# 1997 LOOMIS LAKE SURVEY: A COASTAL WARMWATER FISH COMMUNITY BEFORE IMPLEMENTATION OF AN AQUATIC PLANT MANAGEMENT PLAN

by

Karl W. Mueller
Warmwater Enhancement Program
Washington Department of Fish and Wildlife
600 Capitol Way North
Olympia, Washington 98501-1091

# INTRODUCTION AND BACKGROUND

Loomis Lake is a long (6.9 km), narrow eutrophic body of water which runs parallel to Washington's coast on the Long Beach Peninsula in Pacific County. The shallow lake (mean depth = 1.5 m; max depth = 2.7 m) is fed by rainfall and groundwater. Surface water exits the lake (surface area = 68 ha) through an unnamed creek at the far north end, eventually discharging into the Pacific Ocean. Dense stands of emergent burreed (*Sparganium* sp.) surround most of the lake, whereas spatterdock, or yellow waterlilly (*Nuphar polysepala*), is patchily distributed at the north and south ends. The predominant submerged aquatic plants include flat stemmed pondweed (*Potamogeton zosteriformis*), waterweed (*Elodea canadensis*), coontail (*Ceratophyllum demersum*) and, unfortunately, invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Details of these and other characteristics can be found in a 1998 draft report prepared by Envirovision Corporation (Debra Bouchard; personal communication) and through the Washington Department of Ecology (Kirk Smith; personal communication).

Development on the lake is minimal. The western shoreline has few private homes, whereas most of the eastern shoreline, which is owned by the Washington Parks Department, remains completely natural. Recreational activities include both warmwater and trout fishing (the lake is stocked annually with rainbow trout, *Oncorhynchus mykiss*), swimming, small water craft use, and wildlife viewing. The Washington Department of Fish and Wildlife (WDFW) maintains a public access and boat launch located mid-lake on the western shore.

In recent years, Long Beach Peninsula residents have expressed concern about the invasion of the lake by Eurasian watermilfoil and the spread of the nearshore burreed. Accordingly, the Loomis Lake Group was convened in 1996 to address the matter. By the fall of 1997, an aquatic plant control plan was developed by a private contractor and presented to the group for approval (Envirovision *in review*). The January 1998 draft of the Loomis Lake Integrated Aquatic Plant Management Plan, which was largely funded by the Aquatic Weeds Program of the Washington Department of Ecology and the Pacific Conservation District, recommended applications of the herbicides Sonar® and Rodeo™ to control the spread of nuisance aquatic plants in Loomis Lake.

Although much information exists regarding the community structure of aquatic plants at Loomis Lake (Parsons *in press*), including that gathered for the plan above, there is no current information regarding the status of aquatic animals, i.e., the fish community. Given its physical characteristics, Loomis Lake is well suited for warmwater fish species. Therefore, in order to evaluate the fish populations of Loomis Lake before implementing the aquatic plant control plan, personnel from WDFW's Warmwater Enhancement Program conducted a survey of the lake during the late summer of 1997.

# MATERIALS AND METHODS

Loomis Lake was surveyed by a three-person investigation team during August 25 - 28, 1997. Fish were captured using two sampling techniques: electrofishing and gill netting. The electrofishing unit consisted of a 5.5 meter (m) Smith-Root 5.0 GPP ‘shock boat’ using a DC current of 120 cycles/sec at ~ 4 amps power. Experimental gill nets (45.7 m long × 2.4 m deep) were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable-size (1.3, 1.9, 2.5, and 5.1 cm stretched) monofilament mesh.

Sampling locations were selected by arbitrarily dividing the shoreline into 22 consecutively numbered equidistant sections of ~ 366 m each (determined visually from a map). Using the random numbers table from Zar (1984), nine of these sections were then randomly selected as the sampling locations. While electrofishing, the boat was maneuvered through the shallows (depth range ~ 0.2 to 1.5 m), adjacent to the shoreline, at a rate of ~ 18.3 m/minute (linear distance covered over time). Gill nets were set perpendicular to the shoreline. The small-mesh end was attached onshore while the large-mesh end was anchored offshore.

Sampling occurred during evening hours to maximize the type and number of fish captured. Nighttime electrofishing occurred along 20% (~ 1.6 km) of the available shoreline, whereas gill nets were set overnight at six locations around the lake (Figure 1). In order to reduce bias between techniques, the sampling time for each gear type was standardized so that the ratio of electrofishing to gill netting was 1:1 (Fletcher et al. 1993). Total electrofishing time was 5436 seconds (‘pedal-down’ time), or roughly *three* standard units of 0.5 hours each; total gill netting time was 82.9 hours, or roughly *three* standard units of 24 hours each.

With the exception of sculpin (family Cottidae), all fish captured were identified to the species level. Each fish was measured to the nearest 1 mm and assigned to a 10-mm size class based on its total length (TL). For example, a fish measuring 156 mm TL was assigned to the 150-mm size class for that species, a fish measuring 113 mm TL was assigned to the 110-mm size class, and so on. However, if a sample included several hundred young-of-year or small juveniles (< 100 mm TL) of a given species, then a sub-sample (N ~ 100 fish) was measured and the remainder counted overboard. The length frequency distribution of the sub-sample was then applied to the total number collected. When possible, up to 10 fish from each size class were weighed to the nearest 1 gram (g). Furthermore, scales were removed from these fish for aging purposes. Scale samples (up to six per size class) were mounted and pressed, and the fish aged according to Jearld (1983) and Fletcher et al. (1993). Members of the catfish family (Ictaluridae) were not aged.

Water quality data was collected during midday from three locations on August 27, 1997 (Figure 1). Using a Hydrolab® probe and digital recorder, information was gathered concerning five parameters: dissolved oxygen, redox, temperature, pH, and conductivity. Secchi disc readings were recorded in feet then converted to m (Table 1).

### *Data analysis*

The species composition by number of the fish captured at Loomis Lake was determined using procedures outlined in Fletcher et al. (1993). The species composition by weight (kg) of the fish

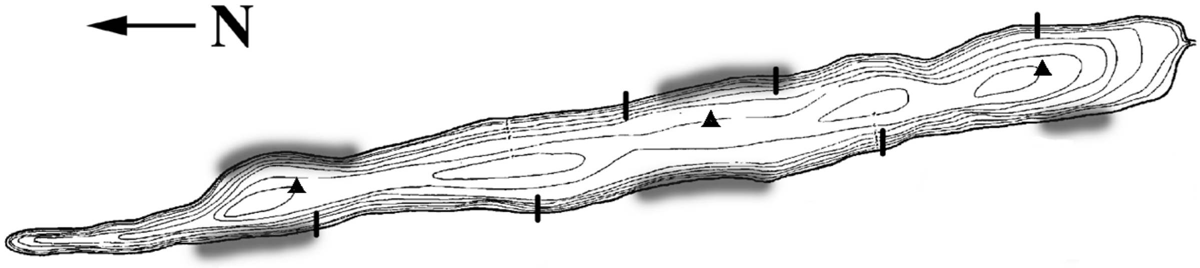


**Figure 1**. Map of Loomis Lake (Pacific County) showing sampling locations. Shaded areas indicate sections of shoreline where electrofishing occurred. Bars extending into lake indicate placement of gill nets. Triangles indicate water quality stations.

