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The Warmwater Fish Community of Loomis Lake, Pacific County, Before and After Aquatic Vegetation Removal

Warmwater Fish Enhancement

by Adam Couto

Washington Department of
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Acknowledgements

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Abstract

Loomis Lake was surveyed in June of 2001 and June of 2005 by three-person teams using multiple gear types (electrofishing, gillnetting, and fyke-netting). These surveys bracketed a total-lake herbicide treatment conducted in 2002. Largemouth bass *Micropterus salmoides*, pumpkinseed *Lepomis gibbosus*, and yellow perch *Perca flavescens*, were the predominant species in both surveys, accounting for 97% of the fish sampled in 2001 and 94% of the sample in 2005. Growth rates for young pumpkinseed and yellow perch (age-1 and age-2) and largemouth bass (age-1) spawned post-treatment were significantly higher than pre-treatment growth rates. Post treatment, the size structures of all three species shifted toward larger fish, and the mean lengths of all three species increased. Post-treatment changes in relative abundance data were mixed and a proper comparison of pre- and post-treatment data may have been compromised by changes in gear efficiency due to vegetation removal. Consistent with published reports, the total-lake herbicide treatment of Loomis Lake appears to have provided a short-term benefit to fish growth and size-structure.

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Introduction

Loomis Lake is a narrow, shallow, 69 ha dune lake oriented north and south on the Long Beach peninsula in Pacific County. It is less than 300 meters (m) wide at its widest point and 3500 m long, with an average depth of 2 m and a maximum depth of 4.1 m. Both rainfall and subsurface water feed the lake, with surface water flowing out of the lake to the north by way of an intermittent, unnamed creek. The lake is essentially all littoral area and most likely naturally eutrophic. The shore is almost entirely natural, with only 5% residential development. The Washington State Parks and Recreation Commission owns most of the eastern shoreline, and the Washington Department of Fish and Wildlife (WDFW) maintains a small access area with a fishing dock and unpaved boat launch on the west side. The lake is used primarily for fishing, boating, and wildlife viewing.

Washington Department of Fish and Wildlife (WDFW) warmwater enhancement staff conducted fish surveys of Loomis Lake in August, 1997, June 2001, and in June, 2005. The 1997 survey was completed prior to standardization of the WDFW warmwater fish survey protocol, limiting our ability to compare those results to later surveys. The results of the 1997 survey were previously published (Mueller 1998), so this report focuses on the 2001 and 2005 surveys. (The aging data from 1997 were re-analyzed using standardized methods and the new results are included here.) The 1997 report indicated an unbalanced warmwater fish community with fish suffering from a combination of slow growth and poor condition, and recommended either aquatic plant removal or the addition of a ‘super predator’ to help restore balance.

Eurasian milfoil (*Myriophyllum spicatum*) was first reported in 1996, and Brazilian elodea (*Egeria densa*) in 1999. When found outside their native ranges, these two invasive aquatic plants can spread rapidly and displace the native aquatic plant community, creating an undesirable monoculture (Smith and Barko 1990, Madsen et al. 1991, Wells and Clayton 1991). In 1996, a Loomis Lake management group was formed to address this problem and improve the lake for swimming, fishing, and boating. Using grant funds they commissioned the Envirovision Corporation, a private consulting firm, to produce an Integrated Aquatic Lake Management Plan (Envirovision 1998). The plan recommended a total-lake herbicide treatment to control aquatic plants, focusing on Eurasian milfoil and the native species giant bur-reed (*Sparganium eurycarpum*) as the greatest threats to lake usage.

The entire lake was treated with the herbicide fluridone (trade name SONAR®) in 2002 and in 2006. The results of the 2002 treatment were a reduction in total aquatic plant presence from 97% to 25%, a reduction in Eurasian milfoil from 82% to 0%, and a reduction in Brazilian elodea from 59% to 16%, one year after treatment. At the time of the fish survey in June of

2005, total aquatic plants presence had rebounded to 70%, but Eurasian milfoil had recolonized only 13% of the lake, and Brazilian elodea presence had declined further to 8% (Parsons et al. 2009).

Methods and Materials

Data Collection

Loomis Lake was surveyed from June 12 - 15, 2001, and again on May 31 to June 2, 2005, each time by a three-member crew using the methods described in the "Standard Fish Sampling Guidelines for Washington State Ponds and Lakes" (Bonar et al. 2000). Fish were captured using three sampling techniques: electrofishing, gillnetting, and fyke-netting. The electrofishing unit consisted of a Smith-Root SR-16s electrofishing boat, with a 5.0 GPP 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 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.

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. In order to reduce the gear-induced bias in the data, the sampling time for each gear was standardized so the ratio of electrofishing to gillnetting to fyke-netting was 3:2:2. At Loomis Lake, twelve (12) 400 m sections were electrofished, and gill nets and fyke nets were each set overnight at eight (8) locations around the lake, resulting in the 3:2:2 ratio.

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 similarly 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 the 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 at 1 m intervals through the water column. Secchi disk readings were taken by the methods outlined by Wetzel (1983).

Data Analysis

Species Composition

The species composition by number of fish captured was determined by dividing the number of fish in a given species by the total number of fish in the sample. Species composition by weight of fish captured was determined by dividing the total weight of fish of a given species by the total weight of the sample. 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 where no published stock-size (i.e., sculpins, suckers, etc.) is available, CPUE is calculated using all individuals captured. Analysis of means for CPUE data was calculated using the Mann-Whitney rank-sum test with $\alpha = .05$.

For these surveys, the CPUE of sub-stock length fish was also calculated for some species. These calculations were identical to the calculations for stock-length fish described above, but the number of stock-length fish was replaced with the number of fish less than stock-length (excluding stock-length and above). CPUE data of sub-stock length fish are labeled accordingly throughout this report.

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 an 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 represents the national 75^{th} percentile for that species and size and generally indicates a fish in good condition. 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 were determined by staff from the Department of Fish and Wildlife Aging Unit. Total lengths at annulus formation were 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. Age data from the 1997 survey (Mueller 1998) were recalculated using these methods and the new results presented below. Age data were statistically compared using the Mann-Whitney rank sum test per Klumb et al. (1999).

Length frequency and Age frequency

The length frequency histogram was created for each warmwater gamefish species by calculating the number of individuals of a species in a given size or age-class divided by the total individuals of that species sampled, creating a percentage graph. For this report, all gear types are combined on a single graph. Plotting the histogram by percentages tends to flatten out large peaks created by an abundant size class, and makes the graph easier to read. Age frequency histograms were calculated using the methods described in DeVries and Frie (1996). Histograms from one survey to another were compared with the chi-square goodness of fit test, $\alpha = .05$.

Results

Water Quality and Habitat

Water quality data can be found in Table 1. In 2001, the aquatic vegetation was so dense it prevented the Hydrolab® probe from sinking below one meter, and the only open water was a small area near the boat launch. After the 2005 herbicide treatment, 90% of the lake was free of vegetation (based on visual estimate of vegetation extent).

Table 1. Water quality measurements taken from Loomis Lake, Pacific County.

	Depth m	Temp C°	pH	DO mg/l	Conductance µs/cm	Salinity
06/12/2001	1	18.82	8.53	10.02	75.7	n/a
06/02/2005	0	19.26	6.91	8.17	98.9	0.04
	1	18.89	6.88	8.24	99.1	0.04
	2	18.64	6.85	8.22	99.1	0.04
	3	18.32	6.76	7.53	99.6	0.04
	4	16.83	6.99	2.99	180.3	0.08

Species Composition and Relative Abundance

Nine fish taxa were collected from Loomis Lake in 2001; yellow perch *Perca flavescens*, largemouth bass *Micropterus salmoides*, rainbow trout *Oncorhynchus mykiss*, pumpkinseed *Lepomis gibbosus*, black crappie *Pomoxis nigromaculatus*, bluegill *L. macrochirus*, brown bullhead *Ameiurus nebulosus*, sculpin *Cottus* spp, and three-spine stickleback *Gasterosteus aculeatus*. Eight of the nine were also present in the 2005 sample, with bluegill missing (Table 2). Three species dominated the sample of both surveys. Largemouth bass, pumpkinseed, and yellow perch combined for 97% of the abundance and 89% of the biomass in the 2001 survey, and 94% of the abundance and 76% of the biomass in the 2005 survey.

