	3	2	3	0	0	0	0
	Brown trout	3	100	0	100	0	100	0	100	0
	Largemouth bass	12	42	18	25	16	0	0	0	0
	Rainbow trout	9	33	20	0	0	0	0	0	0
	Yellow perch	42	38	10	0	0	0	0	0	0
Offut Lake										
EB	Brown bullhead	24	79	11	0	0	0	0	0	0
	Largemouth bass	28	0	0	0	0	0	0	0	0
	Pumpkinseed	28	0	0	0	0	0	0	0	0
	Yellow perch	11	55	19	0	0	0	0	0	0
GN	Brown bullhead	17	65	15	0	0	0	0	0	0
	Largemouth bass	13	31	16	0	0	0	0	0	0
	Pumpkinseed	82	0	0	0	0	0	0	0	0
	Rainbow trout	3	0	0	0	0	0	0	0	0
	Yellow perch	135	88	4	5	2	0	0	0	0
FN	Brown bullhead	66	59	8	0	0	0	0	0	0
	Pumpkinseed	24	0	0	0	0	0	0	0	0

Table 4. Average Catch Per Unit Effort (CPUE) separated by gear type and lake, for fish sampled in fall, 2003

	Electrofishing			Gill Netting			Fyke Netting		
	(# / hour)	80% CI	Sites	# per net night	80% CI	net nights	# per net night	80% CI	net nights
Munn Lake									
Brown bullhead	2	2.56	3	0		2	0		2
Black crappie	4	2.56	3	1.5	0.64	2	0.5	0.64	2
Bluegill	2	2.56	3	0.5	0.64	2	0		2
Largemouth bass	22	6.78	3	0		2	0		2
Yellow perch	162	145.15	3	16	1.28	2	0		2
Ohop Lake									
Brown bullhead	2.8	1.48	15	0.75	0.32	8	1.63	1.11	8
Black crappie	64.67	12.95	15	7.38	3.53	8	5.5	6.51	8
Bluegill	3.2	1.27	15	0.5	0.48	8	0		8
Sculpin	3.2	1.48	15	0		8	0		8
Largemouth bass	22.38	5.12	15	0.625	0.42	8	0		8
Largescale sucker	41.54	7.49	15	20.38	5.55	8	0.25	0.32	8
Lake whitefish	0		15	0.13	0.16	8	0		8
Pumpkinseed	6.39	2.54	15	0.63	0.48	8	0.5	0.48	8
Rainbow trout	2.4	1.64	15	0.25	0.21	8	0		8
Rock bass	0		15	0.25	0.32	8	0		8
Yellow perch	96.16	22.84	15	56	13.57996	8	0		8
McIntosh Lake									
Bluegill	54.78	13.06	8	7.17	0.96	6	0		6
Yellow perch	36.83	12.72	8	7	2.32	6	0		6
Rainbow trout	12.21	5.16	8	1.5	0.72	6	0.17	0.21	6
Largemouth bass	19.01	4.39	8	2	0.57	6	0		6
Brown trout	0.75	0.96	8	0.5	0.44	6	0		6
Sculpin	0.75	0.96	8	0		6	0		6
Brown bullhead	0		8	0		6	0.17	0.21	6
Offut Lake									
Brown bullhead	16	17.71	9	2.83	2.68	6	11	13.59	6
Coho	0		9	0.67	0.27	6	0		6
Sculpin	25.33	10.86	9	0		6	0		6
Largemouth bass	18.67	4.87	9	2.17	1.60	6	0		6
Largescale sucker	0.67	0.85	9	2.33	1.08	6	0		6
Pumpkinseed	18.67	7.07	9	13.67	3.84	6	4	2.67	6
Rainbow trout	0.67	0.85	9	0.5	0.44	6	0		6
Redside shiner	0		9	1.33	1.71	6	0		6
Yellow perch	7.33	6.25	9	22.5	4.32	6	0		6

Table 4 contains CPUE data. Catch rate trends by gear type in all four lakes followed patterns typically seen in western Washington warmwater surveys; electrofishing catch rates are generally highest and fyke net CPUE generally lowest, with some species-specific variations. Some indices show variability by season (Pope and Willis 1996), which must be considered when evaluating these data.

Summary by Species

Munn Lake

Largemouth Bass (*Micropterus salmoides*)

Of the 51 largemouth bass sampled at Munn Lake, only 11 were stock size or larger. Length-at-age data can be found in Table 5. Growth of age-1 largemouth bass in Munn Lake were below

Table 5. Mean back-calculated length-at-age for largemouth bass sampled from Munn Lake, Thurston County, fall 2003.

		Age Class								
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2002	14	75								
2001	5	62	168							
2000	2	65	178	305						
1999	1	76	174	276	370					
1998	1	81	208	281	321	379				
1997	0									
1996	0									
1995	0									
1994	1	66	124	219	297	333	372	391	407	427
Fraser Lee	**24**	**71**	**170**	**277**	**329**	**356**	**372**	**390**	**407**	**426**
W WA Ave		**82**	**181**	**277**	**337**	**382**	**420**	**445**	**461**	**478**

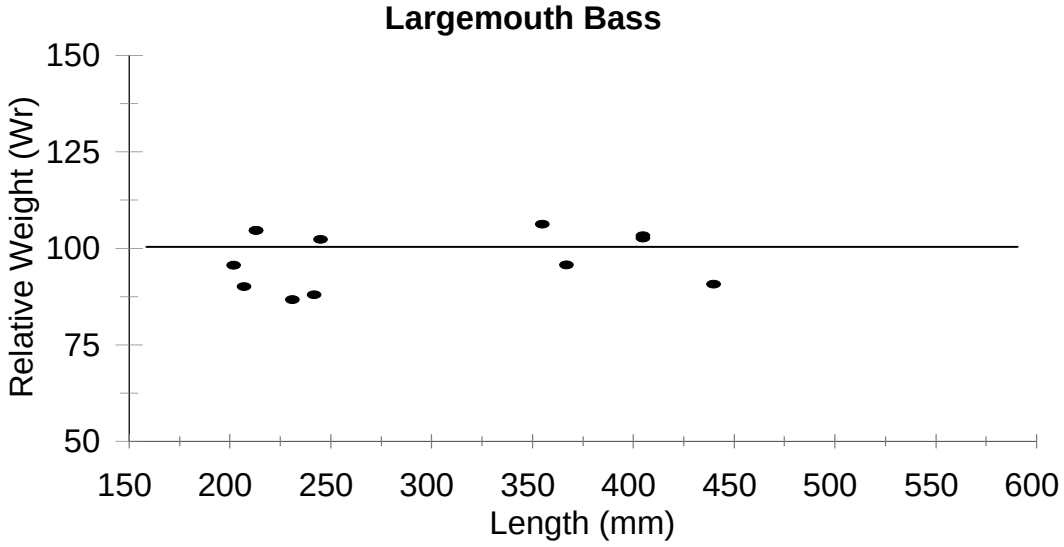

Figure 1. Relative weights of stock size largemouth bass from the fall, 2003 survey of Munn Lake, Thurston County. Horizontal line at 100 represents the national 75th percentile.

the western Washington average ($P < .0001$); age-2 and -3 were statistically within the range of regional means ($P = .1794$ and .4898, respectively). Relative weights for stock size fish (Figure 1) ranged from 87 to 106, with a mean of 96. Although this population appears typical for western Washington, the small sample size limits our ability to analyze these results.

Yellow Perch *(Perca flavescens)*

Yellow perch in our Munn Lake sample were numerous (Table 2) and were dominated by stock size fish (81%), which resulted in a very high CPUE (Table 4). However quality size fish were scarce (Table 3). Length-at-age data can be found in Table 6. Mean growth of age-1 fish was statistically typical for western Washington lakes ($P = .3170$). Relative weights for stock size

Table 6. Mean back-calculated length-at-age data for yellow perch sampled from Munn Lake, Thurston County fall 2003

		Age Class	
Year Class	**# Fish**	**1**	**2**
2002	40	88	
2001	2	97	179
Fraser Lee	**42**	**88**	**179**
W WA Ave		**90**	**161**

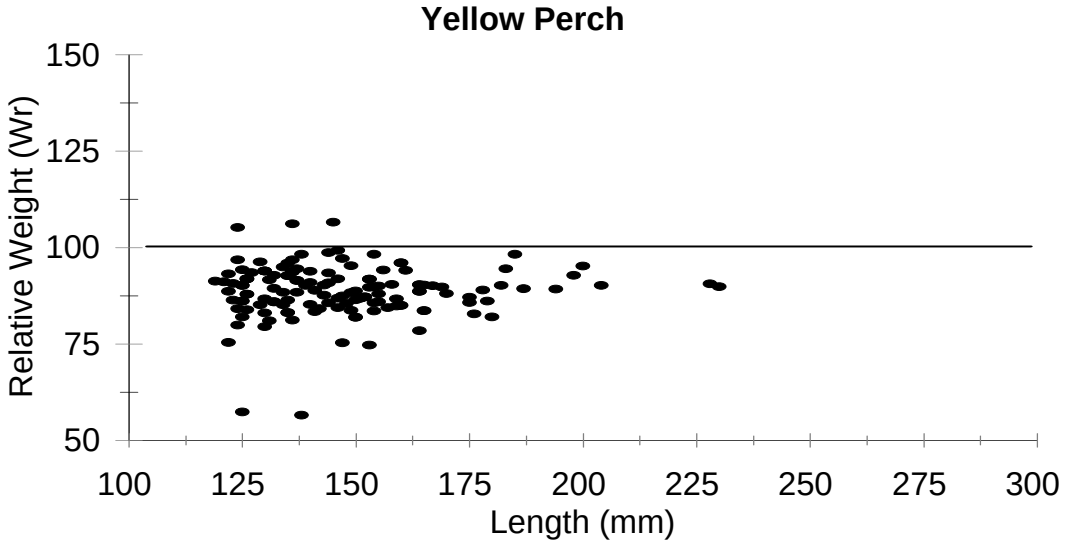

Figure 2. Relative weights of stock size yellow perch from the fall, 2003 survey of Munn Lake, Thurston County. Horizontal line at 100 represents the national 75th percentile.

yellow perch (Figure 2) ranged from 57 to 107, with a mean of 89. Figure 3 shows the length frequency distribution separated by gear type. Note the size distinction between gear types.