**Table 1**. Water quality from three locations (north end, mid-lake, and south end) at Loomis Lake (Pacific County). Samples were collected midday on August 27, 1997.

| | | Parameter | | | | | |
|---|---|---|---|---|---|---|---|
| Location | Secchi (m) | Depth (m) | DO | Temp (°C) | pH | Conductivity | Redox |
| North end | 1.5 | 1 | 8.1 | 18.7 | 7.6 | 134 | 413 |
| | | 1.5 | 8.1 | 18.4 | 7.6 | 132 | 416 |
| Mid-lake | bottom | 1 | 8.0 | 18.4 | 7.1 | 132 | 430 |
| | visible | 1.3 | 7.9 | 18.4 | 7.2 | 135 | 428 |
| South end | 1.5 | 1 | 6.5 | 18.7 | 7.1 | 129 | 445 |
| | | 1.6 | 6.5 | 18.7 | 7.0 | 129 | 444 |

captured, excluding non-game fish (e.g., sculpin), was determined using procedures adapted from Swingle (1950). Percentage of the aggregate biomass for each species provides useful information regarding the balance and productivity of the community (Swingle 1950; Bennett 1962a). Only those fish estimated to be at least one year old were used to determine species composition. These were inferred from the length frequency distributions described below, in conjunction with the results of the aging process. Young-of-year or small juveniles were not considered because large fluctuations in their numbers may cause distorted results (Fletcher et al. 1993). For example, the length frequency distribution of largemouth bass (*Micropterus salmoides*) may suggest very successful spawning during a given year, as indicated by a preponderance of fish in the smallest size classes. However, most of these fish would be subject to natural attrition during their first winter (Chew 1974) resulting in a totally different size distribution by the following year. For panfish, such as pumpkinseed (*Lepomis gibbosus*) or bluegill (*Lepomis macrochirus*), the cut-off was 80 mm TL. For larger fish, such as largemouth bass or yellow perch (*Perca flavescens*), the cut-off was 100 mm TL.

The catch per unit effort (CPUE) of electrofishing for each warmwater species was determined by dividing the number of fish captured in each size class by the total electrofishing time (Reynolds 1983). The CPUE of gill netting was determined similarly, except that the number of fish captured in each size class was divided by the total soak time of all nets deployed (Royce 1972). These proportions (fish/hour) were then used to make length frequency histograms to evaluate the size structure of the warmwater fish species and their relative abundance in the lake. Furthermore, since it is standardized, the CPUE is useful for comparing stocks between lakes.

A relative weight ($W_r$) index was used to evaluate the condition (plumpness or robustness) of fish in the lake. The $W_r$ is useful for comparing the condition of different size groups within a single population to determine if all sizes are finding adequate forage or food (ODFW 1997). Following Murphy and Willis (1991), the index was calculated as $W_r = W/W_s \times 100$, where $W$ is the weight (g) of an individual fish and $W_s$ is the standard weight of a fish of the same total length (mm). $W_s$ is calculated from a standard $\log_{10}$weight-$\log_{10}$length relationship defined for the species of interest. The $W_s$ equations for many warmwater fish species, including the minimum length recommendations for their application, are listed in Murphy et al. (1991). Liao et al. (1995) derived the $W_s$ equation for pumpkinseed. A $W_r$ value of 1.0 generally indicates that a fish is in good condition when compared to the national average for that species (ODFW 1997). The $W_r$ values from this study were compared to both the state average and national standard. Furthermore, given the inherent differences in growth between eastern and western Washington largemouth bass, the $W_r$ values of the Loomis Lake fish were plotted against the western average only.

Age and growth of warmwater fish in Loomis Lake were evaluated according to Fletcher et al. (1993). Total length at annulus formation, $L_n$, was back-calculated as $L_n = (A \times TL)/S$, where $A$ is the radius of the fish scale at age $n$, $TL$ is the total length of the fish captured, and $S$ is the total radius of the scale. Mean back-calculated lengths at age $n$ for each species were presented in tabular form for easy comparison between year classes. Differences in growth between the

Loomis Lake fish and the state average for the same species (listed in Fletcher et al. 1993) were compared by plotting their overall mean back-calculated lengths vs. age *n*. However, for the same reason above, the back-calculated lengths of the Loomis Lake largemouth bass were plotted against the western average only.

## RESULTS

### *Species composition*

Table 2 summarizes the species composition and size of fish captured at Loomis Lake during the study period. The predominant fish in the lake were yellow perch, largemouth bass, and pumpkinseed. Black crappie (*Pomoxis nigromaculatus*), brown bullhead (*Ameiurus nebulosus*), and bluegill were less abundant. Species other than the warmwater variety accounted for less than 5% of the total biomass and number captured (Table 2; Figures 2 and 3).

**Table 2**. Species composition (excluding young-of-year) by weight (kg) and number, and total number and size of fish captured (including young-of-year) at Loomis Lake (Pacific County) during a late summer 1997 survey of warmwater fish.

| | Species composition | | Total # | |
|---|---|---|---|---|
| Type of fish | by kg | by # | captured | Size range |
| Yellow perch (*Perca flavescens*) | 25.7 | 570 | 701 | 81 - 290 mm TL |
| Largemouth bass (*Micropterus salmoides*) | 21.9 | 94 | 3432 | 51 - 510 mm TL |
| Pumpkinseed (*Lepomis gibbosus*) | 5.6 | 136 | 147 | 26 - 162 mm TL |
| Black crappie (*Pomoxis nigromaculatus*) | 3.2 | 86 | 197 | 57 - 220 mm TL |
| Brown bullhead (*Ameiurus nebulosus*) | 2.8 | 21 | 21 | 122 - 260 mm TL |
| Rainbow trout (*Oncorhynchus mykiss*) | 2.7 | 9 | 9 | 155 - 403 mm TL |
| Bluegill (*Lepomis macrochirus*) | 1.5 | 41 | 47 | 32 - 147 mm TL |
| Sculpin (*Cottus* sp.) | --- | 15 | 15 | 35 - 100 mm TL |
| Three-spine stickleback (*Gasterosteus aculeatus*) | --- | 1 | 1 | 55 mm TL |
| Total | 63.4 | 973 | | |

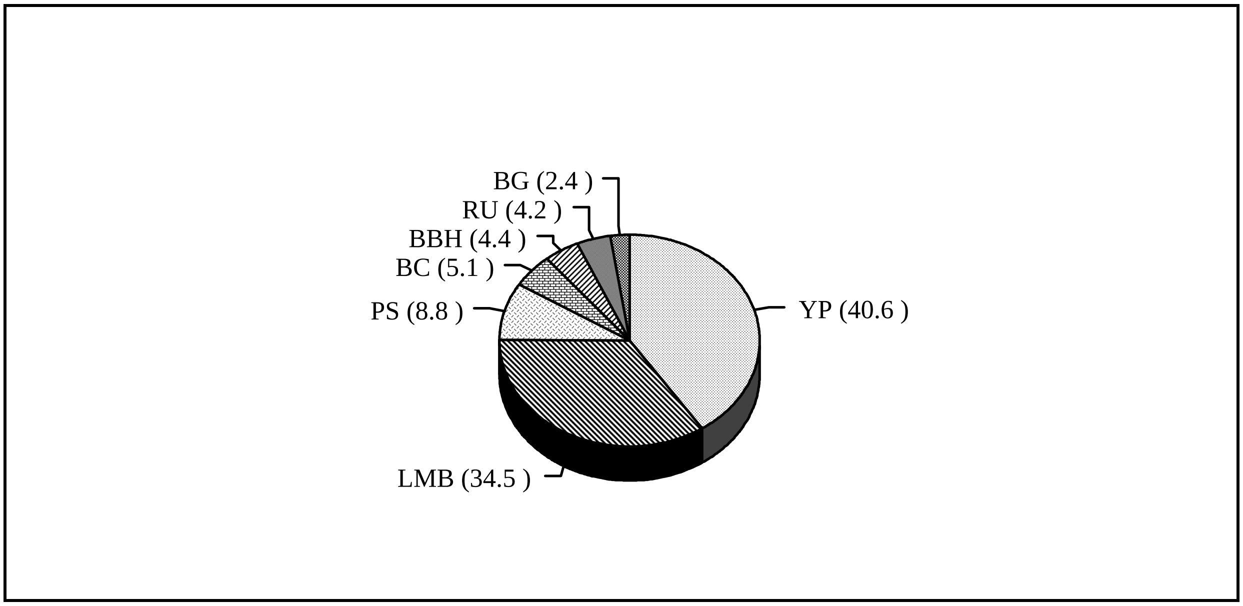


**Figure 2**. Species composition by weight (kg) of fish captured at Loomis Lake (Pacific County) during late summer 1997. YP = yellow perch, LMB = largemouth bass, PS = pumpkinseed, BC = black crappie, BG = bluegill, BBH = brown bullhead, and RU = rainbow trout (unknown race). Values are percent of total biomass (63.4 kg, excluding young-of-year and non-game fish).