Table 2. Species composition by weight and number for all fish sampled from Loomis Lake, Pacific County, spring 2001 and spring 2005.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Type of Fish	**(kg)**	**(%w)**	**(#)**	**(%n)**	**Min**	**Max**
2001						
Yellow perch	29.61	45.56	1178	81.86	26	317
Largemouth bass	26.87	41.35	116	8.06	20	530
Rainbow trout	5.03	7.74	16	1.11	273	504
Brown bullhead	1.58	2.43	4	0.28	250	345
Pumpkinseed	1.52	2.34	100	6.95	40	174
Bluegill	0.16	0.25	5	0.35	80	130
Black crappie	0.10	0.16	3	0.21	134	143
Sculpin	0.10	0.15	13	0.90	35	111
Three-spine stickleback	0.01	0.01	4	0.28	33	64
2005						
Yellow perch	13.41	35.88	242	35.12	105	212
Largemouth bass	9.77	26.12	49	7.11	77	445
Rainbow trout	8.52	22.80	25	3.63	266	425
Pumpkinseed	5.19	13.88	355	51.52	40	199
Black crappie	0.20	0.53	5	0.73	127	168
Sculpin	0.16	0.41	8	1.16	91	117
Brown bullhead	0.13	0.36	2	0.29	163	171
Three-spine stickleback	0.01	0.02	3	0.44	57	60

Despite the decrease in total biomass caught, most catch rates (Table 3) remained statistically unchanged. The exceptions were gillnetted largemouth bass, which declined (P = .0084), and electrofished and fyke netted pumpkinseeds, both of which increased (P = .0078 and .0010 respectively). Catch per unit effort data for sub-stock length largemouth bass, pumpkinseeds, and yellow perch show a decline in the relative abundance of fyke-netted largemouth bass (P = .0102), electrofished yellow perch (P < .0001) and fyke-netted yellow perch (P = .0060).

Most size-structure sample sizes (Table 5) were too small to draw meaningful conclusions or to compare PSDs from 2001 to 2005. The larger samples (n > 10) show a community of relatively small fish with the exception of bass, which retained a healthy PSD post-treatment.

Table 3. Average catch per unit effort for stock-size fish sampled from Loomis Lake, Pacific County, spring 2001 and spring 2005.

	Electrofishing			Gill Netting			Fyke Netting		
Species	no. per hour	80% CI	shock sites	no. per net night	80% CI	net nights	no. per net night	80% CI	net nights
2001									
Yellow perch	75	15.36	12	5.83	1.64	6	5	3.89	6
Pumpkinseed	9	4.18	12	0.33	0.27	6	0.33	0.27	6
Largemouth bass	7	2.29	12	2.67	0.85	6	0	-	6
Sculpin	6.5	2.00	12	0	-	6	0	-	6
Brown bullhead	2	1.45	12	0	-	6	0	-	6
Three-spine stickleback	1.5	1.38	12	0	-	6	0.17	0.21	6
Bluegill	0.5	0.64	12	0.5	0.44	6	0.17	0.21	6
Rainbow trout	0.5	0.64	12	2.5	1.35	6	0	-	6
Black crappie	0.5	0.64	12	0	-	6	0.33	0.43	6
2005									
Yellow perch	89.34	26.06	12	3.13	1.27	8	3.25	2.09	8
Pumpkinseed	27.24	8.86	12	0.25	0.32	8	12.88	3.23	8
Largemouth bass	7.39	3.79	12	0.38	0.23	8	0	-	8
Sculpin	3.5	1.76	12	0.13	0.16	8	0	-	8
Rainbow trout	3.40	2.16	12	2.38	1.35	8	0	-	8
Black crappie	1.5	1.38	12	0	-	8	0.13	0.16	8
Three-spine stickleback	0	-	12	0	-	8	0.38	0.23	8
Brown bullhead	0	-	12	0	-	8	0.25	0.21	8

Table 4. Average catch per unit effort for sub-stock-size largemouth bass, pumpkinseeds and yellow perch sampled from Loomis Lake, Pacific County, spring 2001 and spring 2005.

	Electrofishing			Gill Netting			Fyke Netting		
Species	no. per hour	80% CI	shock sites	no. per net night	80% CI	net nights	no. per net night	80% CI	net nights
2001									
Largemouth bass	28.99	9.26	12	0.33	0.27	6	4.33	2.00	6
Pumpkinseed	22.50	11.48	12	0	-	6	5.67	3.17	6
Yellow perch	398.92	40.97	12	1.5	1.43	6	26	13.71	6
2005									
Largemouth bass	15.00	4.78	12	0	-	8	0.25	0.21	8
Pumpkinseed	48.49	17.15	12	0	-	8	12.50	3.17	8
Yellow perch	7.50	3.30	12	0	-	8	0.125	0.16	8

Table 5. Stock-density indices, by gear type, for fish sampled from Loomis Lake, Pacific County, spring 2001 and spring 2005.

Species	# Stock Length	Quality PSD	80% CI	Preferred RSD-P	80% CI	Memorable RSD-M	80% CI	Trophy RSD-T	80% CI
2001									
Electrofishing									
Brown bullhead	4	100	0	75	28	0	-	0	-
Largemouth bass	14	71	15	36	16	0	-	0	-
Pumpkinseed	18	17	11	0	-	0	-	0	-
Yellow perch	150	4	2	3	2	1	1	0	-
Gill net									
Bluegill	3	0	-	0	-	0	-	0	-
Largemouth bass	16	88	11	44	16	6	8	0	-
Pumpkinseed	2	0	0			0	-	0	-
Rainbow trout	15	13	11	7	8	0	-	0	-
Yellow perch	35	3	4	0	-	0	-	0	-
Fyke net									
Black crappie	2	0	-	0	-	0	-	0	-
Pumpkinseed	2	0	-	0	-	0	-	0	-
Yellow perch	30	13	8	3	4	0	-	0	-
2005									
Electrofishing									
Black crappie	3	0	-	0	-	0	-	0	-
Largemouth bass	14	36	16	21	14	0	-	0	-
Pumpkinseed	53	11	6	0	-	0	-	0	-
Rainbow trout	6	0	-	0	-	0	-	0	-
Yellow perch	175	1	1	0	-	0	-	0	-
Gill Netting									
Largemouth bass	3	67	35	0	-	0	-	0	-
Pumpkinseed	2	0	-	0	-	0	-	0	-
Rainbow trout	19	11	9	0	-	0	-	0	-
Yellow perch	25	4	5	0	-	0	-	0	-
Fyke Netting									
Brown bullhead	2	0	-	0	-	0	-	0	-
Pumpkinseed	103	3	2	0	-	0	-	0	-
Yellow perch	26	0	-	0	-	0	-	0	-

Summary by Species

Yellow Perch (*Perca flavescens*)

Despite a decline in sample size, catch rates of stock-size yellow perch and stock-density indices remained essentially unchanged (tables 3 and 5). However, CPUE of sub-stock-length perch declined significantly for both electrofished ($P < .0001$) and fyke-netted fish ($P = .006$).

Length at age data are in tables 6, 7 and 8. Age-1 yellow perch from the 1997 survey grew faster than age-1 fish from the later two surveys and faster than the regional average ($P < .0001$ to $P = .0013$). The 2001 survey included the slowest growers for both age –1 and –2, ($P < .0001$ to $P = .0301$), although age-1 fish from 2001 were not significantly different from the regional average (P = .0853). Age -1 and –2 fish from 2005 grew slower than the 1997 sample and faster than 2001 and the regional averages ($P = .0048$ to $P = .0021$).

Table 6. Mean back-calculated length at age for yellow perch collected from Loomis Lake, Pacific County, August 1997.

		Age-class		
Year-class	**# Fish**	**1**	**2**	**3**
1996	34	97		
1995	4	112	173	
1994	2	132	186	225
Fraser-Lee	**40**	**100**	**177**	**225**
W WA Ave		**90**	**158**	**199**

Table 7. Mean back-calculated length at age for yellow perch collected from Loomis Lake, Pacific County, June 2001.