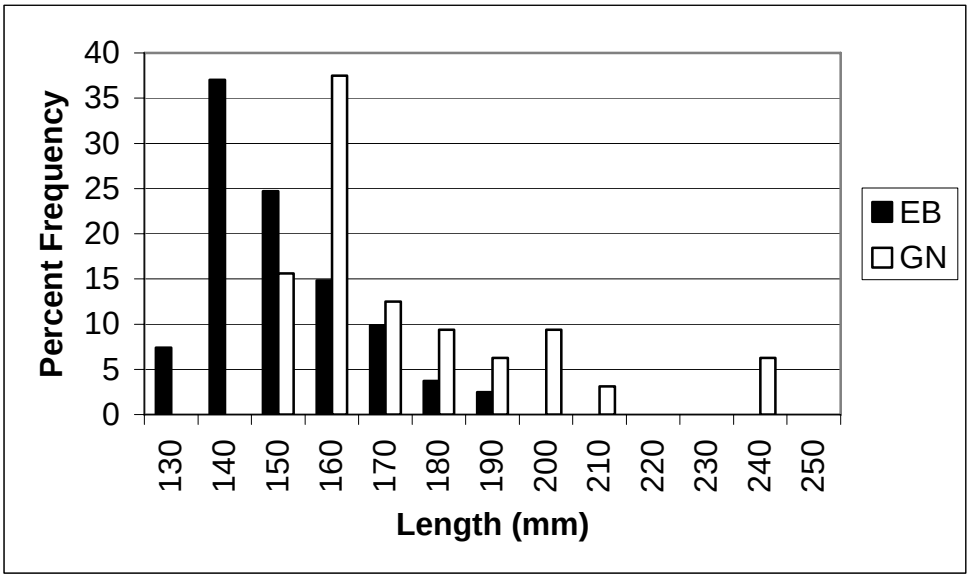

Figure 3. Length-frequency distribution for yellow perch collected from Munn Lake, Thurston County, fall 2003.

Black Crappie (*Pomoxis nigromaculatus*)

Table 7 has the length-at-age data for black crappie. Six of the twelve fish in our sample were young-of-the-year; stock size fish ranged from 148 to 261 mm total length. Relative weights of stock size black crappie ranged from 96 to 112, with a mean of 103. Too few fish were collected for meaningful analyses.

Table 7. Mean back-calculated length-at-age data for black crappie sampled from Munn Lake, Thurston County, fall 2003

		Age Class	
Year Class	**# Fish**	**1**	**2**
2002	2	62	
2001	4	70	180
Fraser Lee	**6**	**67**	**180**
W WA Ave		**75**	**148**

Bluegill (*Lepomis macrochirus*)

Only two of the 175 bluegills collected at Munn Lake exceeded 50 mm in total length. The first was an age-1 bluegill, 81 mm, and the other was an age-4 fish, 229 mm.

Brown Bullhead (*Ameiurus nebulosus*)

A single brown bullhead was collected at Munn Lake, 235 mm total length. No age or growth analysis was conducted.

Ohop Lake

Yellow Perch (*Perca flavescens*)

Yellow perch were the most common fish in our sample at Ohop Lake and represented the most biomass of any game fish (Table 2). Only ten of the 692 yellow perch collected were less than stock size, and stock density data (Table 3) show a large percentage of fish greater than stock size. Length-at-age data is in Table 8. Age-1 yellow perch were smaller than the western Washington mean ($P < .0001$) and smaller in 2003 than they were in 2000 ($P = .0001$); age-2 fish were statistically similar in size to the regional mean and across surveys ($P = .1767$ and .2442, respectively). Relative weights (Figure 4) ranged from 70 to 115, with a mean of 96. Figure 5 shows the length-frequency distribution, separated by gear type. Again, note the different sizes for each gear type.

Table 8. Mean back-calculated length-at-age for yellow perch sampled from Ohop Lake, Pierce County, fall 2003.

		Age Class			
Year Class	**# Fish**	**1**	**2**	**3**	**4**
2002	28	75			
2001	25	69	157		
2000	0				
1999	2	68	149	184	222
Fraser Lee	**55**	**72**	**156**	**184**	**222**
2000 Survey	**44**	**80**	**159**	**196**	
W WA Ave		**90**	**161**	**201**	**230**

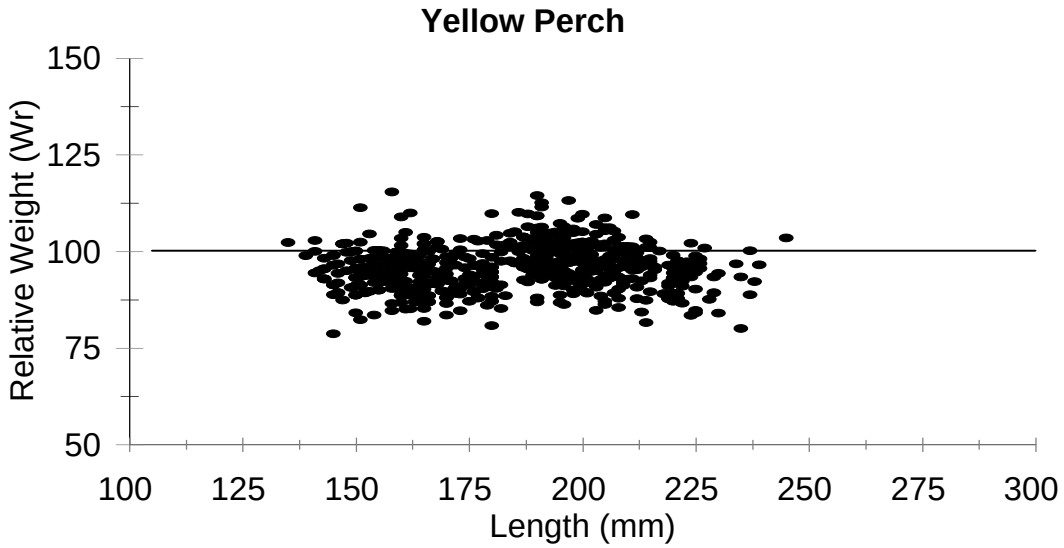

Figure 4. Relative weights of stock size yellow perch from the fall, 2003 survey of Ohop Lake, Pierce County. Horizontal line at 100 represents the national 75th percentile

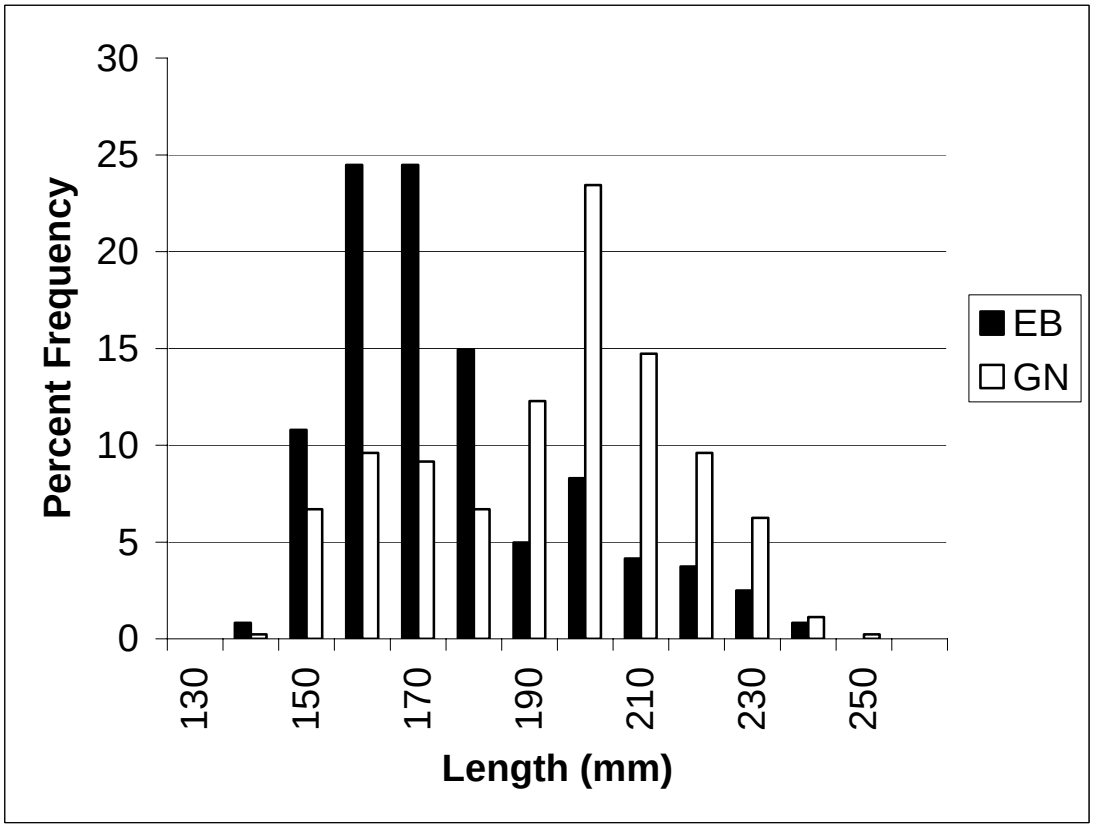

Figure 5. Length-frequency distribution for yellow perch collected from Ohop Lake, Pierce County, fall 2003.

Largemouth Bass (*Micropterus salmoides*)

Largemouth bass were the second most abundant game fish in Ohop Lake, both by number and by weight (Table 2). Our sample consisted of 13% stock size fish or larger, including several large fish in the 15 – 21" range (400 - 545 mm, Figure 5). Length-at- age data can be found in Table 9. Largemouth bass in Ohop Lake were larger than the western Washington average at every age with sufficient sample size (age-1 to age-7, $P = .0106$ to $P < .0001$), and were larger in 2003 than in 2000 at every age except age-3 ($P = .0115$ to $P = .0003$;

Table 9. Mean back-calculated length-at-age for largemouth bass sampled from Ohop Lake, Pierce County, fall 2003.