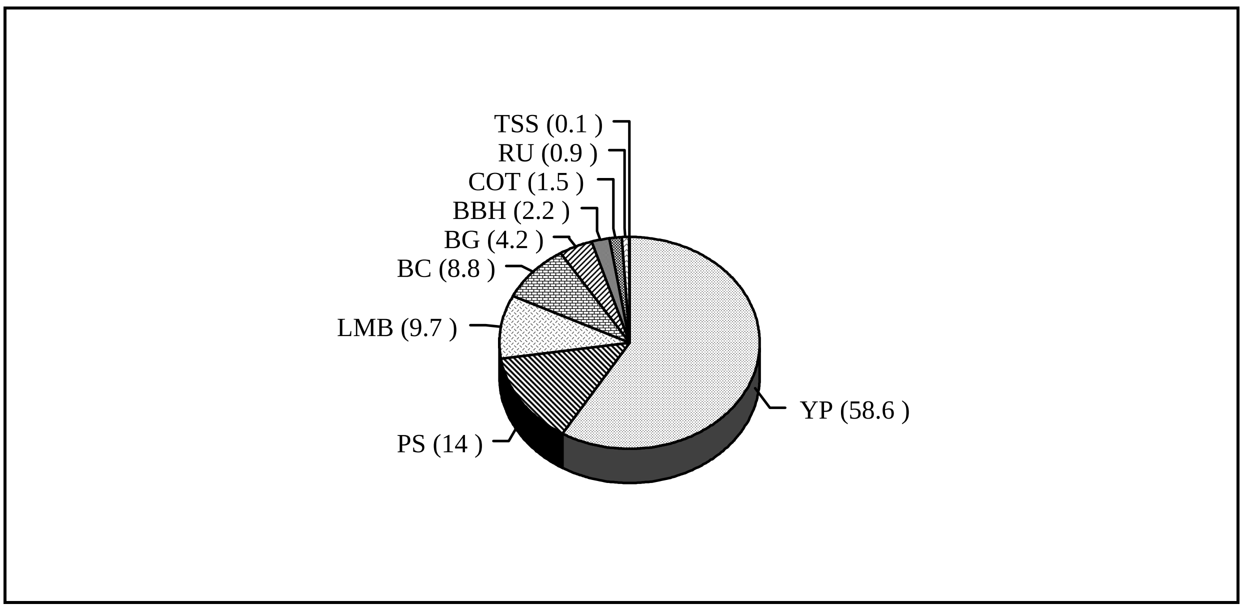


**Figure 3**. Species composition by number of fish captured at Loomis Lake (Pacific County) during late summer 1997. YP = yellow perch, PS = pumpkinseed, LMB = largemouth bass, BC = black crappie, BG = bluegill, BBH = brown bullhead, COT = sculpin (Cottidae), RU = rainbow trout (unknown race), and TSS = three-spine stickleback. Values are percent of total (N = 973, excluding young-of-year).

### *Yellow perch*

The size of yellow perch ranged from 81 to 290 mm TL (Table 2; age 0+ to 8+). Of all species captured, yellow perch > 100 mm TL were dominant in terms of both biomass and number (Table 2; Figures 2 and 3). Most of these were two and three years old (~ 130 - 170 mm TL). Although there was a moderate number of one year old fish (~ 90 - 120 mm TL), relatively few young-of-year (~ 80 mm TL and below) were captured. Large, older fish (> 200 mm TL, age 5+) were rarely observed; furthermore, the 1991 year class (age 7+) was absent from samples (Table 3; Figures 4 and 5). During their first four years, Loomis Lake yellow perch had similar relative weights, but slightly lower growth than the state average. However, after age 5, relative weights decreased while growth exceeded that of the state average (Table 3; Figures 6 and 7). In general, the relative weights decreased with length (or age), which is consistent for the species statewide (Figure 7).

**Table 3**. Age and growth of yellow perch (*Perca flavescens*) captured at Loomis Lake (Pacific County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| | | Mean length (mm) at age | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year class | # fish | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1997 | 8 | **88.9** | | | | | | | |
| 1996 | 12 | 79.7 | **128.2** | | | | | | |
| 1995 | 16 | 86.1 | 129.1 | **150.5** | | | | | |
| 1994 | 4 | 66.9 | 103.3 | 142.8 | **163.2** | | | | |
| 1993 | 4 | 73.1 | 114.1 | 158.6 | 185.8 | **204.2** | | | |
| 1992 | 1 | 94.5 | 135.0 | 167.8 | 200.6 | 221.8 | **233.4** | | |
| 1991 | 0 | | | | | | | | |
| 1990 | 1 | 84.7 | 131.8 | 165.7 | 192.1 | 216.6 | 241.0 | 254.2 | **282.5** |
| Overall mean | | **82.3** | **124.8** | **151.8** | **178.9** | **209.2** | **237.2** | **254.2** | **282.5** |
| State average | | 59.7 | 119.9 | 152.1 | 192.5 | 206.0 | 197.4 | 194.8 | 242.6 |

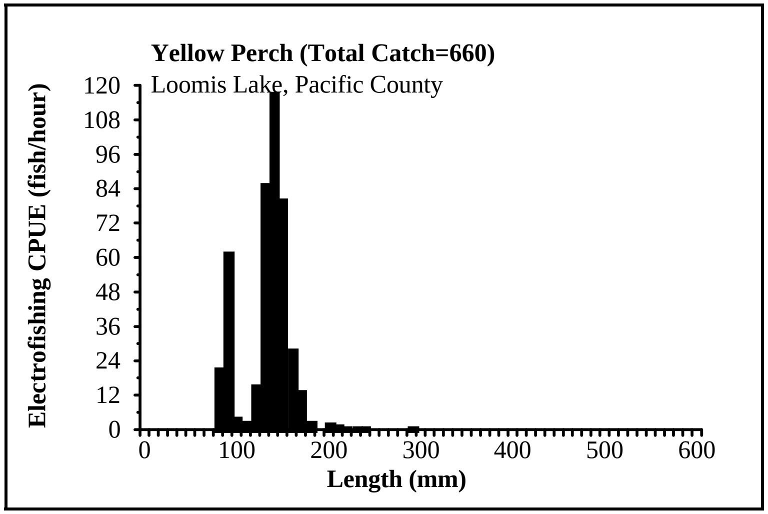


**Figure 4**. Relationship between total length and catch per unit effort of electrofishing for yellow perch (*Perca flavescens*) at Loomis Lake (Pacific County) during late summer 1997.

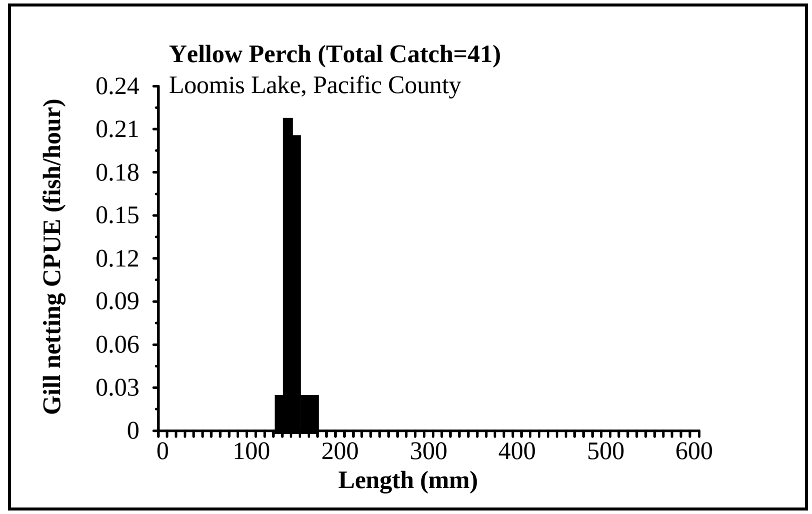


**Figure 5**. Relationship between total length and catch per unit effort of gill netting for yellow perch (*Perca flavescens*) at Loomis Lake (Pacific County) during late summer 1997.