				Age-class		
Year-class	**# Fish**	**1**	**2**	**3**	**4**	**5**
2000	1	82				
1999	46	74	132			
1998	9	97	168	205		
1997	5	111	160	199	251	
1996	1	90	158	189	253	317
Fraser-Lee	**62**	**80**	**140**	**202**	**251**	**317**
W WA Ave		**90**	**158**	**199**	**226**	**259**

Table 8. Mean back-calculated length at age for yellow perch collected from Loomis Lake, Pacific County, June 2005.

		Age-class	
Year-class	**# Fish**	**1**	**2**
2004	9	96	
2003	39	87	152
Fraser-Lee	**48**	**89**	**152**
W WA Ave		**90**	**158**

Both the length frequency distribution (Figure 1) and age frequency distribution (Figure 2) of yellow perch changed significantly from 2001 to 2005 ($P < .005$). Mean length increased from 120 to 159 mm.

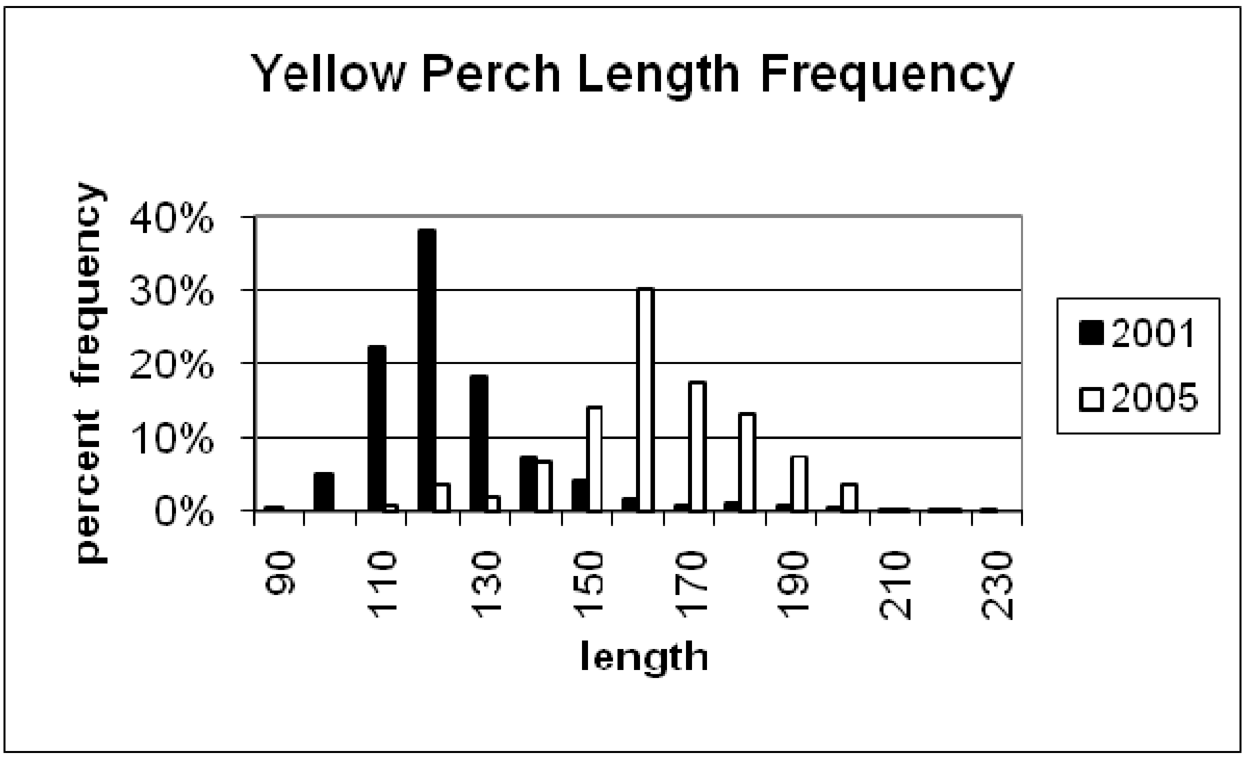

Figure 1. Length frequency distribution for yellow perch, excluding young-of-the- year, collected from Loomis Lake, Pacific County, June 2001 and June 2005.

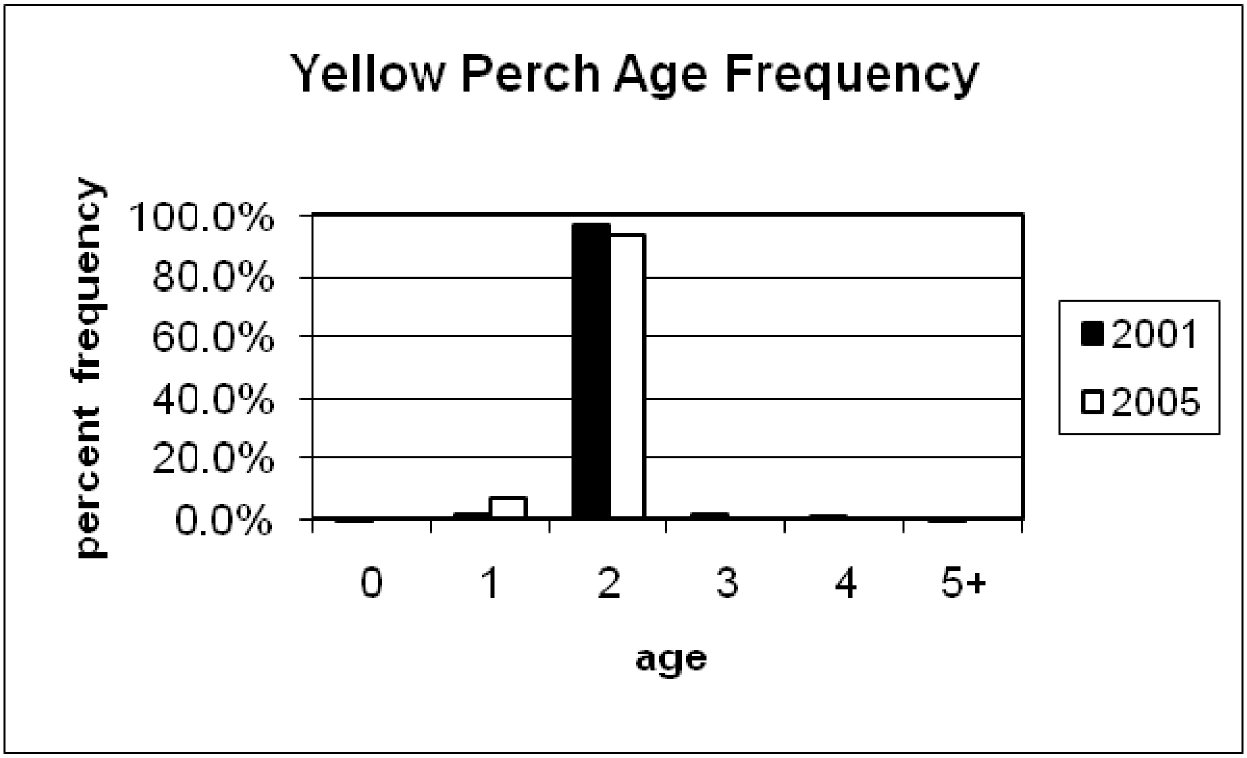

Figure 2. Age frequency distribution for yellow perch collected from Loomis Lake, Pacific County, June 2001 and June 2005.