		Age Class											
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
2002	49	103											
2001	5	84	210										
2000	1	93	219	338									
1999	1	66	194	299	357								
1998	1	82	199	312	392	428							
1997	1	98	184	291	370	418	446						
1996	1	122	284	379	443	473	488	505					
1995	1	66	245	328	398	426	444	475	490				
1994	2	69	232	325	414	448	468	492	506	516			
1993	0												
1992	0												
1991	1	56	201	255	356	417	452	468	487	499	509	524	538
Fraser Lee	**63**	**98**	**217**	**317**	**393**	**437**	**461**	**486**	**497**	**511**	**509**	**524**	**538**
2000 Survey	**38**	**86**	**192.4**	**297.3**	**364**	**402.4**	**419.7**	**432.7**	**450.1**	**465.4**	**472.6**	**486.2**	**479.5**
W WA Ave		**82**	**181**	**277**	**337**	**382**	**420**	**445**	**461**	**478**	**489**	**496**	**504**

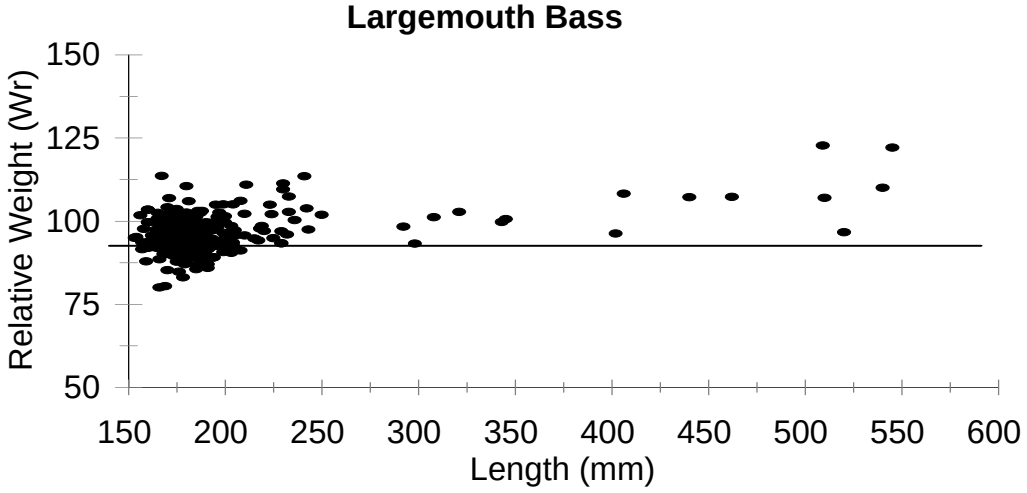

Figure 6. Relative weights of stock size largemouth bass from the fall, 2003 survey of Ohop Lake, Pierce County. Horizontal line at 100 represents the national 75th percentile.

age-3 *P* = .0991). Relative weights (Figure 6) ranged from 80 to 123 with a mean of 96.

Black Crappie (*Pomexis nigromaculatus*)

Only 2 of the 267 black crappie collected at Ohop Lake in 2003 were less than stock size. Age data can be found in Table 10. Length-at-age of age-1 and -2 black crappie were similar to western Washington averages (*P* = .1941 and .1231, respectively); across surveys, age-1 fish from 2003 were slightly smaller than their 2000 counterparts (*P* = .0379) while age-2 crappie remained similar in size (*P* = .2283). Relative weights ranged from 88 to 125 and averaged 108, declining with length (*r* = -.5437) (Figure 7).

Figure 8 shows the length-frequency distribution for the 2003 black crappie sample. Fish captured by electrofishing show a distinct bimodal distribution; gillnetted fish were similar in size to the first electrofishing peak and fyke netted fish were mimicked the second peak.

Table 10. Mean back-calculated length-at-age for black crappie sampled from Ohop Lake, Pierce County, fall 2003.

		Age Class		
Year Class	**# Fish**	**1**	**2**	**3**
2002	26	73		
2001	26	70	153	
2000	1	72	181	248
Fraser Lee	**53**	**72**	**154**	**248**
2003 Survey	**28**	**76**	**159**	**231**
W WA Ave		**75**	**148**	**203**

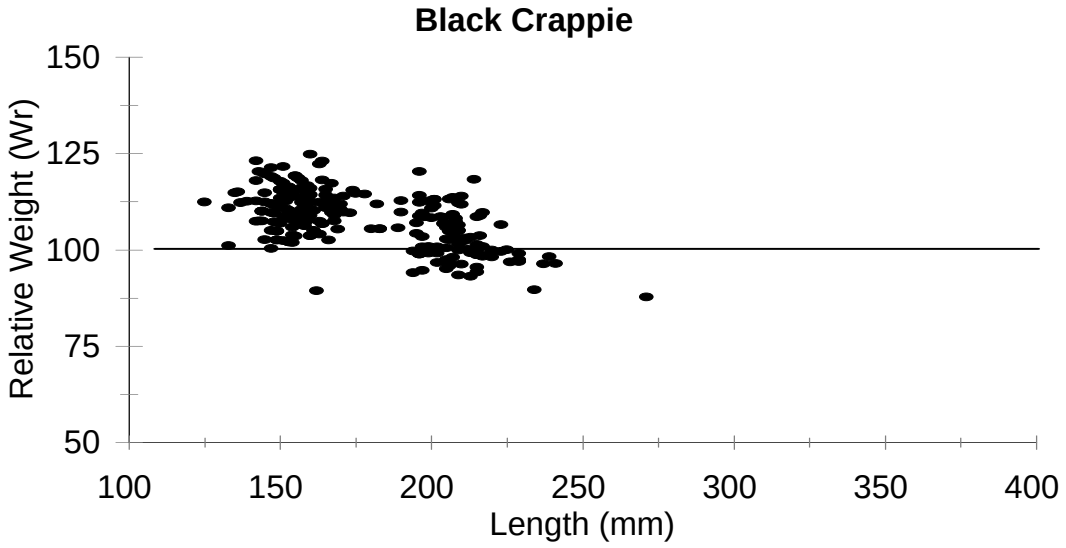

Figure 7. Relative weights of stock size black crappie from the fall, 2003 survey of Ohop Lake, Pierce County. Horizontal line at 100 represents national 75th percentile.

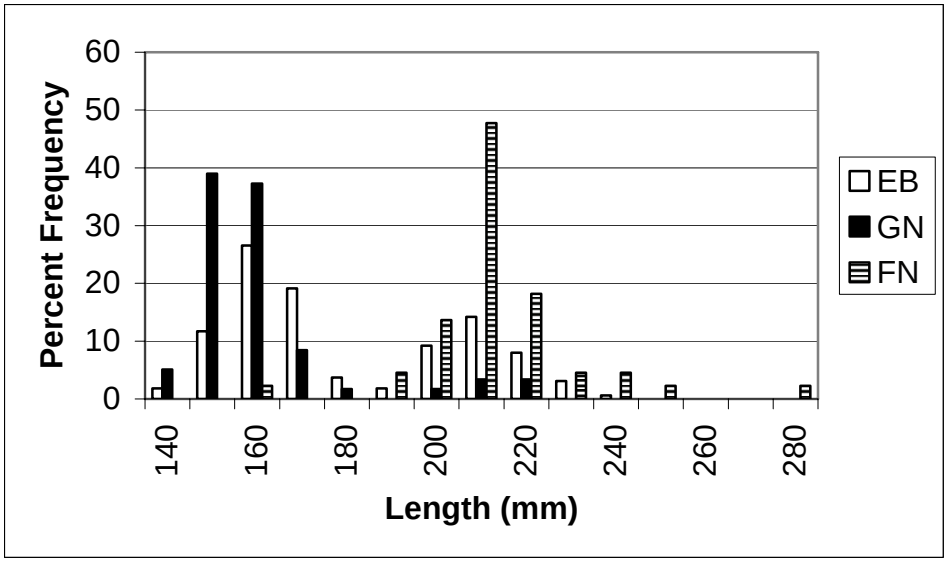

Figure 8. Length-frequency distribution for black crappie collected from Ohop Lake, Pierce County, fall 2003.

Brown Bullhead (*Ameirus nebulosus*)

Twenty-six brown bullheads were collected from Ohop Lake in 2003 (Table 2); all were stock size, and several were large specimens in excess of 12" (305 mm). No age or growth analysis was conducted; relative weights were generally low and averaged 89 (Figure 9), increasing with length (r = .1079). Only 3 brown bullhead were collected in the spring 2000 survey.

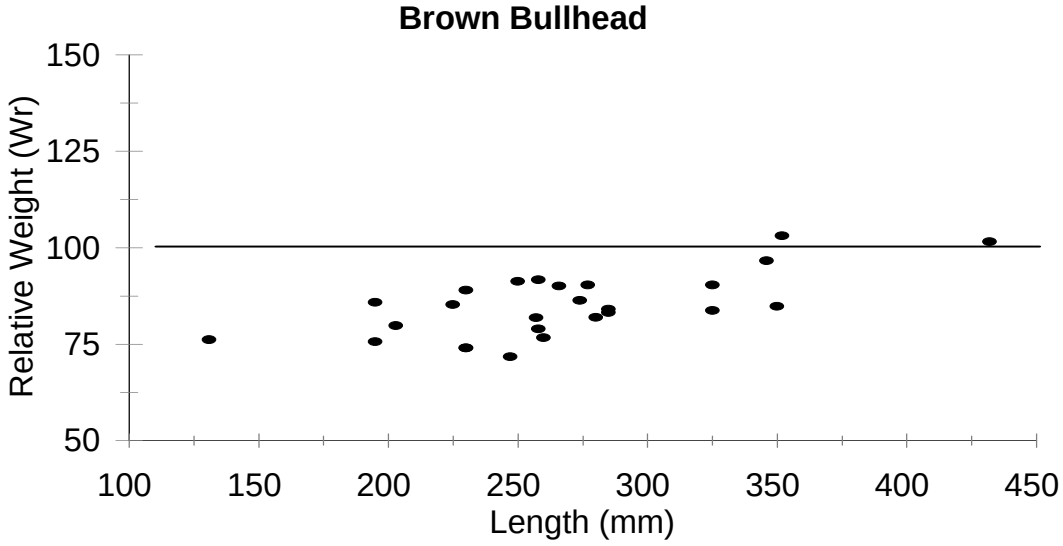

Figure 9. Relative weights of stock size brown bullhead from the fall, 2003 survey of Ohop Lake, Pierce County. Horizontal line at 100 represents national 75th percentile.