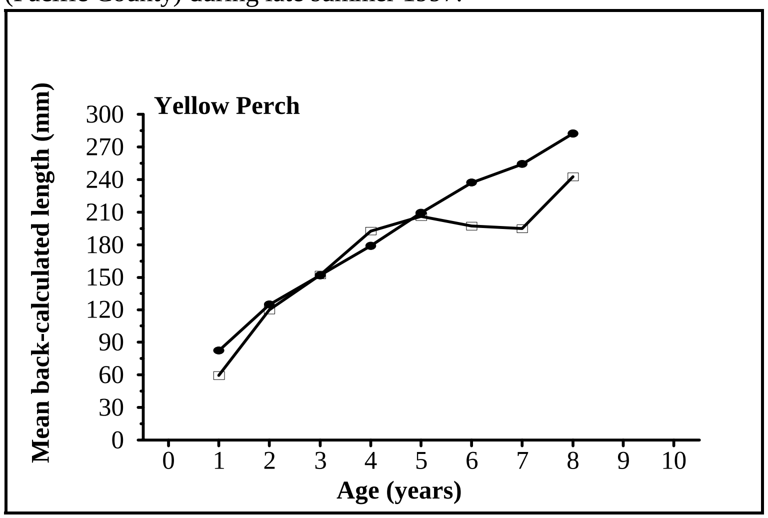


**Figure 6**. Growth of yellow perch (*Perca flavescens*) from Loomis Lake, Pacific County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.

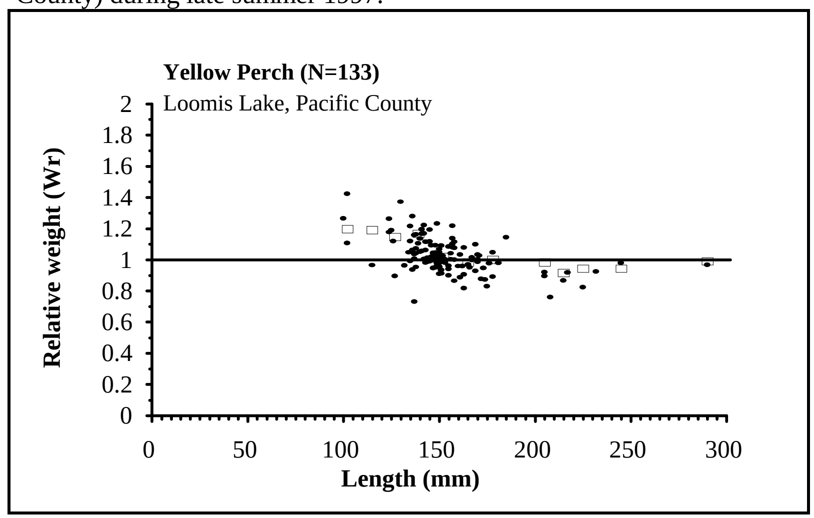


**Figure 7**. Relationship between total length and relative weight ($W_r$) of yellow perch (*Perca flavescens*) from Loomis Lake, Pacific County (closed, black circles) compared to the Washington State average (open, clear rectangles) and the national standard (horizontal line at 1.0).

### ***Largemouth bass***

The size range of Loomis Lake largemouth bass was 51 to 510 mm TL (Table 2; age 0+ to 11+). The percentage biomass of largemouth bass > 100 mm TL was second only to yellow perch (Table 2; Figure 2). And although the number of the former was modest compared to the latter (Table 2; Figure 3), the CPUE of electrofishing was extraordinarily high because of the number of largemouth bass in the smallest size classes (Figure 8). For example, over 2000 young-of-year (~ 50 - 80 mm TL) were captured per hour of electrofishing. Of the remaining year classes, ages 1+ (~ 90 - 110 mm TL) and 2+ (~130 - 170 mm TL) were dominant, whereas few, large old fish were observed (Table 4; Figures 8 and 9). Growth of Loomis Lake largemouth bass was generally lower when compared to the western Washington average, as indicated by lower mean back-calculated lengths irrespective of age *n* (Table 4; Figure 10). However, the relative weights were consistent with the western Washington average and, unlike yellow perch, constant with length or age (Figure 11).

**Table 4**. Age and growth of largemouth bass (*Micropterus salmoides*) captured at Loomis Lake (Pacific County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| | | Mean length (mm) at age | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year class | # fish | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1997 | 11 | **77.4** | | | | | | | | | | |
| 1996 | 18 | 63.6 | **124.4** | | | | | | | | | |
| 1995 | 12 | 61.4 | 117.8 | **154.7** | | | | | | | | |
| 1994 | 7 | 60.5 | 139.2 | 190.0 | **226.6** | | | | | | | |
| 1993 | 5 | 61.1 | 148.1 | 196.5 | 224.4 | **251.6** | | | | | | |
| 1992 | 2 | 70.4 | 126.7 | 182.8 | 223.0 | 258.5 | **278.3** | | | | | |
| 1991 | 8 | 64.8 | 137.4 | 192.1 | 236.5 | 262.1 | 289.1 | **310.8** | | | | |
| 1990 | 3 | 59.1 | 129.0 | 184.6 | 229.1 | 267.4 | 298.0 | 323.2 | **342.4** | | | |
| 1989 | 2 | 72.9 | 148.7 | 203.3 | 239.3 | 284.4 | 320.2 | 340.9 | 360.5 | **378.8** | | |
| 1988 | 1 | 57.5 | 135.3 | 181.7 | 213.2 | 246.5 | 283.6 | 304.0 | 324.4 | 355.9 | **380.0** | |
| 1987 | 1 | 59.6 | 150.1 | 211.9 | 271.6 | 335.6 | 412.9 | 446.0 | 463.6 | 474.7 | 487.9 | **499.0** |
| Overall mean | | **65.1** | **130.3** | **181.1** | **230.9** | **264.8** | **300.0** | **325.8** | **362.3** | **397.0** | **434.0** | **499.0** |
| W. WA avg | | 60.4 | 145.5 | 222.2 | 261.1 | 289.3 | 319.0 | 367.8 | 396.0 | 439.9 | 484.6 | 471.7 |

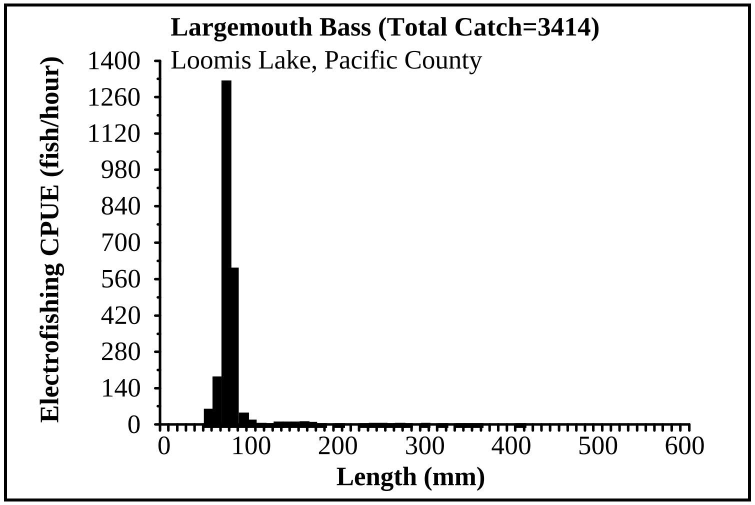


**Figure 8**. Relationship between total length and catch per unit effort of electrofishing for largemouth bass (*Micropterus salmoides*) at Loomis Lake (Pacific County) during late summer 1997.