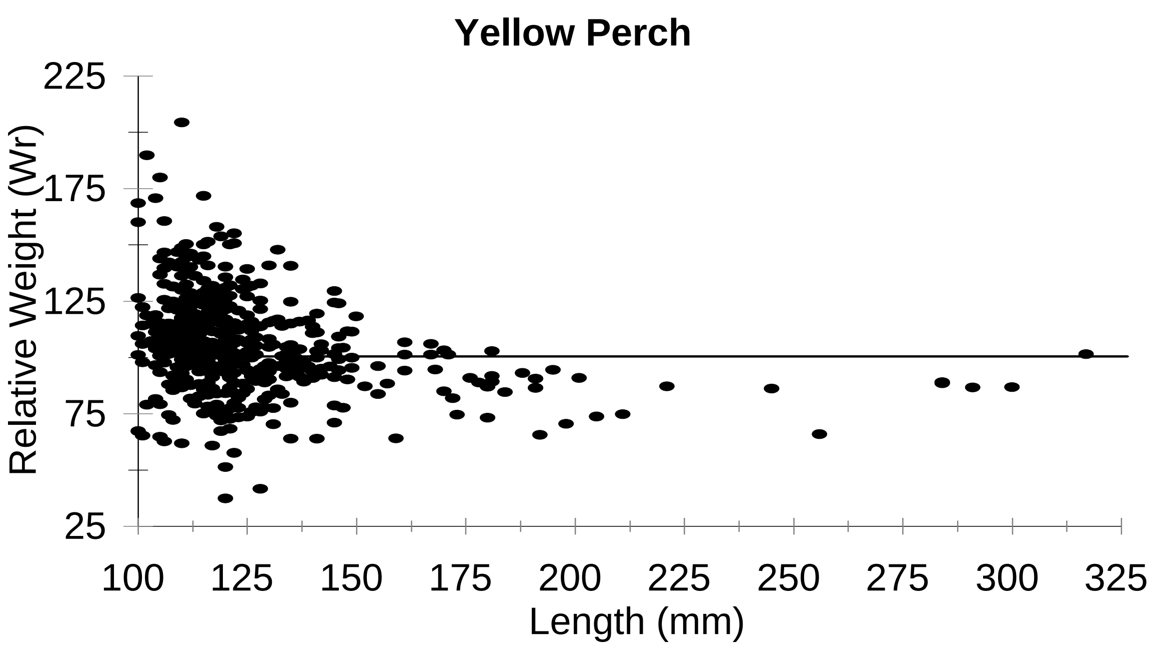

Figure 3. Relative weights of yellow perch from the spring 2001 survey of Loomis Lake, Pacific County.

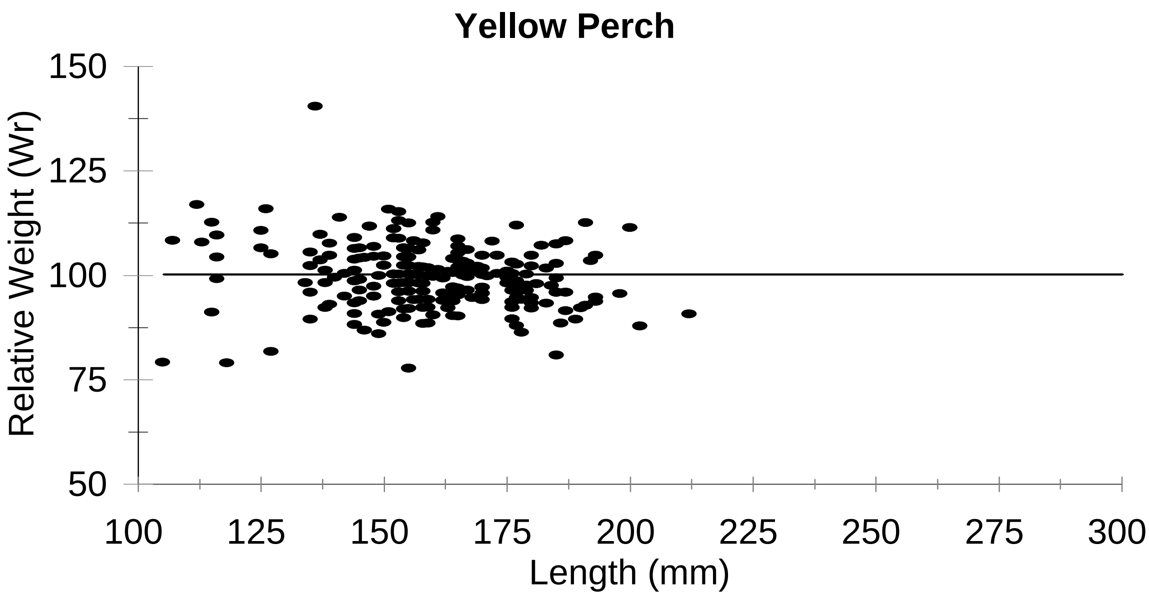

Figure 4. Relative weights of yellow perch from the spring 2005 survey of Loomis Lake, Pacific County.

In 2001, yellow perch relative weights ranged from 37 to 205 and averaged 106 (Figure 3). Relative weights declined with increasing length (slope = -.24), and averaged 97 for stock length and larger fish (≥130 mm). The 2005 sample ranged from 78 to 141 with a mean of 100 (Figure 4). The slope of the graph is a relatively flat -.07.

Largemouth Bass (*Micropterus salmoides*)

The total number of largemouth bass collected declined nearly 60% from 2001 to 2005 (Table 2). Although electrofishing catch rates of stock-size fish were statistically unchanged (P = .1423), the gill-net CPUE declined (P = .0084) (Table 3) and no stock-size largemouth bass were caught in the fyke nets in either survey. Sub-stock electrofishing CPUE also remained static (P = .1251), Fyke-net sub-stock CPUE declined (P = .0102), and gill-net samples were too small to evaluate (Table 4).

Tables 9, 10, and 11 show largemouth bass age data. Lengths-at-age were statistically similar (P > .05) for age-1, –2 and –3 in all three surveys (age-3 sample in 2005 was too small for comparison) with one exception; age-1 fish from 2005 grew faster than 2001 fish (P = .0082). Age-1 and –2 fish from the 1997 and 2001 surveys grew slower than the western Washington average (P = .0228 to P < .0001), but age-3 fish from both surveys, and age-1 and age-2 fish from the 2005 survey were all similar to regional averages (WDFW unpublished data).

Table 9. Mean back-calculated length at age for largemouth bass collected from Loomis Lake, Pacific County, August 1997.

		Age-class							
Year-class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1996	31	73							
1995	15	78	161						
1994	10	84	165	265					
1993	3	79	199	316	367				
1992	0								
1991	0								
1990	0								
1989	1	74	223	353	406	432	458	479	500
Fraser-Lee	**60**	**77**	**168**	**282**	**377**	**432**	**458**	**479**	**500**
W WA Ave		**84**	**183**	**271**	**333**	**376**	**417**	**439**	**457**

Table 10. Mean back-calculated length at age for largemouth bass collected from Loomis Lake, Pacific County, June 2001.

		Age-class									
Year-class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2000	18	66									
1999	8	64	171								
1998	4	76	170	268							
1997	10	88	154	254	344						
1996	4	68	189	281	335	379					
1995	3	81	159	289	348	374	407				
1994	4	81	170	281	349	392	412	432			
1993	1	87	130	195	295	381	401	414	423		
1992	0										
1991	1	86	239	352	404	439	464	484	497	514	530
Fraser-Lee	**53**	**73**	**168**	**270**	**344**	**386**	**415**	**438**	**460**	**514**	**530**
W WA Ave		**84**	**183**	**271**	**333**	**376**	**417**	**439**	**457**	**471**	**483**

Table 11. Mean back-calculated length at age for largemouth bass collected from Loomis Lake, Pacific County, June 2005.

		Age-class							
Year-class	**# Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2004	19	98							
2003	18	70	179						
2002	2	93	202	307					
2001	2	64	141	270	353				
2000	0								
1999	0								
1998	2	67	157	279	341	386	411	439	
1997	1	83	134	230	323	354	385	405	431
Fraser-Lee	**44**	**83**	**175**	**277**	**342**	**376**	**402**	**428**	**431**
W WA Ave		**84**	**183**	**271**	**333**	**376**	**417**	**439**	**457**

Figure 5 shows the length frequency distributions from the two surveys, which were significantly different (*P* < .005). The mean length increased from 154 to 192 mm, despite the fact that the maximum length (Table 2) and maximum age (tables 10 and 11) both decreased and the number of older fish (age-3 and older) declined from 23.3% of the population in 2001 to 14.3% in 2005.The age distributions (Figure 6) were significantly different (*P* < .005), with a noticeable shift in year-class strength from age-1 (in 2001) to age-2 (in 2005).