Rainbow Trout (*Oncorhynchus mykiss*)

Nine rainbow trout were collected from Ohop Lake in 2003, ranging in size from 9 – 16". No age or growth analysis was conducted on these fish. These fish are presumed to be the result of annual hatchery plants (Table 11).

Table 11. Hatchery planting data for Ohop Lake, Pierce County, 1998-2003.

Date of Release	Species	Brood Year	Size	Fish Per Pound	Number Planted
Mar-98	Rainbow	1996	legals	4.0	18,000
May-98	Rainbow	1996	legals	3.4	15,215
May-98	Rainbow	1997	fry	21.5	29,992
Apr-99	Rainbow	1997	legals	4.1	20,000
Feb-00	Rainbow	1998	legals	1.2	150
Apr-00	Rainbow	1998	legals	4.1	16,000
Apr-01	Rainbow	1999	legals	4.0	20,000
May-01	Rainbow	1999	legals	0.7	500
Feb-02	Rainbow	2000	legals	8.0	5,000
Apr-02	Rainbow	2000	legals	2.7	16,500
Apr-02	Rainbow	2000	legals	1.0	500
May-02	Rainbow	2000	legals	2.8	1,500
May-02	Rainbow	2000	legals	0.6	130
Apr-03	Rainbow	2001	legals	3.1	22,500
May-03	Rainbow	2000	legals	0.7	500

Pumpkinseed (*Lepomis gibbosus*)

All 25 pumpkinseed collected from Ohop Lake were stock size or larger fish. Length-at-age data can be found in Table 12; age-1 and –2 lengths-at-age were consistent with both the western Washington average and the 2000 sample (P = .1199 to .3375). Relative weights (Figure 10) were high, ranging from 100 to 122 with a mean of 109.

		Age Class			
Year Class	**# Fish**	**1**	**2**	**3**	**4**
2002	12	54			
2001	5	52	121		
2000	2	40	96	132	
1999	1	39	97	151	175
Fraser Lee	**20**	**51**	**112**	**138**	**175**
2000 Survey	**16**	**49**	**115**	**156**	
W WA Ave		**50**	**102**	**137**	**151**

Table 12. Mean back-calculated length-at-age for pumpkinseed sampled from Ohop Lake, Pierce County, fall 2003.

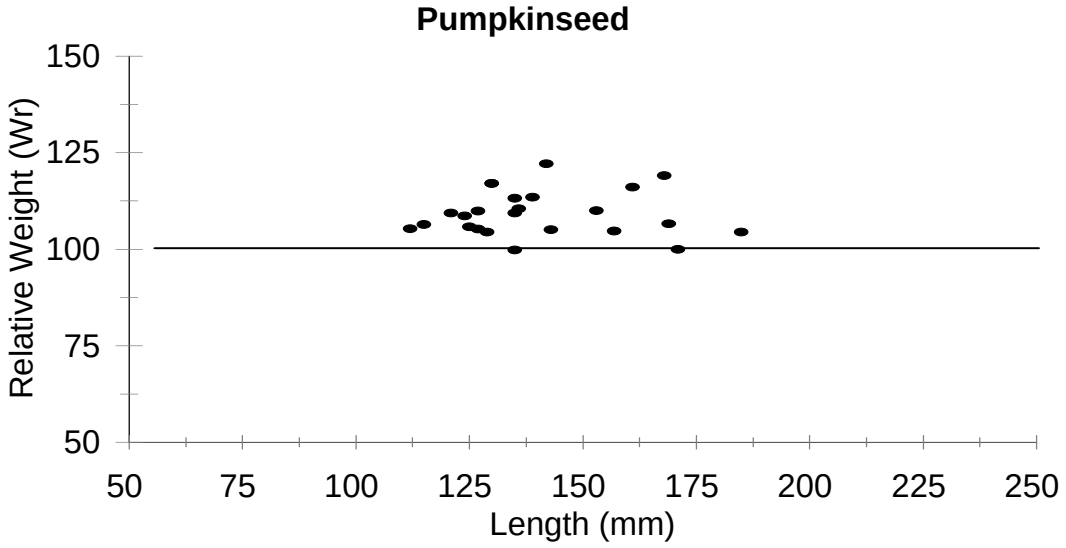

Figure 10. Relative weights of stock size pumpkinseed from the fall, 2003 survey of Ohop Lake, Pierce County. Horizontal line at 100 represents national 75th percentile.

Bluegill (*Lepomis macrochirus*)

Only 12 of the 21 bluegills in our sample were stock size, and none reached quality size. Eleven fish were aged; all were age-1 with a mean length of 47 mm, consistent with the western Washington average length-at-age (P = .0004). Relative weights ranged from 92 to 116 with a mean of 101. Only two bluegills were collected in the 2000 survey.

Rock Bass (*Ambloplites rupestris*)

Two rock bass were collected in Ohop Lake in 2003 (Table 2): 142 mm (age-1) and 177 mm (age-3). Relative weights were 93 and 100, respectively. No rock bass were present in the spring 2000 survey.

Other Taxa

Non-game fish in our sample included 269 largescale suckers (the largest percentage of fish in our sample by weight), 8 sculpin, and a single lake whitefish (Table 2). No age or growth analysis was conducted on these fish.

McIntosh Lake

Largemouth Bass (*Micropterus salmoides*)

Largemouth bass dominated the McIntosh Lake sample both numerically and by weight (Table 2), but only 4% were stock-length or larger. Length-at-age data can be found in Table 13. Largemouth bass in McIntosh Lake grew faster than the western Washington average at every age class up to age-6 ($P < .0001$ to $P = .0253$). Age-4 and older fish grew much faster than the average, possibly due to missing or weak age classes. Relative weights (Figure 11) ranged from 44 to 143 with a mean of 103 and increased with length ($r = .7492$). Figure 12 shows the length-frequency distribution of stock-length fish, with a gap from 365 mm (age-2) to 440 mm (age-4).

Table 13. Mean back-calculated length-at-age for largemouth bass sampled from McIntosh Lake, Thurston County, fall 2003.

		Age Class						
Year Class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2002	39	86						
2001	4	88	203					
2000	0							
1999	2	108	203	334	401			
1998	0							
1997	5	104	224	335	404	440	464	
1996	1	92	181	315	403	448	480	501
Fraser Lee	**51**	**89**	**210**	**332**	**403**	**441**	**467**	**501**
W WA Ave		**82**	**181**	**277**	**337**	**382**	**420**	**445**

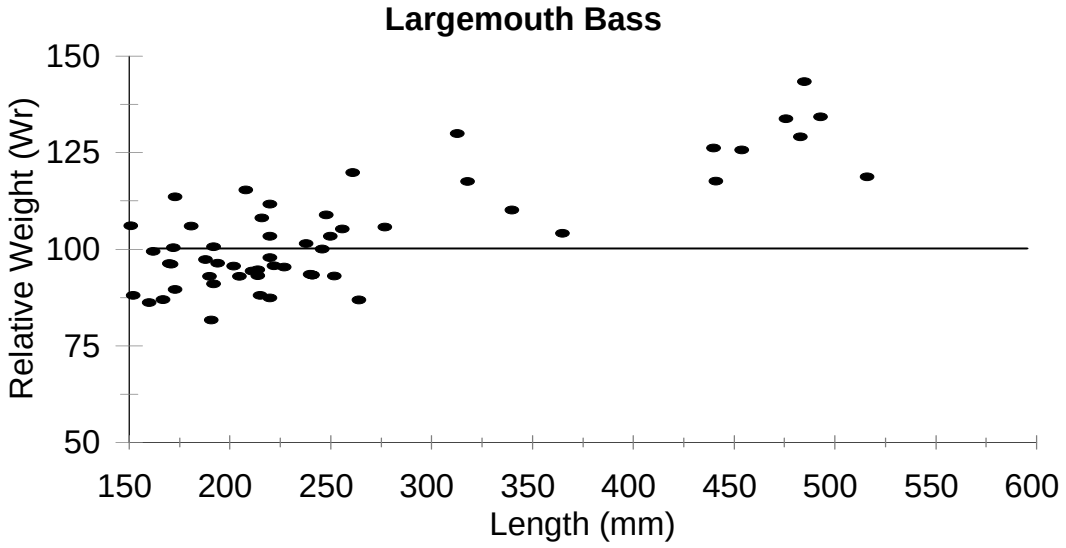

Figure 11. Relative weights of stock size largemouth bass from the fall, 2003 survey of McIntosh Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

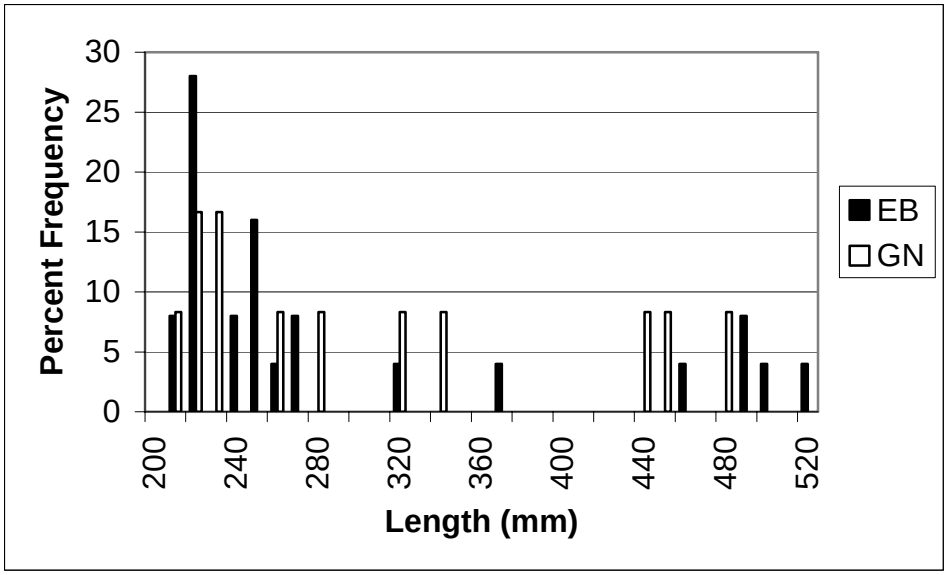

Figure 12. Length-frequency distribution for stock-length largemouth bass collected from McIntosh Lake, Thurston County, fall 2003.