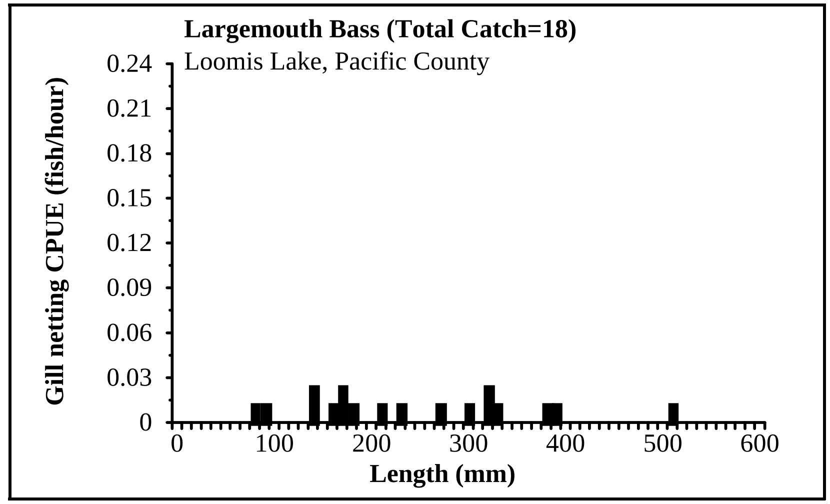


**Figure 9**. Relationship between total length and catch per unit effort of gill netting for largemouth bass (*Micropterus salmoides*) at Loomis Lake (Pacific County) during late summer 1997.

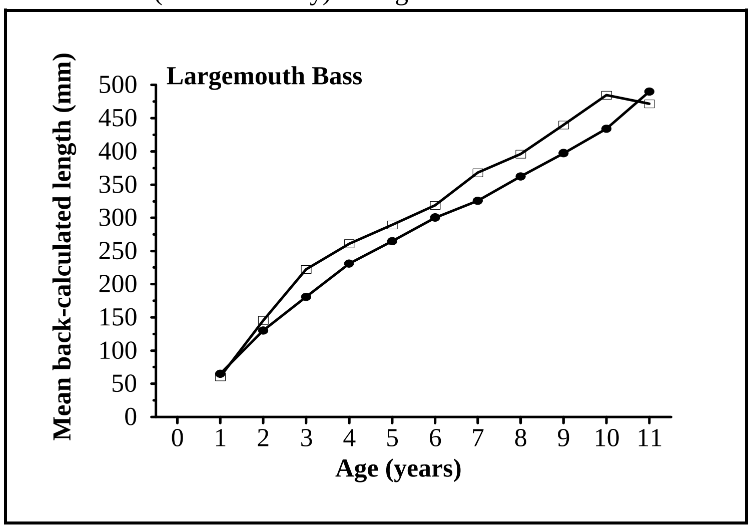


**Figure 10**. Growth of largemouth bass (*Micropterus salmoides*) from Loomis Lake, Pacific County (closed, black circles), compared to the western Washington average (open, clear rectangles). Values are mean back-calculated lengths at age.

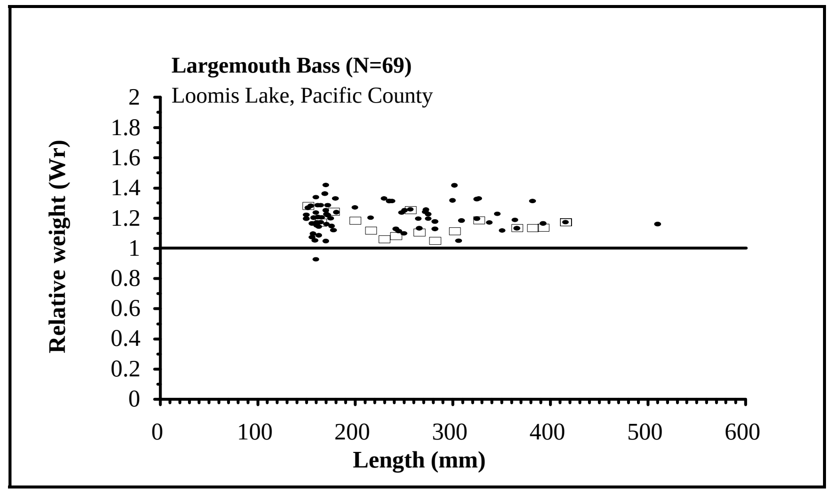


**Figure 11**. Relationship between total length and relative weight ($W_r$) of largemouth bass (*Micropterus salmoides*) from Loomis Lake, Pacific County (closed, black circles) compared to the western Washington average (open, clear rectangles) and the national standard (horizontal line at 1.0).

***Pumpkinseed***

Loomis Lake pumpkinseed ranged in size from 26 to 162 mm TL (Table 2; age 0+ to 5+). Most of these exceeded 100 mm TL (age 3+), whereas small, young fish were rarely observed. The predominant year class (age 4+) consisted of fish measuring ~ 120 - 130 mm TL (Table 5; Figures 12 and 13). During the first three years, growth of Loomis Lake pumpkinseed was slightly higher than the state average. However, after age 3, there was little difference in growth of these fish when compared to pumpkinseed statewide (Table 5; Figure 14). Furthermore, the relative weights were lower than the state average and, like yellow perch, decreased with length or age (Figure 15).

**Table 5**. Age and growth of pumpkinseed (*Lepomis gibbosus*) captured at Loomis Lake (Pacific County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| | | Mean length (mm) at age | | | | |
|---|---|---|---|---|---|---|
| Year class | # fish | 1 | 2 | 3 | 4 | 5 |
| 1997 | 3 | **61.7** | | | | |
| 1996 | 5 | 48.6 | **78.6** | | | |
| 1995 | 14 | 49.6 | 79.8 | **99.4** | | |
| 1994 | 16 | 46.8 | 85.9 | 108.6 | **124.3** | |
| 1993 | 3 | 51.0 | 88.7 | 115.2 | 136.5 | **145.6** |
| | Overall mean | **49.4** | **82.9** | **105.3** | **126.2** | **145.6** |
| | State average | 23.6 | 72.1 | 101.6 | 122.7 | 139.4 |

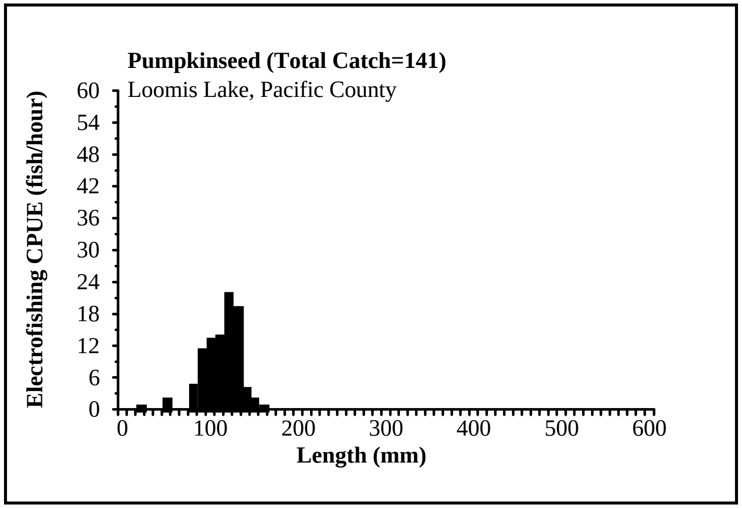


**Figure 12**. Relationship between total length and catch per unit effort of electrofishing for pumpkinseed (*Lepomis gibbosus*) at Loomis Lake (Pacific County) during late summer 1997.