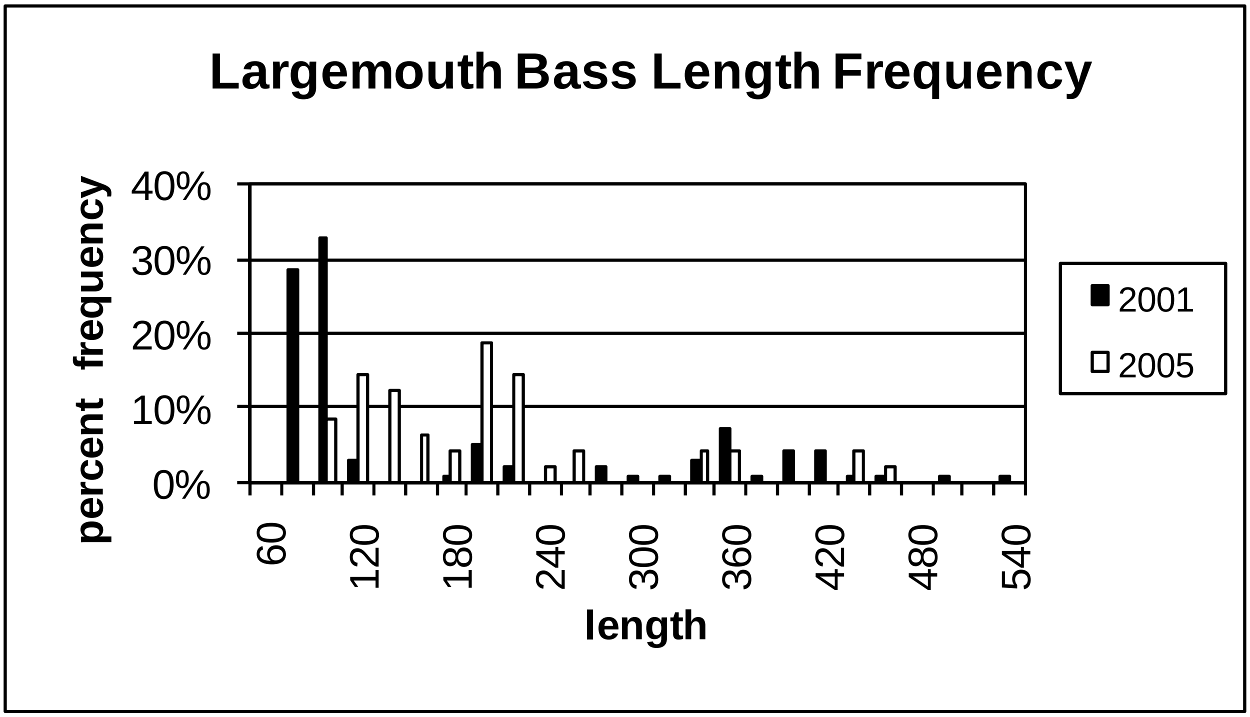

Figure 5. Length frequency distribution for largemouth bass, excluding young of the year, collected from Loomis Lake, Pacific County, June 2001 and June 2005.

In 2001, relative weights averaged 120 and ranged from 51 to 215 (Figure 7). In 2005 the average was 104 and the range was from 79 to 122 (Figure 8). Both graphs have a relatively flat slope, increasing very slightly with increasing length (.03 in 2001; .01 in 2005).

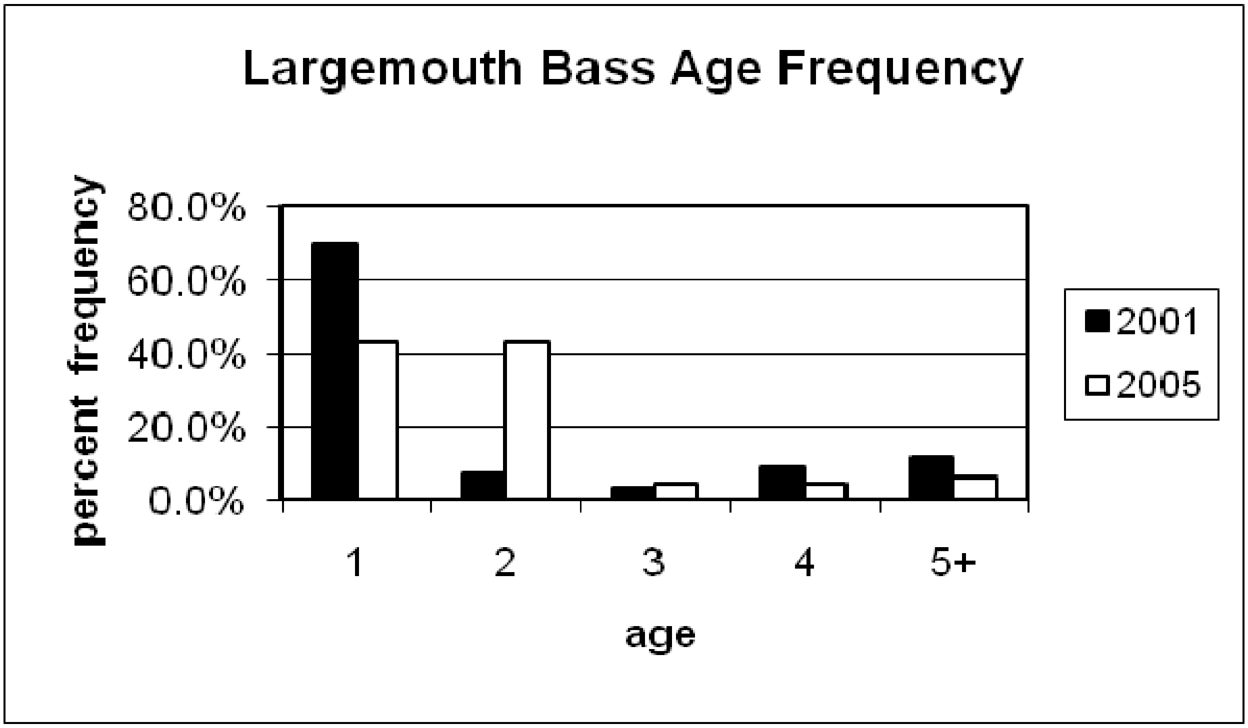

Figure 6. Age frequency distribution for largemouth bass collected from Loomis Lake, Pacific County, June 2001 and June 2005.

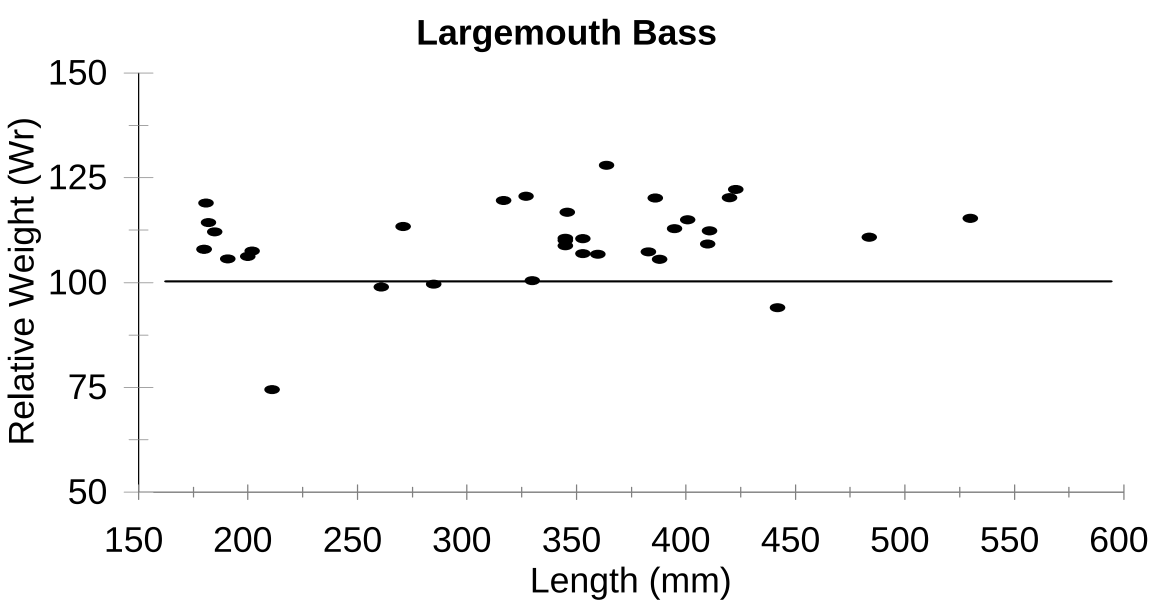

Figure 7. Relative weights of largemouth bass from the spring 2001 survey of Loomis Lake, Pacific County.