Rainbow Trout (*Oncorhynchus mykiss*)

Three hundred and thirty-two rainbow trout were collected from McIntosh Lake, ranging in size from 6 – 19". No age or growth analysis was collected on these fish. These fish are presumed to be the result of annual hatchery plants of both rainbow and steelhead trout (Table 14). Because rainbow and steelhead are considered a single species, *Oncorhynchus mykiss* (Wydoski and Whitney 2003; Behnke 1992), they are referred to jointly as rainbow trout.

Table 14. Hatchery planting data for McIntosh Lake, Thurston County, 1998-2003

Date of Release	Species	Brood Year	Size	Fish Per Pound	Number Planted
Apr-98	Rainbow	1996	legals	3.8	10,013
Jun-98	Rainbow	1997	fry	87.0	33,060
Mar-99	Cutthroat	1996	legals	1.2	504
Apr-99	Steelhead	adult	adults	0.1	38
Apr-99	Rainbow	1997	legals	3.3	10,008
May-99	Cutthroat	1999	fry	231.0	5,082
Jun-99	Rainbow	1998	fry	88.0	35,200
Mar-00	Rainbow	1998	legals	3.3	5,200
Apr-00	Steelhead	adult	adults	0.1	37
Apr-00	Rainbow	1998	legals	3.1	4,798
Apr-00	Cutthroat	1997	jumbos	1.3	200
Jun-00	Cutthroat	2000	fry	278.0	5,004
Jun-00	Rainbow	1999	fry	102.0	35,190
Apr-01	Rainbow	1999	legals	3.4	9,996
May-01	Cutthroat	2001	fry	238.1	5,000
May-01	Rainbow	2000	fry	127.7	35,000
Mar-02	Steelhead	adult	adults	0.1	124
Apr-02	Rainbow	2000	legals	3.5	10,089
Apr-02	Rainbow	1999	jumbos	0.6	132
Jun-02	Cutthroat	2002	fry	116.0	5,104
Jun-02	Rainbow	2001	fry	87.0	44,979
Mar-03	Rainbow	2001	legals	3.4	3,009
Mar-03	Rainbow	adult	adults	0.4	100
Apr-03	Rainbow	2001	legals	3.6	7,003
May-03	Rainbow	2002	fry	95.0	38,000

Yellow Perch (*Perca flavescens*)

Yellow perch were the second most abundant fish in our survey. Stock length fish comprised 19.5% of the sample. Of 60 yellow perch aged, none were older than age-1. Age-1 mean length-at-age was 126 mm, well beyond the western Washington average of 90 mm ($P < .0001$). Relative weights (Figure 13) ranged from 66 to 121 and averaged 94. Figure 14 shows the length-frequency distribution separated by gear type.

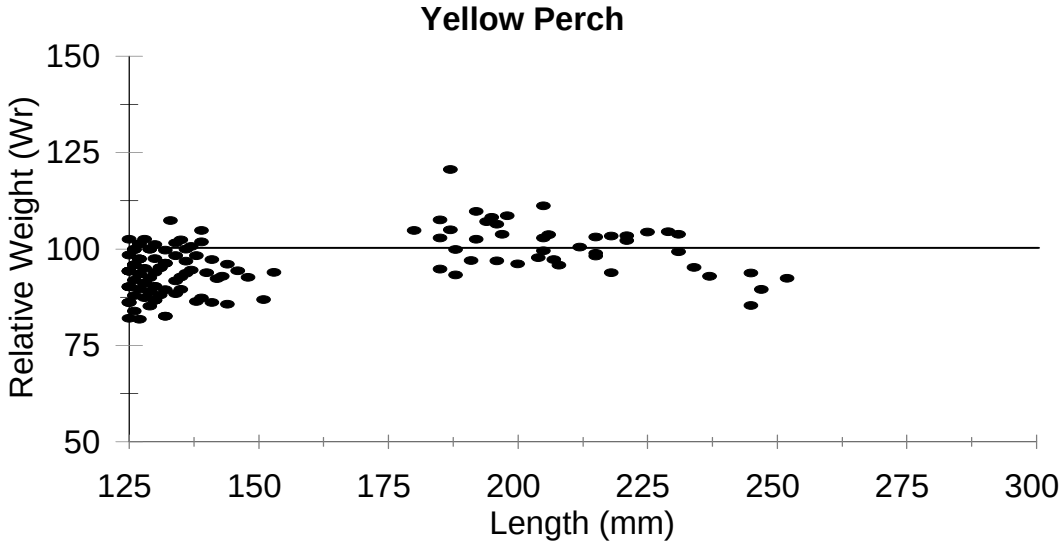

Figure 13. Relative weights of stock size yellow perch from the fall, 2003 survey of McIntosh Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

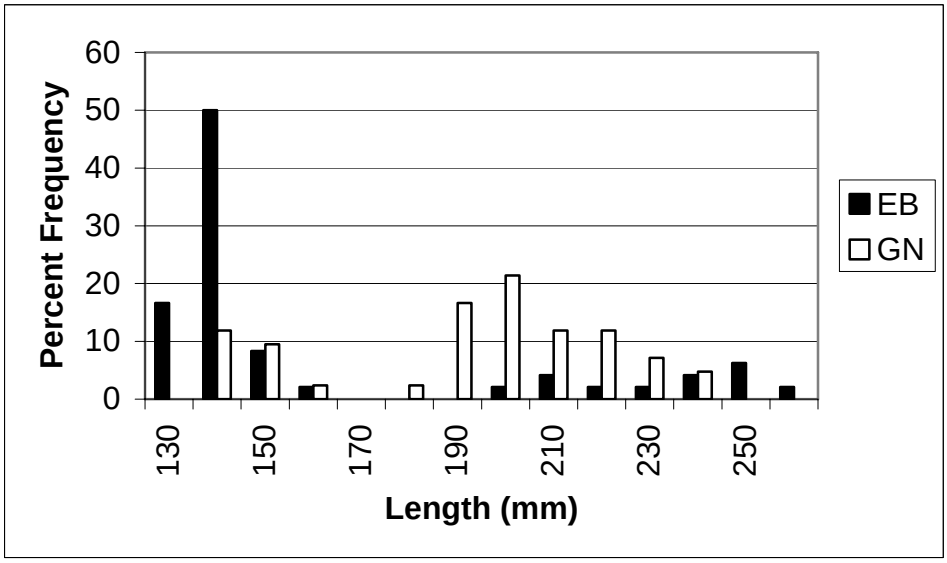

Figure 14. Length-frequency distribution for stock size yellow perch collected from McIntosh Lake, Thurston County, fall 2003

Brown Trout (*Salmo trutta*)

Four brown trout were collected from McIntosh Lake, ranging in size from 20-22". Brown trout are a non-native species that have never been officially planted in McIntosh Lake according to WDFW records (WDFW Hatchery Data Unit, unpublished data). No age or growth analysis was conducted on these fish.

Bluegill (*Lepomis macrochirus*)

Nearly 90% of the bluegill collected from McIntosh Lake were stock size fish. Table 15 shows length-at-age data. The growth of age-1 fish was consistent with the state average (P = .3270). Relative weights (Figure 15) ranged from 85 to 121 with a mean of 102. Relative weights showed a positive correlation to length (r = .5784).

Table 15. Mean back-calculated length-at-age for bluegill sampled from McIntosh Lake, Thurston County, fall 2003

		Age Class			
Year Class	**# Fish**	**1**	**2**	**3**	**4**
2002	38	36.8			
2001	0				
2000	1	34.1	108.7	147.2	
1999	1	38.5	101.7	181.7	223.8
Fraser Lee	**40**	**37**	**105**	**164**	**224**
W WA Ave		**38**	**88**	**131**	**170**

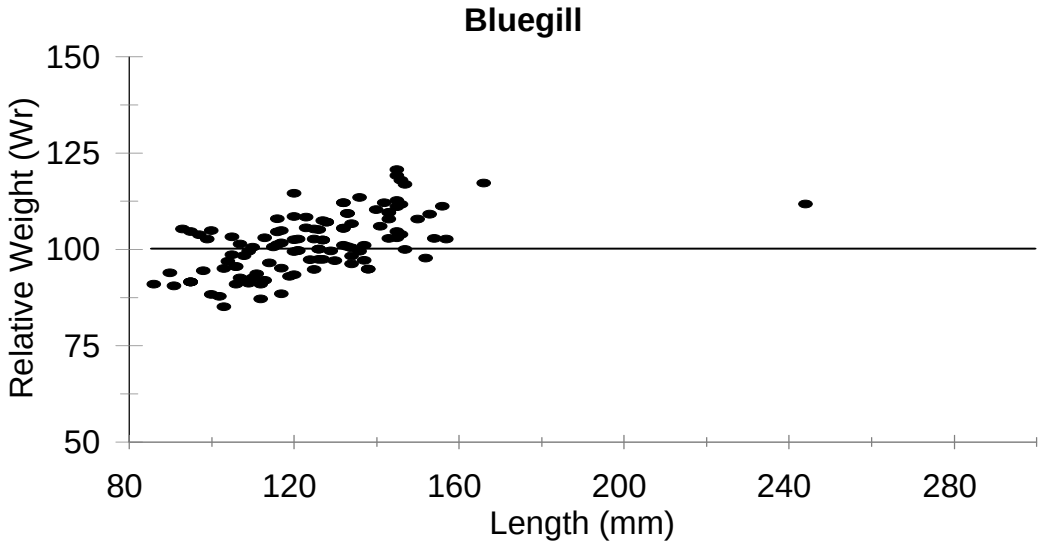

Figure 15. Relative weights of stock size bluegill from the fall, 2003 survey of McIntosh Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

Other Taxa

One brown bullhead and one sculpin were also included in the McIntosh Lake sample (Table 2). No age or growth analysis was conducted on these fish.