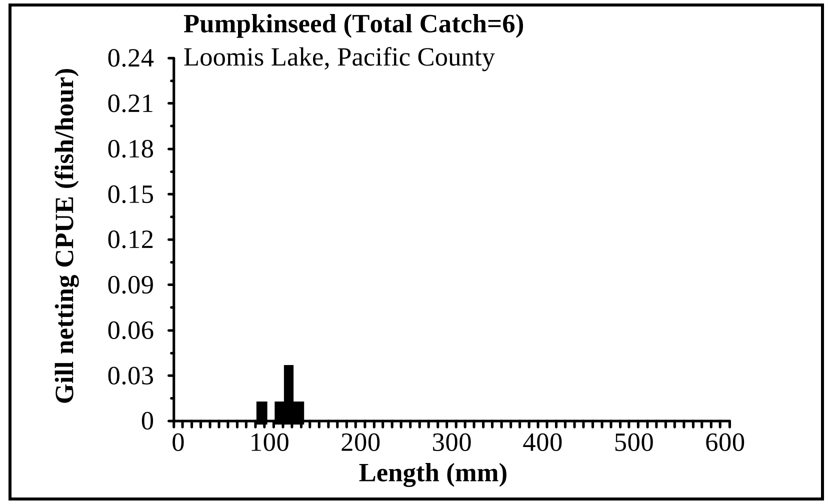


**Figure 13**. Relationship between total length and catch per unit effort of gill netting for pumpkinseed (*Lepomis gibbosus*) at Loomis Lake (Pacific County) during late summer 1997.

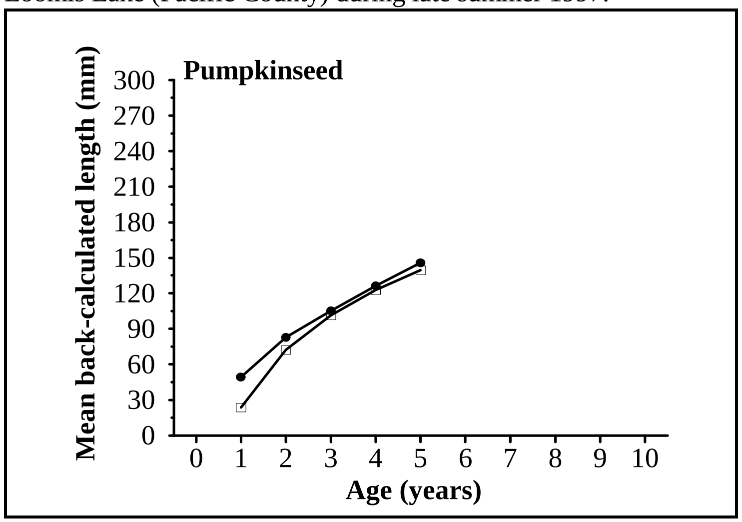


**Figure 14**. Growth of pumpkinseed (*Lepomis gibbosus*) from Loomis Lake, Pacific County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.

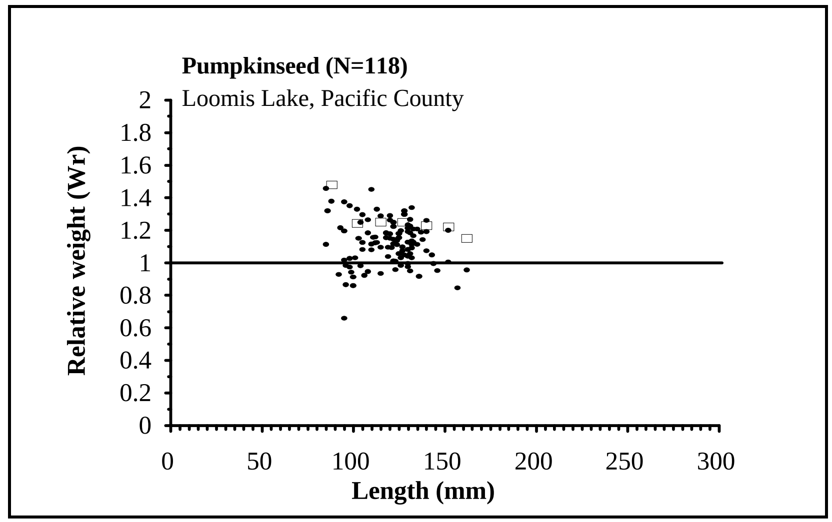


**Figure 15**. Relationship between total length and relative weight ($W_r$) of pumpkinseed (*Lepomis gibbosus*) from Loomis Lake, Pacific County (closed, black circles) compared to the Washington State average (open, clear rectangles) and the national standard (horizontal line at 1.0).

*Black crappie*

The size of black crappie ranged from 57 to 220 mm TL (Table 2; age 0+ to 5+). Most of these were young-of-year (~ 80 mm TL and below) and two year old fish (~ 110 - 150 mm TL). Large, older fish (> 180 mm TL, age 4+) were scarce (Table 6; Figures 16 and 17). Growth and relative weights of Loomis Lake black crappie were generally lower than the state average (Table 6; Figures 18 and 19).

**Table 6**. Age and growth of black crappie (*Pomoxis nigromaculatus*) captured at Loomis Lake (Pacific County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| | | Mean length (mm) at age | | | | |
|---|---|---|---|---|---|---|
| Year class | # fish | 1 | 2 | 3 | 4 | 5 |
| 1997 | 5 | **73.9** | | | | |
| 1996 | 21 | 57.4 | **109.2** | | | |
| 1995 | 7 | 56.8 | 115.5 | **149.3** | | |
| 1994 | 1 | 49.5 | 110.5 | 141.8 | **169.8** | |
| 1993 | 2 | 54.0 | 101.5 | 127.9 | 164.0 | **190.0** |
| | Overall mean | **59.2** | **110.2** | **144.3** | **165.9** | **190.0** |
| | State average | 46.0 | 111.2 | 156.7 | 183.4 | 220.0 |

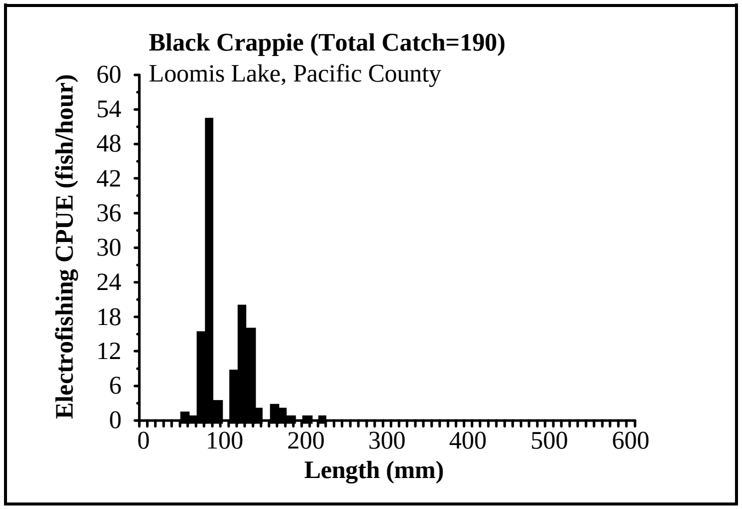


**Figure 16**. Relationship between total length and catch per unit effort of electrofishing for black crappie (*Pomoxis nigromaculatus*) at Loomis Lake (Pacific County) during late summer 1997.

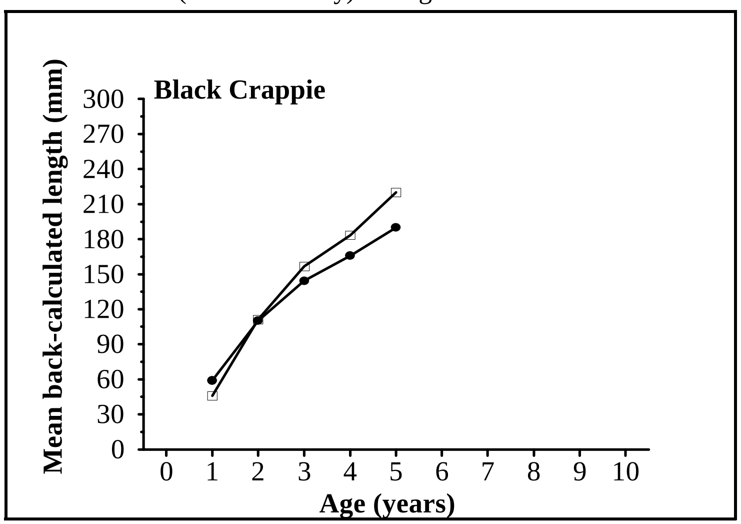


**Figure 18**. Growth of black crappie (*Pomoxis nigromaculatus*) from Loomis Lake, Pacific County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.