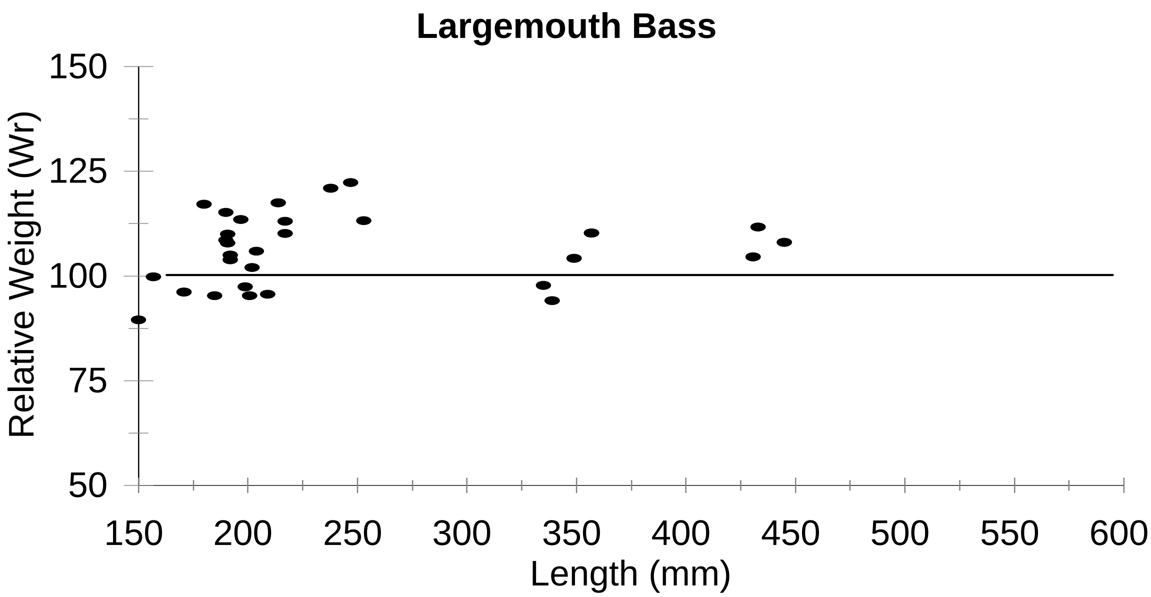

Figure 8. Relative weights of largemouth bass from the spring 2005 survey of Loomis Lake, Pacific County.

Rainbow Trout (*Oncorhynchus mykiss*)

Sixteen rainbow trout were collected in 2001, and 25 were collected in 2005. These fish are most likely the result of hatchery plantings. Planting data is in table 12. No age or growth analysis was conducted on these fish.

Table 12. Hatchery planting data for rainbow trout in Loomis Lake, Pacific County, 1995-2006.

Date of Release	Brood Year	Size	Fish Per Pound	Number Planted
Apr-95	1993	legals	3.2	7200
Apr-96	1994	legals	4	12000
Apr-97	1995	legals	4	12000
Apr-98	1996	legals	4.3	12040
Apr-99	1997	legals	3.8	2129
Jul-03	2002	legals	3	1200
Apr-03	2001	legals	3.1	600
Apr-05	2004	legals	2	1500
Apr-05	2003	legals	2	12000
Apr-05	2003	triploid legals	0.6	60
Apr-06	2004	triploid legals	0.8	50
Apr-06	2004	legals	2.5	2800
May-06	2004	legals	1	2200

Pumpkinseed (*Lepomis gibbosus*)

Pumpkinseed were the most numerous fish species in 2005, representing over half the sample and exhibiting an increase of 250% from 2001 to 2005 (Table 2). Catch rates for stock-length fish increased for both electrofishing and fyke-netting (Table 3), with fyke nets collecting the majority of stock length pumpkinseed in 2005 (Table 5). Catch rates of sub-stock pumpkinseeds were statistically unchanged, and PSDs were effectively static (Table 5).

Table 13. Mean back-calculated length at age for pumpkinseed collected from Loomis Lake, Pacific County, August 1997.

		Age-class		
Year-class	**# Fish**	**1**	**2**	**3**
1996	19	43		
1995	14	47	109	
1994	8	40	98	121
Fraser-Lee	**41**	**44**	**105**	**121**
W WA Ave		**48**	**101**	**139**

Table 14. Mean back-calculated length at age for pumpkinseed collected from Loomis Lake, Pacific County, June 2001.

		Age-class			
Year-class	**# Fish**	**1**	**2**	**3**	**4**
2000	10	53			
1999	6	38	92		
1998	4	36	75	137	
1997	4	38	82	119	141
Fraser-Lee	**24**	**44**	**84**	**128**	**141**
W WA Ave		**48**	**101**	**139**	**144**

Table 15. Mean back-calculated length at age for pumpkinseed collected from Loomis Lake, Pacific County, June 2005.

		Age-class				
Year-class	**# Fish**	**1**	**2**	**3**	**4**	**5**
2004	26	69				
2003	4	47	129			
2002	3	46	95	126		
2001	0					
2000	2	34	84	116	138	151
Fraser-Lee	**35**	**63**	**108**	**122**	**138**	**151**
W WA Ave		**48**	**101**	**139**	**144**	**168**

Age data are in tables 13, 14, and 15. Pumpkinseeds age-1 and age-2 grew faster in 2005 than in the other two surveys (P = .0069 to P < .0001), except for age-2 fish in 1997 (P = .4129). Age-1 pumpkinseed also grew faster in 2005 than the regional average (P < .0001), but age-2 fish from the same survey were statistically similar to the regional average (P = .2843). Age-1, -2, and –3 fish from 2001 and 1997 generally grew slower than the regional average (P < .05), except for age-3 fish from 2001 and age-2 fish in 1997, which were statistically similar (P = .0516 and P = .1335, respectively).

Figure 9 shows the length frequency distributions for both surveys, which were significantly different. The mean length increased from 74 mm in 2001 to 81mm in 2005. The age frequency distributions are in Figure 10 and were statistically similar. In contrast to both largemouth bass and yellow perch, the maximum length and age of pumpkinseed in the samples increased from 2001 to 2005 (tables 2, 15, and 16).