Offut Lake

Largemouth Bass (*Micropterus salmoides*)

Largemouth bass were the most abundant fish in the Offut Lake sample both numerically and by weight (Table 2), but only 2% were stock-length fish. Table 16 has length-at-age data. The mean length of age-1 largemouth bass in Offut Lake was below the western

Table 16. Mean back-calculated length-at-age for largemouth sampled from Offut Lake, Thurston County, fall 2003.

		Age Class	
Year Class	**# Fish**	**1**	**2**
2002	46	69	
2001	3	75	182
Fraser Lee	**49**	**70**	**182**
W WA Ave		**82**	**181**

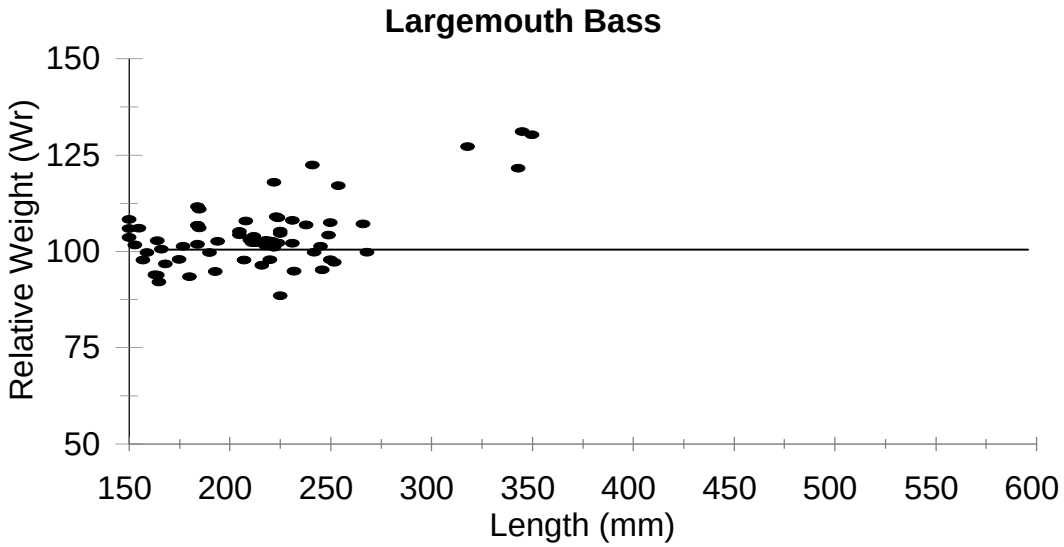

Figure 16. Relative weights of stock size largemouth bass from the fall, 2003 survey of Offut Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

Washington average ($P < .0001$). Relative weights ranged from 88 to 131 with a mean of 104 and were positively related to length ($r = .5931$) (Figure 16).

Rainbow Trout (*Orcorhynchus mykiss*)

Rainbow trout were the second most abundant species in our sample by both weight and number and ranged in size from 7 – 14". No age or growth analysis was conducted on these hatchery-planted fish. Hatchery planting data is in Table 16.

Table 17. Hatchery planting data for Offut Lake, Thurston County, 1998-2003.

Date of Release	Species	Brood Year	Size	Fish Per Pound	Number Planted
Mar-98	Rainbow	1995	legals	0.4	200
Apr-98	Rainbow	1996	legals	3.8	15,029
May-98	Rainbow	1996	legals	3.0	4,185
Jun-98	Rainbow	1997	fry	85.0	44,965
Oct-98	Rainbow	1996	legals	0.3	365
Mar-99	Rainbow	1997	legals	3.8	10170
Apr-99	Rainbow	1997	legals	4.0	5,840
Jun-99	Rainbow	1998	fry	101.0	49,995
Oct-99	Rainbow	1996	fry	65.0	13
Oct-99	Rainbow	1997	fry	276.7	83
Nov-99	Black crappie	1999	fry	298.0	2,384
Apr-00	Cutthroat	1997	yearlings	1.3	200
Jun-00	Rainbow	1999	fry	102.0	44,370
Mar-01	Rainbow	1998	legals	0.5	125
Mar-01	Rainbow	2001	legals	0.7	400
May-01	Rainbow	2000	fry	128.0	47,350
June-01	Rainbow	2000	fry	44.0	7,700
Mar-02	Rainbow	1999	legals	0.4	126
Mar-02	Rainbow	1999	yearlings	1.2	204
Apr-02	Rainbow	2001	legals	5.0	20,000
May-02	Rainbow	1999	legals	0.6	102
May-02	Rainbow	2001	fry	121.0	50,094
Nov-02	Rainbow	2001	legals	8.5	9,285
Mar-03	Rainbow	adult	adult	0.4	100
Apr-03	Rainbow	2002	legals	5.0	19,800
May-03	Rainbow	2001	legals	3.0	4,995
May-03	Rainbow	2000	legals	0.7	500
May-03	Rainbow	2002	fry	95.0	60,800

Yellow Perch (*Perca flavescens*)

Only four of the 150 yellow perch collected from Offut Lake were less than stock length. Growth exceeded the state average for both age classes collected ($P < .0001$ for both ages); age data is in table 17. Relative weights ranged from 70 to 103 with a mean of 83 (Figure 17). Length frequency data, separated by gear type, is shown in Figure 18. Once again, the size difference between the electrofishing sample and the gill netted sample is evident.

Table 18. Mean back-calculated length-at-age for yellow perch sampled from Offut Lake, Thurston County, fall 2003

		Age Class	
Year Class	**# Fish**	**1**	**2**
2002	23	107	
2001	14	105	199
Fraser Lee	**37**	**106**	**199**
W WA Ave		**90**	**161**

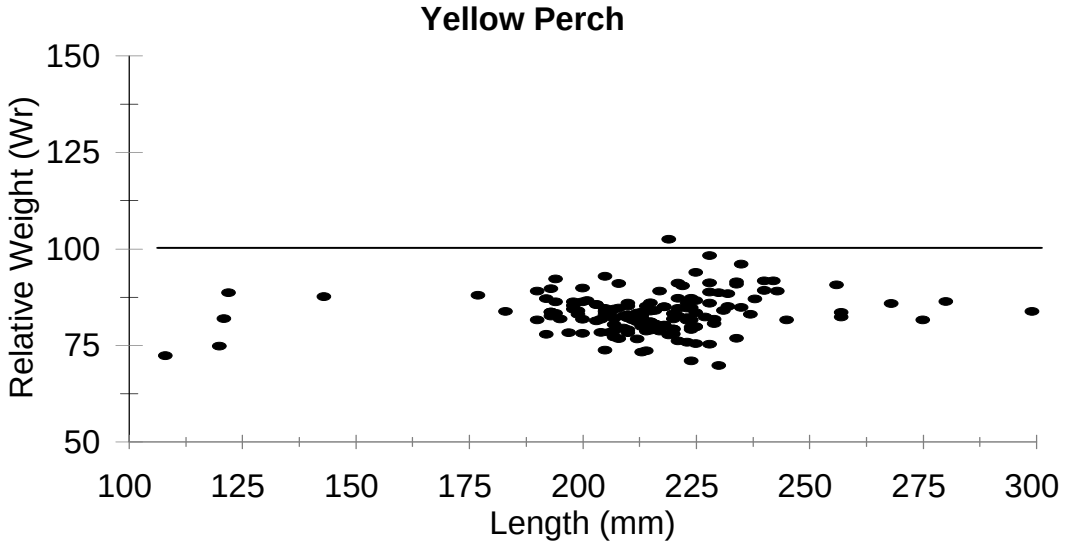

Figure 17. Relative weights of stock size yellow perch from the fall, 2003 survey of Offut Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

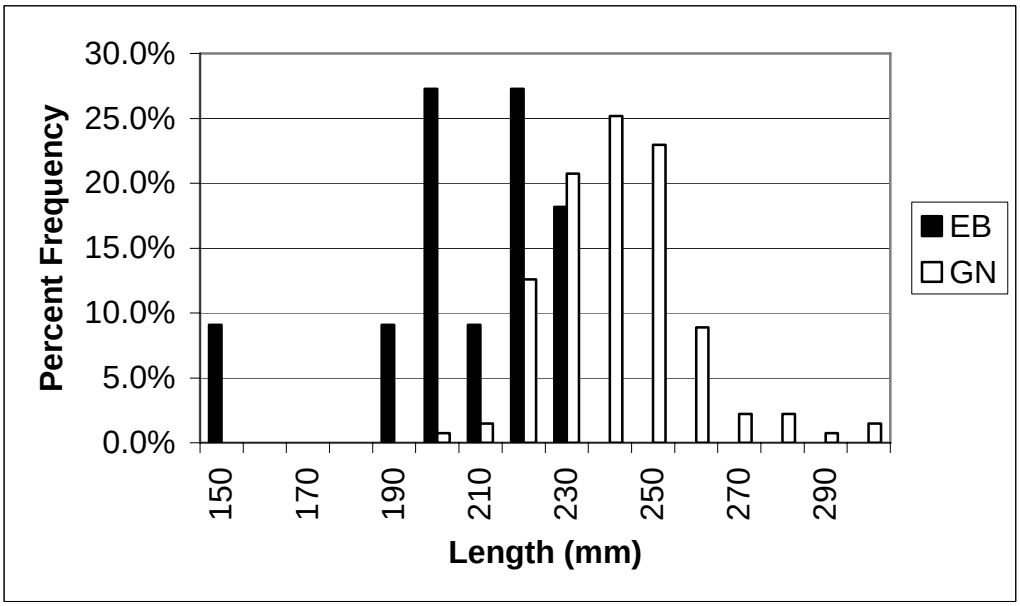

Figure 18. Length-frequency distribution for stock size yellow perch collected from Offut Lake, Thurston County, fall 2003

Brown Bullhead (*Ameiurus nebulosus*)

Nearly three-fourths of the 144 brown bullhead collected in Offut Lake were stock size or larger, with most of the stock size fish collected in fyke nets (Tables 2 and 3). No age or growth analysis was conducted on these fish. PSDs were high for every gear type (Table 2). Relative weights ranged from 72 to 100, with a mean of 83 (Figure 19). The length-frequency distribution, separated by gear type, can be seen in Figure 20.