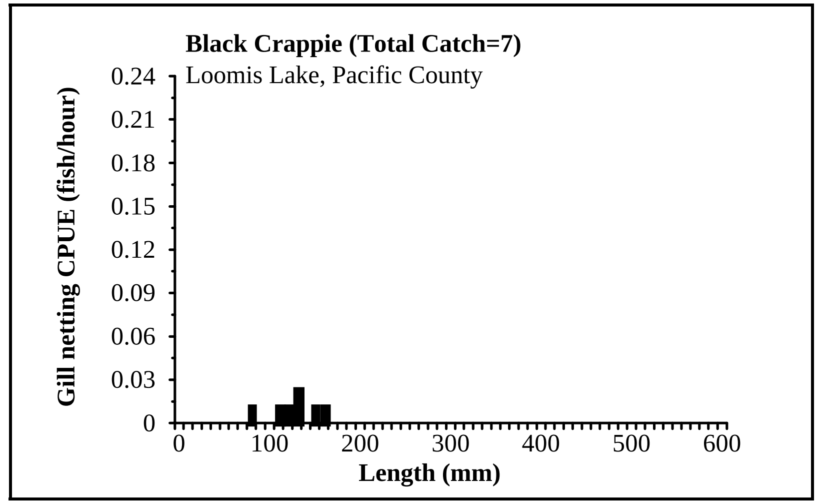


**Figure 17**. Relationship between total length and catch per unit effort of gill netting for black crappie (*Pomoxis nigromaculatus*) at Loomis Lake (Pacific County) during late summer 1997.

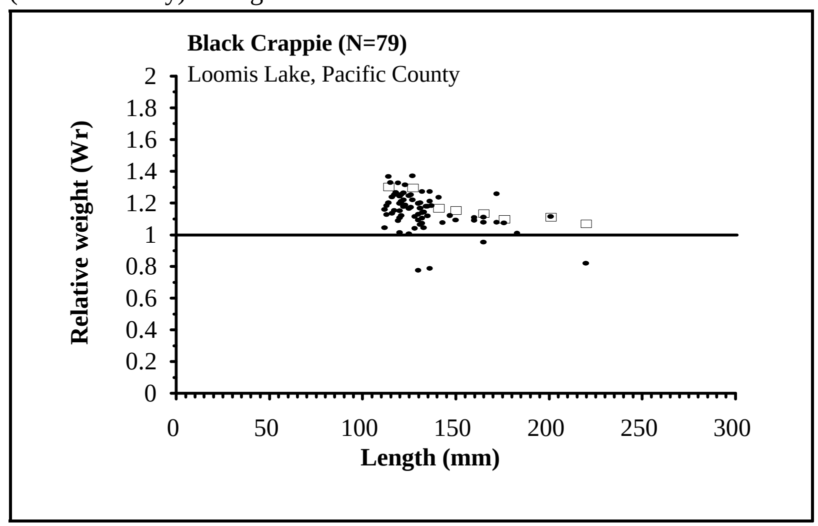


**Figure 19**. Relationship between total length and relative weight ($W_r$) of black crappie (*Pomoxis nigromaculatus*) from Loomis Lake, Pacific County (closed, black circles) compared to the Washington State average (open, clear rectangles) and the national standard (horizontal line at 1.0).

### *Brown bullhead*

The size range of brown bullhead was 122 to 260 mm TL (Table 2). Gill netting proved to be the best sampling method for these fish, most of which were above 200 mm TL (Figure 21). At least three year classes were evident from the length frequency histograms (Figures 20 and 21), however, their actual ages were unknown.

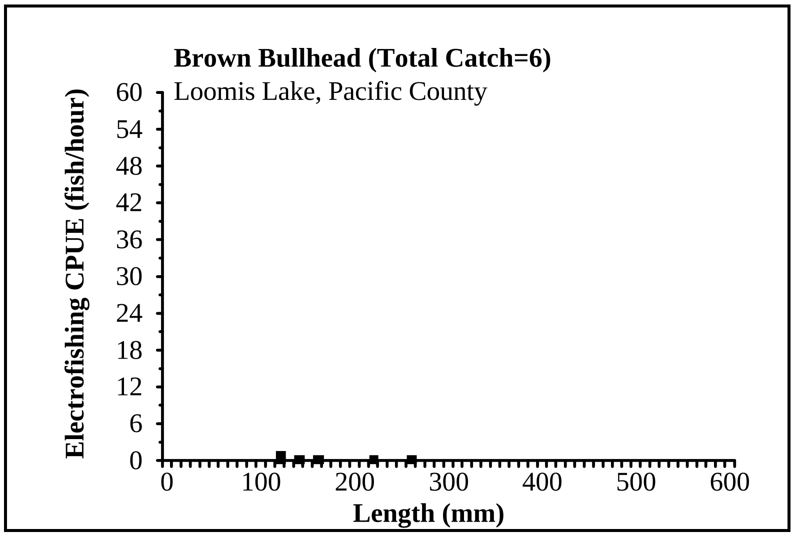


**Figure 20**. Relationship between total length and catch per unit effort of electrofishing for brown bullhead (*Ameiurus nebulosus*) at Loomis Lake (Pacific County) during late summer 1997.

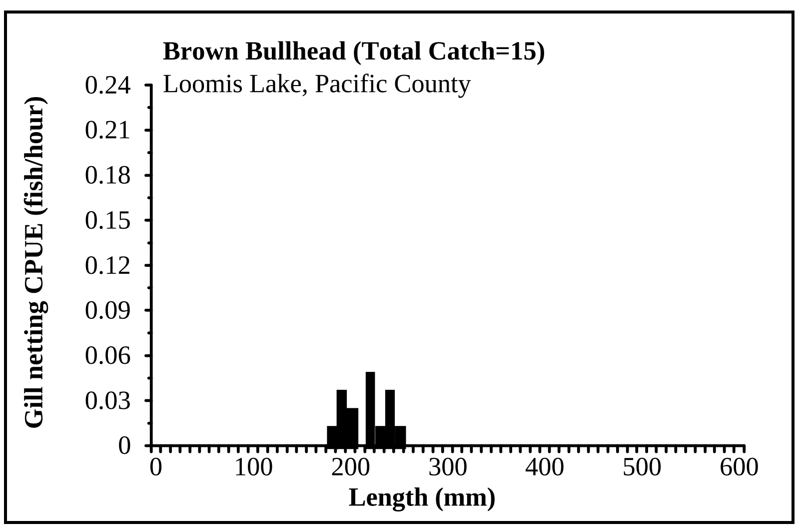


**Figure 21**. Relationship between total length and catch per unit effort of gill netting for brown bullhead (*Ameiurus nebulosus*) at Loomis Lake (Pacific County) during late summer 1997.

### ***Bluegill***

Loomis Lake bluegill ranged in size from 32 to 147 mm TL (Table 2; age 0+ to 4+). Two and three year old fish (~ 90 - 120 mm TL) were dominant. Young and old fish were the least abundant (Table 7; Figures 22 and 23). Although the mean back-calculated length at age 1 was higher than that of the state average, below average growth resulted in smaller fish by age 4. The relative weights of Loomis Lake bluegill were generally consistent with the state average for the species (Table 7; Figures 24 and 25).