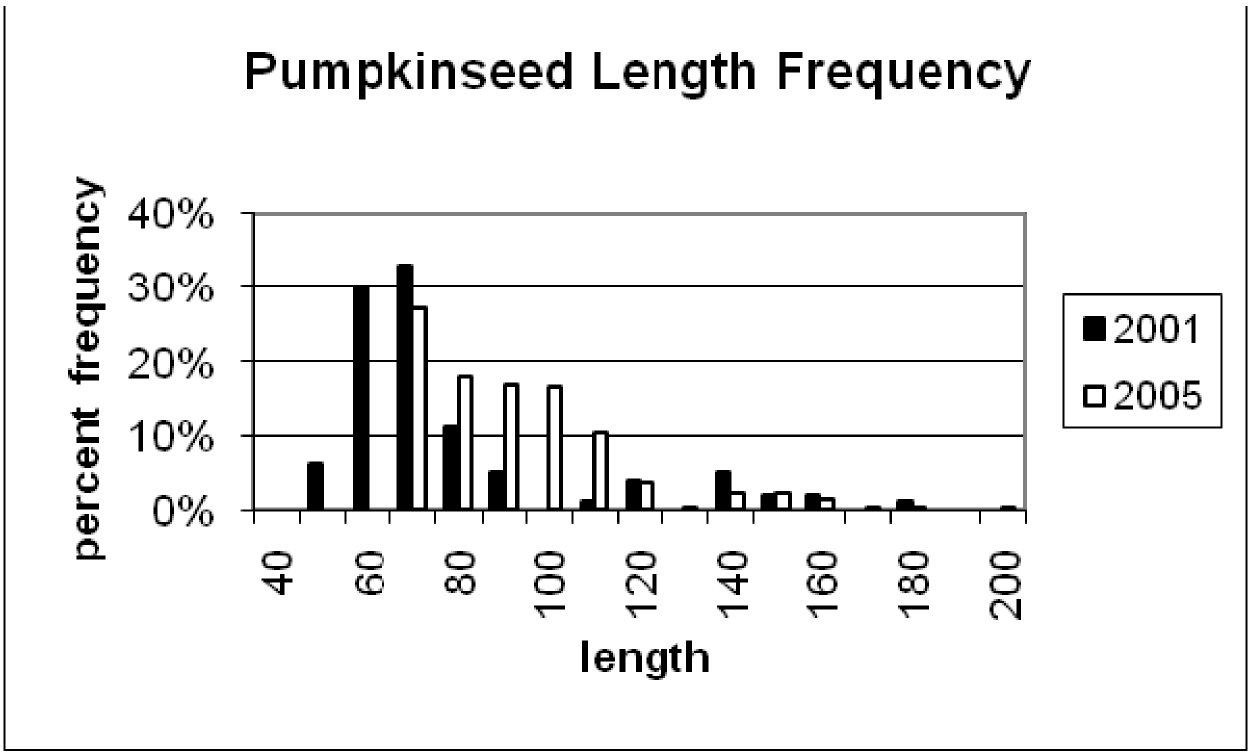

Figure 9. Length frequency distribution for pumpkinseed, excluding young of the year, collected from Loomis Lake, Pacific County, June 2001 and June 2005.

Relative weights for pumpkinseed collected in 2001 ranged from 33 to 281 and averaged 125 (Figure 11). (Note the scale of the y-axis in Figure 11; an unusually high percentage of fish exhibited relative weights above 150.) The 2005 sample ranged from 43 to 167 with a mean of 106 (Figure 12). 2001 relative weights declined slightly with increasing length (slope = -.07) and 2005 data had a slightly positive slope of .15.

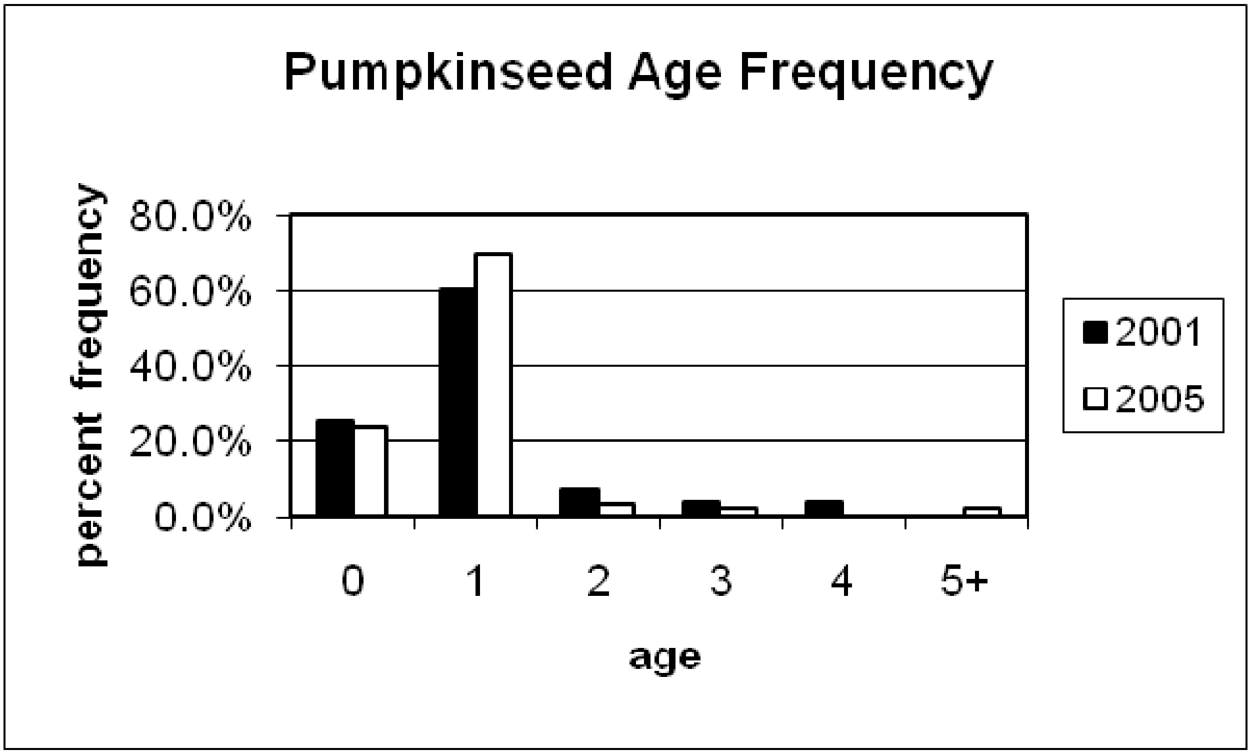

Figure 10. Age frequency distribution for pumpkinseed collected from Loomis Lake, Pacific County, June 2001 and June 2005.

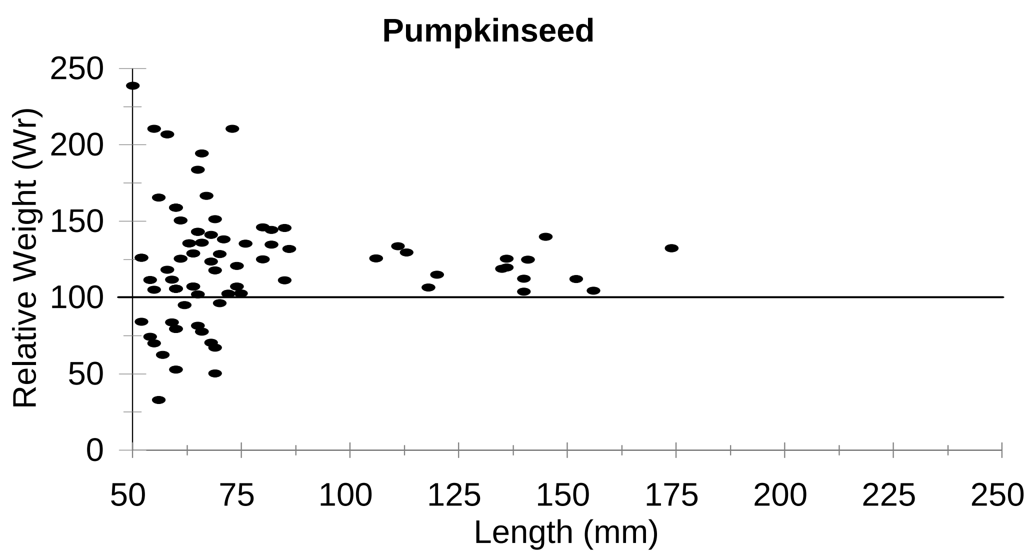

Figure 11. Relative weights of pumpkinseed from the spring 2001 survey of Loomis Lake, Pacific County.

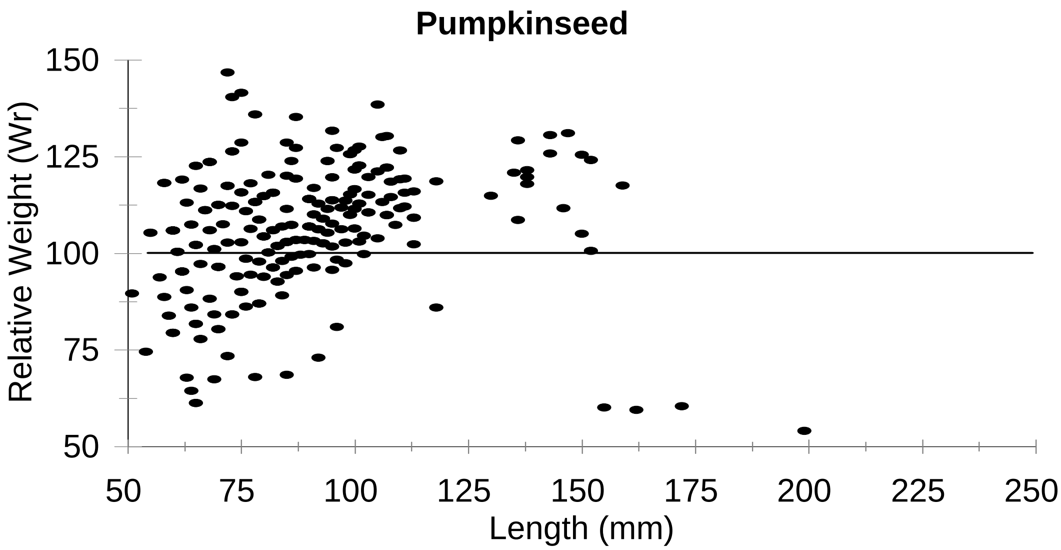

Figure 12. Relative weights of pumpkinseed from the spring 2005 survey of Loomis Lake, Pacific County.