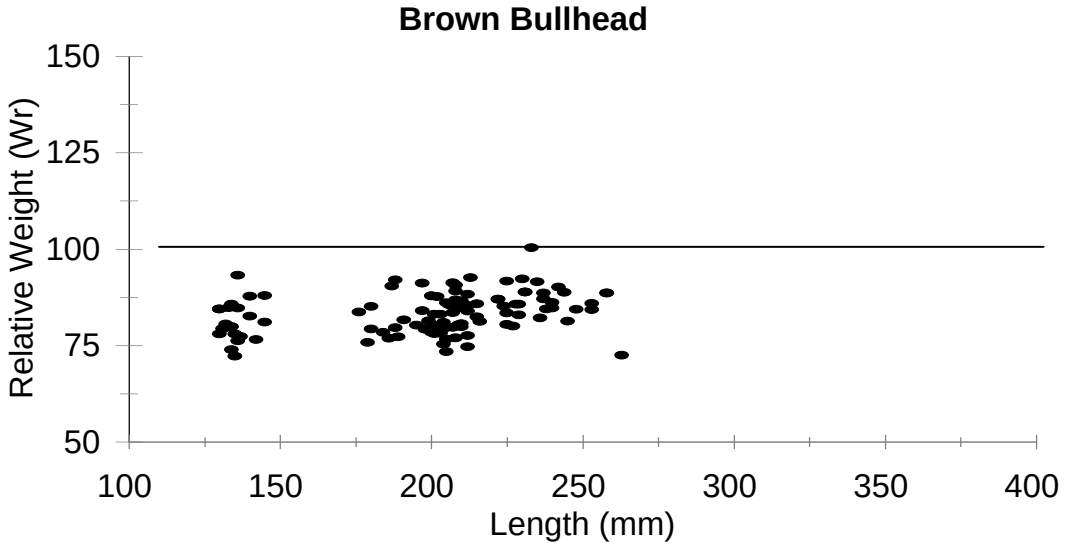

Figure 19. Relative weights of stock size brown bullhead from the fall, 2003 survey of Offut Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

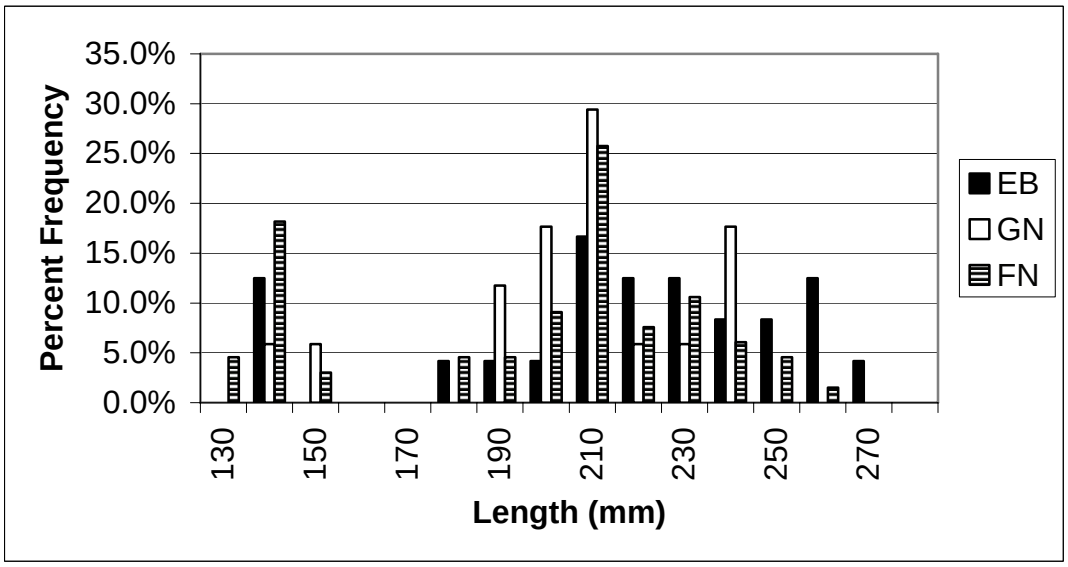

Figure 20. Length-frequency distribution for stock size brown bullhead collected from Offut Lake, Thurston County, fall 2003

Pumpkinseed (*Lepomis gibbosus*)

Only four of the 138 pumpkinseed collected at Offut Lake were less then stock size (Table 2), but none exceeded quality size (Table 3). Thirty-one fish were aged; all were age-1, with a mean length-at-age of 46 mm. This was statistically similar to the western Washington average of 50 mm at age-1 (P = .0932). Relative weights ranged from 75-117 with a mean of 102, and were positively correlated to length (r = .6836) (Figure 21). The relative weights graph shows a distinct bi-modal distribution, more typical of samples with multiple year classes. In this case it is likely the result of multiple spawning periods within the brood year.

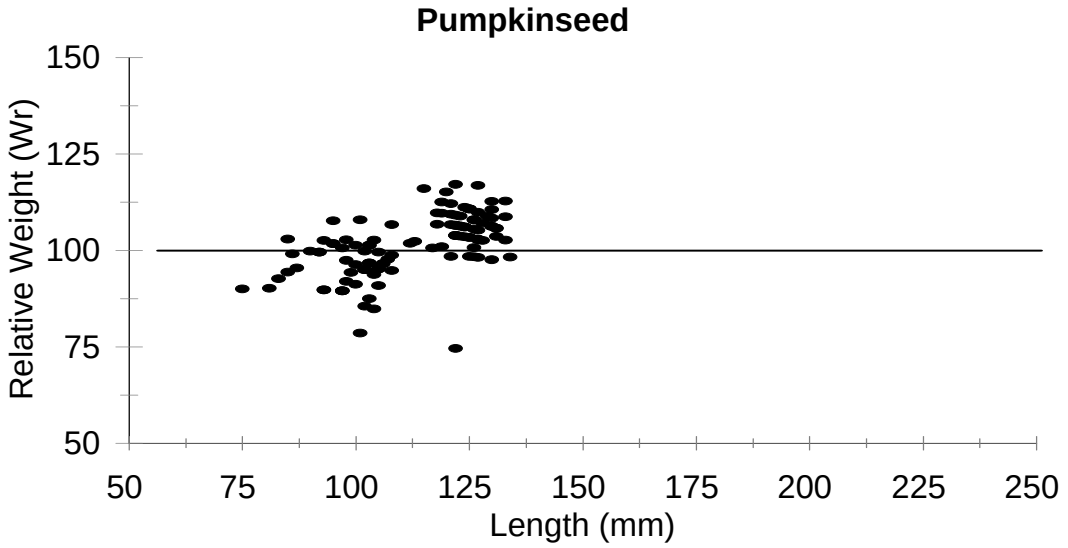

Figure 21. Relative weights of stock size pumpkinseed from the fall, 2003 survey of Offut Lake, Thurston County. Horizontal line at 100 represents national 75th percentile.

Other Taxa

Four other fish taxa were collected at Offut Lake: largescale suckers, coho salmon, redside shiner, and sculpin. Relative abundances and size ranges can be found in Table 2. No age or growth analysis was conducted on any of these fish. Due to their size and condition, the coho salmon were believed to be landlocked fish that found their way into the lake as smolts the previous winter during a flood event on the Deschutes River.

Discussion

Changes to the black bass harvest regulations designed to improve black bass size-structure in Washington lakes took effect in May 2002. The results of those changes are expected to be gradual and long-term, so our ability to measure impacts by the fall of 2003 is limited.

Munn Lake

The Munn Lake sample consisted entirely of five species of warmwater game fish (largemouth bass, yellow perch, black crappie, bluegill, and brown bullhead), despite the fact that rainbow and cutthroat trout are planted annually. Although the overall sample of 378 fish was reasonable for a lake of its size, only 34% were stock size fish, and most of those were yellow perch. The largemouth bass sample indicated typical growth and relative weights, and included some older and larger specimens, all of which bode well for this population. However the small sample size limits confidence in these results. Yellow perch, which did have a healthy number of stock size fish, had average growth, a mean relative weight of 89, low PSDs, and no fish older than age-2 in the sample. These data suggest the possibility of insufficient forage and high mortality of older and larger fish. Black crappie, bluegill, and brown bullhead were all represented in our sample in numbers too small to evaluate.

Ohop Lake

Ohop Lake was previous surveyed in the spring of 2000. Due to seasonal variation in population condition and sampling efficacy, comparisons between spring and fall surveys are unproductive for most results (Pope and Willis 1996; Bonar et al. 2000). One exception is length-at-age data, which is relatively immune to seasonal fluctuation.

Game fish in the sample included yellow perch, largemouth bass, black crappie, brown bullhead, rainbow trout, pumpkinseed, bluegill, and rock bass. The spring 2000 survey occurred just as the management of the lake changed from a year-round lake to opening-day access. The fall 2003 survey provides an opportunity to evaluate this management change and the resulting impact of reduced fishing pressure on growth rates. Growth of largemouth bass increased at every age class except one (age-3), while other species (yellow perch, black crappie, and pumpkinseed) mostly remained the same. (Age-1 yellow perch and age-1 black crappie length-at-age declined.) Other species could not be compared due to insufficient data.

Since fishing pressure is inversely related to mortality for all species (Goedde and Coble 1981), increased growth rates for piscivores (e.g., largemouth bass) would be expected as more forage becomes available. Conversely, planktivores would have experienced stagnant or reduced growth as competition increased with density. These expectations correlate well with our findings. Most warmwater game fish were well represented in our sample and showed signs of good growth and a well-balanced size-structure. The exceptions were bluegill and rock bass, neither of which were present in sufficient quantity to evaluate.

McIntosh Lake

With the exception of a single sculpin, the McIntosh Lake sample consisted entirely of game fish (largemouth bass, rainbow trout, yellow perch, brown trout, bluegill, and one brown bullhead). Cutthroat trout, which have also been planted annually (an average of 5000 fry per year since 1999), did not appear in our sample. The presence of brown trout is puzzling since there is no official record of this non-native fish being planted in McIntosh Lake (WDFW Hatchery Data Unit, unpublished data).

The overall impression of the warmwater community is very healthy. The three primary species all demonstrated good growth, relative weights around 100, and appropriate PSDs for largemouth bass and yellow perch (Table 3). The bluegill PSD was low but typical for western Washington waters. The only possible concern is the potentially weak year class (or classes) in the largemouth bass population; future surveys will help determine if this is an anomaly or a recurring problem. Although McIntosh Lake is not likely to produce a state record fish in any of the sampled species, the warmwater population appears to be of sufficient density and size-structure to provide a rewarding fishing experience.

Offut Lake

The number of fish sampled at Offut Lake was more than 50% greater than the next closest lake in this report, and the number of largemouth bass alone exceed the total number of fish collected at any of the other three surveys. However many of these fish were small - only 15% of the sample consisted of stock size fish.

All four warmwater game fish populations showed some sign of stress, such as slow growth rates, low relative weights, and/or a truncated age structure. Age-1 largemouth bass growth rates were low, and brown bullhead and yellow perch both had mean relative weights of 83, (although growth rates of yellow perch were high). Out of 117 aged fish (largemouth bass, yellow perch,

and pumpkinseed), none exceeded age-2. On the other hand, many of the game fish PSDs were high (Table 3), although several of these were base on small sample sizes.

The lack of older fish in the sample suggests a mortality rate too high to maintain a proper age-structure, and the fact that it crosses species and trophic boundaries is indicative of a systemic, ecosystem-wide problem. Slow growth and high abundance of small largemouth bass (over 1,900 below stock length) suggest stunting (Goedde and Coble 1981; Schneider and Lockwood 1997). Future surveys will be helpful in determining the extent of the imbalance.

Management Considerations

The information gained from a single survey is generally considered insufficient to draw any firm conclusions from. At best we can make some general observations and use the data as the starting point in a series of surveys that can provide us with an ever-increasing clarity about the warmwater community in each lake. Three of the four lakes in this report have not been surveyed previously, and the fourth (Ohop Lake) was previously surveyed in spring, limiting our ability to make comparisons with this fall survey.

Despite these restrictions, some themes appear to have presented themselves. One is the potential impact of year-round lake management as currently practiced, which increases angling pressure both by increasing angler availability to the lake and by focusing winter angling pressure on a very limited number of waters. At Ohop Lake, largemouth bass growth rates appear to have improved simultaneously with the change to opening day management, and Offut Lake, the only year round fishery in this report, has the least balanced community of the four with a preponderance of small, young fish. Goedde and Coble (1981) found that increased angling pressure resulted in higher mortality, smaller mean size and age, and shorter life spans. Although further investigation is required, it is worth noting that our results at Offut Lake are consistent with the effects of higher than ideal angling pressure.

A second trend is the size selectivity of electrofishing and gill netting when collecting yellow perch (figures 3, 5, 14, and 18). For each of these four lakes, the mean lengths of electrofished yellow perch were significantly lower than their gill netted counterparts (Munn, Ohop, and McIntosh, $P < .0001$; Offut, $P = .0230$). A review of lakes surveyed in western Washington since 1999 show this is a common occurrence (Table 18). Managers should be aware of this phenomenon when using electrofished or gill netted samples to determine the size structure of yellow perch populations.

Table 19. Sample size and mean length of yellow perch collected in western Washington lake surveys 1999-2005 by electrofishing and gill netting, and results of statistical comparison of length data using Student's *t*-test. Only lakes with n > 24 for both gear types were included. Bold type indicates no statistically significant difference found between samples.

		Electrofishing data		Gill net data		
Lake	**survey date**	**n**	**mean length**	**n**	**mean length**	***P* (one tailed)**
Big	spring 2005	69	167.12	68	188.78	0.0000
Tanwax	spring 2000	401	182.29	150	188.07	0.0000
Harts	spring 1999	425	180.90	196	193.82	0.0000
Roesiger	spring 1999	151	179.55	69	196.06	0.0000
Terrell	spring 1999	109	148.52	25	158.88	0.0209
St Clair	spring 2000	28	201.29	31	210.97	0.0381
Swofford	spring 2004	27	171.52	74	178.28	0.0415
Loomis	spring 2001	150	149.16	35	153.69	**0.1486**
Pattison	spring 2005	42	191.90	55	193.44	**0.3495**
Spanaway	spring 2000	30	153.67	25	157.12	**0.3519**
Loomis	spring 2005	175	161.13	25	162.36	**0.3819**
Duck	spring 2004	52	171.48	158	169.97	**0.4093**
Sawyer	fall 1999	337	151.28	47	217.49	0.0000
Campbell	fall 1999	93	158.78	194	182.31	0.0000
Ohop	fall 2003	241	171.74	448	189.02	0.0000
Lacamas	fall 2002	231	148.24	114	178.71	0.0000
Munn	fall 2003	81	146.25	32	169.19	0.0000
Leland	fall 1999	31	169.03	31	200.23	0.0000
McIntosh	fall 2003	47	156.66	41	187.07	0.0000
Kapowsin	fall 1999	163	179.43	27	194.89	0.0001

Bibliography

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in Murphy, B.R., and D.W. Willis (eds.), Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Behnke, R. J. 1992. Native trout of western North America. Am. Fish. Soc. Monograph 6.

Bonar, S.A., B.D. Bolding, and M. Divens. 2000. Standard fish sampling guidelines for Washington State ponds and lakes. Wash Dept Fish Wildlife, Inland Fish Investigations. Report FPT 00-28. Olympia.

Bortleson, G.C., N.P. Dion, J.B. McConnell, and L.M. Nelson. 1976. Reconnaissance data on lakes in Washington, Volume 4, Clark, Cowlitz, Grays Harbor, Lewis, Pacific, Skamania, and Thurston Counties. Water-Supply Bullentin 43, WA State.

Carlander, K. D. 1982. Standard intercepts for calculating lengths from scale measurements for some centrarchid and percid fishes. Trans Amer Fish Soc 111:332-336.

Caromile, S.J., and C. S. Jackson. 2002. 2002 warmwater fish survey of Ohop Lake, Pierce County. Washington Department of Fish and Wildlife. FPT 02-07. Olympia.

Fletcher, D., S. A. Bonar, B. D. Bolding, A. Bradbury, and S. Zeylmaker. 1993. Analyzing warmwater fish populations in Washington State. Wash Dept Fish and Wildlife, Warmwater Fish Survey Manual, Olympia.

Gablehouse, E. W. 1984. A length-categorization system to assess fish stocks. N Amer J Fish Mgmt. 4:273-285.

Goedde, L. E., and D. W. Coble. 1981. Effects of angling on a previously fished and an unfished warmwater fish community in two Wisconsin Lakes. Transaction of the American Fisheries Society 110(5):594-603.

Gustafson, K. A. 1988. Approximating confidence intervals for indices of fish population size structure. N Amer J Fish Mgmt. 8:139-141.

Murphy, B. R., and D. W. Willis. 1991. Applications of relative weight (*Wr*) to western warmwater fisheries. Pages 243-248. Proceedings of the Warmwater Fisheries Symposium I. USDA Forest Service, General Technical Report RM-207, Scottsdale, Arizona.

Pope, K. L., and D. W. Willis. 1996. Seasonal influences on freshwater fisheries sampling data. Reviews in Fisheries Science. 4(1):57-73.

Schneider, J. C., and R. N. Lockwood. 1997. Experimental management of stunted bluegill lakes. Fisheries Div. Fish and Wildlife Restoration Program Washington D.C., Lan

Swingle, H. S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Auburn University, Alabama Agricultural Experiment Station Bulleting No 274. Auburn, Alabama.

Wetzel, R. G. 1983. Limnology, 2nd edition. Saunders College Publishing, Philadelphia.

Wydoski, R. S., and R. R. Whitney. 2003. Inland Fishes of Washington. University of Washington Press, Seattle.

Appendix A

Table 20. Length Categories that have been proposed for various fish species. Measurements are for total lengths (updated from Anderson and Neumann 1996).

	Category									
	Stock		Quality		Preferred		Memorable		Trophy	
Species	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)
Black bullhead	6	15	9	23	12	30	15	38	18	46
Black crappie	5	13	8	20	10	25	12	30	15	38
Bluegill	3	8	6	15	8	20	10	25	12	30
Brook trout	5	13	8	20						
Brown bullhead	5	13	8	20	11	28	14	36	17	43
Brown trout	6	15	9	23	12	30	15	38	18	46
Burbot	8	20	15	38	21	53	26	67	32	82
Channel catfish	11	28	16	41	24	61	28	71	36	91
Common carp	11	28	16	41	21	53	26	66	33	84
Cutthroat trout	8	20	14	35	18	45	24	60	30	75
Green sunfish	3	8	6	15	8	20	10	25	12	30
Largemouth bass	8	20	12	30	15	38	20	51	25	63
Pumpkinseed	3	8	6	15	8	20	10	25	12	30
Rainbow trout	10	25	16	40	20	50	26	65	31	80
Rock bass	4	10	7	18	9	23	11	28	13	33
Smallmouth bass	7	18	11	28	14	35	17	43	20	51
Walleye	10	25	15	38	20	51	25	63	30	76
Warmouth	3	8	6	15	8	20	10	25	12	30
White crappie	5	13	8	20	10	25	12	30	15	38
Yellow bullhead	6	15	9	23						
Yellow perch	5	13	8	20	10	25	12	30	15	38

This program receives Federal financial assistance from the U.S. Fish and Wildlife Service Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972. The U.S. Department of the Interior and its bureaus prohibit discrimination on the bases of race, color, national origin, age, disability and sex (in educational programs). If you believe that you have been discriminated against in any program, activity or facility, please write to:

U.S. Fish and Wildlife Service
Office of External Programs
4040 N. Fairfax Drive, Suite 130
Arlington, VA 22203