Bluegill (*Lepomis macrochirus*)

Forty seven bluegills were collected in the summer 1997 survey; five were collected in spring 2001, and none in spring 2005 (Table 2). The five fish collected in 2001 were all stock length, but less than quality length. Age data are in tables 16 and 17. Relative weights for 2001 ranged from 104 to 123 and averaged 116.

Table 16. Mean back-calculated length at age for bluegill collected from Loomis Lake, Pacific County, August 1997.

		Age-class		
Year-class	**# Fish**	**1**	**2**	**3**
1996	2	36		
1995	22	34	78	
1994	1	35	81	115
Fraser-Lee	**25**	**35**	**78**	**115**
W WA Ave		**36**	**84**	**130**

Table 17. Mean back-calculated length at age for bluegill collected from Loomis Lake, Pacific County, June 2001.

		Age-class		
Year-class	**# Fish**	**1**	**2**	**3**
2000	0			
1999	2	30	62	
1998	3	31	55	103
Fraser-Lee	**5**	**30**	**58**	**103**
W WA Ave		**36**	**84**	**130**

Black Crappie (*Pomoxis nigromaculatus*)

One hundred ninety-seven black crappies were collected in the summer of 1997; three were collected in the spring of 2001, and five in the spring of 2005 (Table 2). Age data are in tables 18, 19, and 20. Relative weights from the 2001 sample ranged from 92 to 110 and averaged 100. The 2005 sample ranged from 79 to 107 with a mean of 93.

Table 18. Mean back-calculated length at age for black crappie collected from Loomis Lake, Pacific County, August 1997.

		Age-class	
Year-class	**# Fish**	**1**	**2**
1996	21	65	
1995	11	68	122
Fraser-Lee	**32**	**66**	**122**
W WA Ave		**71**	**147**

Table 19. Mean back-calculated length at age for black crappie collected from Loomis Lake, Pacific County, June 2001.

		Age-class	
Year-class	**# Fish**	**1**	**2**
2000	0		
1999	3	53	124
Fraser-Lee	**3**	**54**	**124**
W WA Ave		**71**	**147**

Table 20. Mean back-calculated length at age for black crappie collected from Loomis Lake, Pacific County, June 2005

		Age-class	
Year-class	**# Fish**	**1**	**2**
2004	0		
2003	5	62	139
Fraser-Lee	**5**	**62**	**139**
W WA Ave		**71**	**147**

Brown Bullhead (*Ameiurus nebulosus*)

The 1997 survey collected 21 brown bullheads. Four were collected in 2001 and two in 2005 (Table 2). Relative weights from the 2001 sample ranged from 82 to 106 with a mean of 95. The 2005 sample had relative weights of 98 and 101. No age or growth analysis was conducted on these fish.

Other Fish

Non-game fish collected at Loomis Lake included three-spine stickleback and sculpin. Numbers of fish collected are in Table 2. Neither of these native fish were a significant portion of the sample in either year. No age or growth analyses were conducted on these fish.

Discussion

Length at age comparisons from 2001 to 2005 show improved growth rates for the three primary species (largemouth bass, pumpkinseeds, and yellow perch). These growth increases were statistically significant in the age-1 and age-2 fish, spawned post-treatment (2003 and 2004 BY). Fish spawned pre-treatment did not appear to benefit from the vegetation removal with faster growth, but small samples sizes limit confidence in this conclusion. Size structure also improved post-treatment for all three species.

These changes are consistent with published literature on the effect of vegetation removal on fish communities (Maceina et al. 1991, Dibble et al. 1997, Olson et al. 1998, Pothoven et al. 1999, Unmuth et al. 1999, and Allen et al. 2003). Despite a wide range of vegetation removal methods (grass carp stocking, muck removal, mechanical cutting, and herbicide treatment), each of these papers reported age-dependent increases in growth for the species studied, typically largemouth bass and bluegill, and typically younger fish. Unmuth et al. (1999) also found improved size structure after vegetation removal (via mechanical cutting) for largemouth bass and bluegill. In a comprehensive literature review, Dibble et al. (1997) determined that moderate vegetation cover, defined as 10-40% of surface area, provided the best conditions for growth, survival, and species richness.

Both predator and forage species in Loomis Lake experienced post-treatment increases in growth, suggesting more than one variable was affected. Largemouth bass growth increases can be attributed to improved predation efficiency associated with a decrease in plant density, which reduces prey cover (Savino and Stein 1982, Gotceitas and Colgan 1987, Trebitz et al. 1997). For forage species, growth is often density dependent (Osenberg et al. 1988, Snow and Staggs 1994), and improved predator efficiency should result in fewer forage fish, thereby improving growth rates (Harders and Davies 1973, Novinger and Legler 1978, Guy and Willis 1990).

At Loomis Lake, abundance of sub-stock length yellow perch followed this expectation, declining significantly post-treatment. Catch rates for stock length yellow perch were essentially unchanged, suggesting that at 130 mm they had outgrown the optimal prey size for largemouth bass. On the other hand, relative abundance of stock length pumpkinseed was significantly higher post-treatment, and sub-stock catch rates were statistically unchanged. These unexpected results suggest that pumpkinseed growth and relative abundance simultaneously experienced a statistically significant increase, and that they did so in the face of improved predator efficiency.

There are two reasonable explanations for this finding. The first is the possibility of bias in the Loomis Lake data or an incorrect assumption about the ability to compare pre- and post-treatment results. A potentially confounding factor to the abundance data is the effect the removal of vegetation may have had on the capture efficiency of the various collection gears. Unfortunately, published research on the subject is limited. Bayley and Austen (2002) found that the catch efficiency of a boat electrofisher was related to the percentage of a lake covered by macrophytes. Gill net efficiency can be affected by twine diameter and color, both of which alter the net's visibility (Hansen 1974, and Jester 1977), which could also be affected by the presence or absence of macrophytes. Weaver et al. (1993) found differences in catch rates of fyke nets fished at multiple sites with a range of macrophyte density and species composition, although whether the results reflect differences in fish abundance at each site or differences in gear efficiency is unclear. In the Methods section of their paper, Unmuth et al. (1999) described calculating and compensating for the changes associated with vegetation removal in the catchability of fish collected with an electrofishing boat and fyke nets, but did not publish the results of those calculations. Clearly this is an area of research ripe for further investigation.

A more precise measure of abundance would have been one of the mark-recapture methods (Ricker 1975), which would have produced a measure of abundance independent of gear efficiency. Of the various studies on the impact of vegetation removal on fish, only Unmuth et al. (1999) used a mark-recapture method, and their results indicated no change in the abundance of either largemouth bass or bluegill following the mechanical cutting of vegetation.

A second possibility is the prey selection of largemouth bass. Largemouth bass readily prey on yellow perch (Guy and Willis 1991), and in some studies show a preference for yellow perch over sunfish (Seaburg and Moyle 1964, Liao et al. 2004). If largemouth bass in Loomis Lake preferentially selected yellow perch as prey over pumpkinseed, this would allow for an increase in pumpkinseed abundance post-treatment. The simultaneous increase in pumpkinseed abundance and growth suggests that the factors controlling the density-dependency of growth, such as availability of food items, were altered by the vegetation removal.

Conclusion

The herbicide treatment and subsequent decline in macrophyte density have successfully improved the growth and size structure of the Loomis Lake fish community in the short term. Plant density has declined sufficiently to allow for angling, and the size structures of all three dominant species have improved. Based on age and length frequency distributions, the 2003 brood year of largemouth bass (spawned immediately post-treatment) appears particularly strong and should provide improved angling opportunity for the next several years.

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Appendix A

Table 21. 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