**Table 7**. Age and growth of bluegill (*Lepomis macrochirus*) captured at Loomis Lake (Pacific County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| | | Mean length (mm) at age | | | |
|---|---|---|---|---|---|
| Year class | # fish | 1 | 2 | 3 | 4 |
| 1997 | 1 | **69.1** | | | |
| 1996 | 11 | 56.2 | **91.6** | | |
| 1995 | 10 | 65.1 | 97.7 | **117.0** | |
| 1994 | 3 | 60.7 | 86.6 | 120.4 | **132.9** |
| | Overall mean | **60.9** | **93.5** | **117.8** | **132.9** |
| | State average | 37.3 | 96.8 | 132.1 | 148.3 |

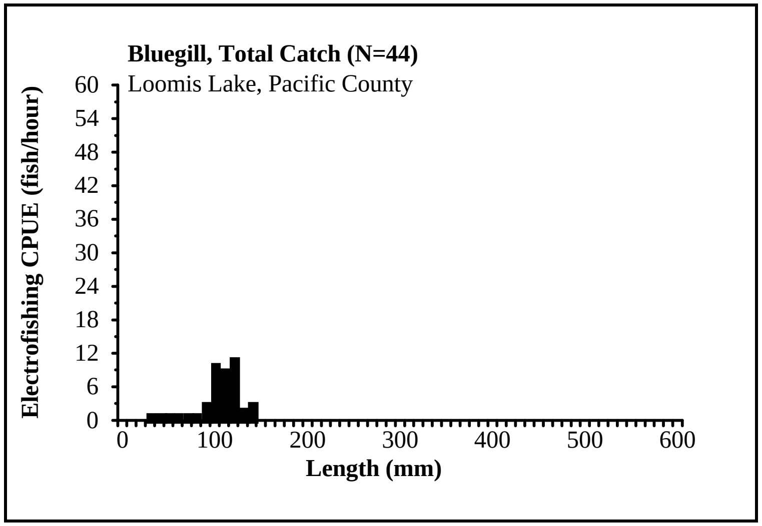


**Figure 22**. Relationship between total length and catch per unit effort of electrofishing for bluegill (*Lepomis macrochirus*) at Loomis Lake (Pacific County) during late summer 1997.

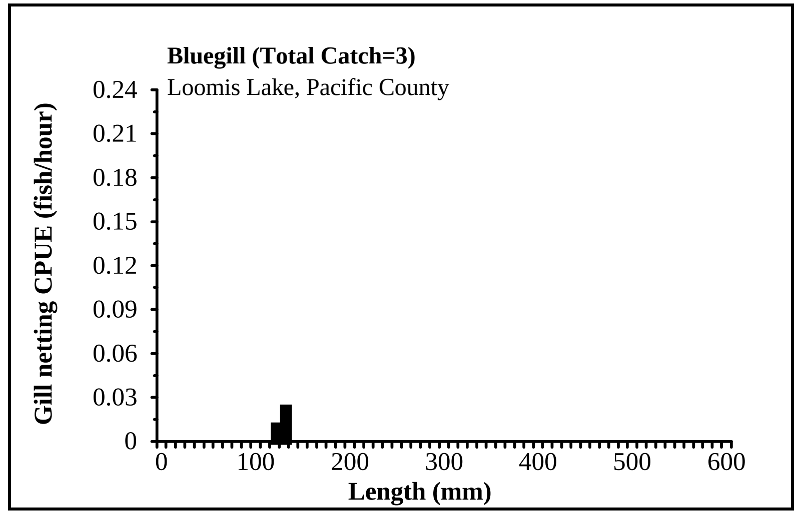


**Figure 23**. Relationship between total length and catch per unit effort of gill netting for bluegill (*Lepomis macrochirus*) at Loomis Lake (Pacific County) during late summer 1997.

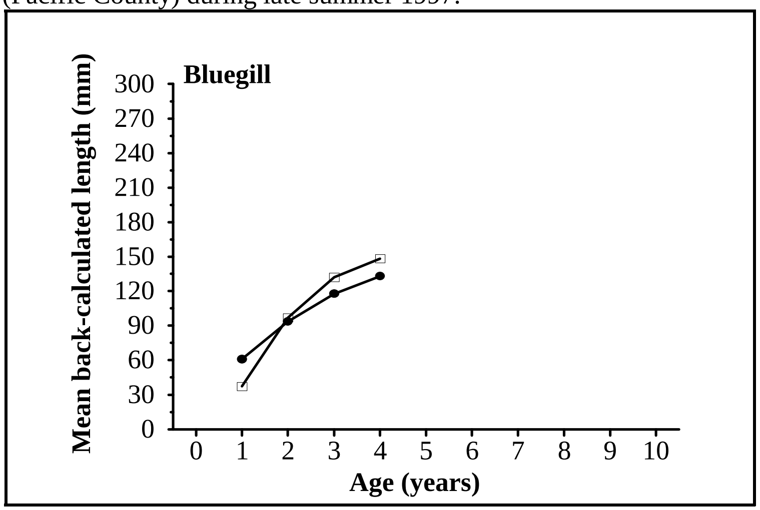


**Figure 24**. Growth of bluegill (*Lepomis macrochirus*) from Loomis Lake, Pacific County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.

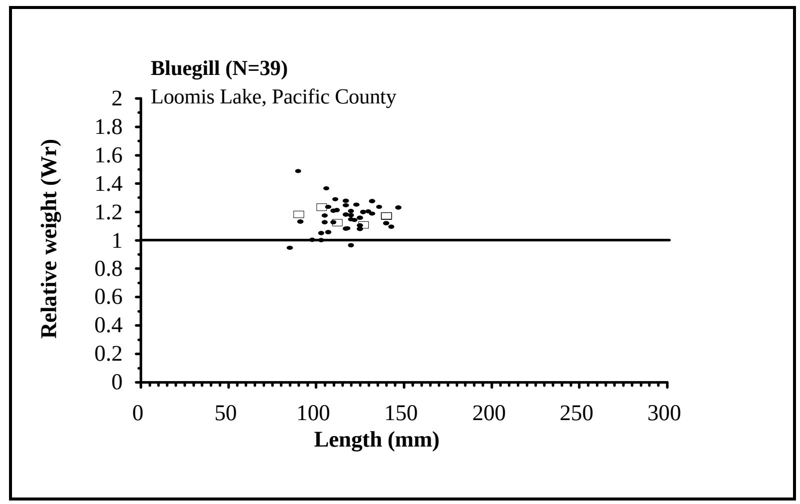


**Figure 25**. Relationship between total length and relative weight ($W_r$) of bluegill (*Lepomis macrochirus*) from Loomis Lake, Pacific County (closed, black circles) compared to the Washington State average (open, clear rectangles) and the national standard (horizontal line at 1.0).

## DISCUSSION

Balancing predator and prey fish populations is the hallmark of warmwater fisheries management. According to Bennett (1962a), the term 'balance' is used loosely to describe a system in which omnivorous fish, such as bluegill or pumpkinseed (prey), maximize food resources to produce harvestable-size stocks for fishermen and an adequate forage base for piscivorous fish, such as largemouth bass (predator). Predators must reproduce and grow to control overproduction of both prey and predator species, as well as provide adequate fishing. Characteristics of unbalanced populations include poor growth or condition, and low recruitment (Swingle 1956; Kohler and Kelly 1991; Masser *undated*). Therefore, in order to maintain balance within a body of water, fish must be able to forage effectively. An evaluation of size structure, growth, and relative weight ($W_r$) provides useful information on the adequacy of the food supply (Kohler and Kelly 1991).

During late summer 1997, Loomis Lake showed some indications of having an imbalanced fish community. For example, the forage fish exhibited either below average growth, below average condition, or both. Largemouth bass exhibited reasonable condition but below average growth. Although young-of-year and small juveniles of some fish species were observed, most notably largemouth bass, they were rarely observed in others (e.g., pumpkinseed and bluegill). Furthermore, few, if any, quality size fish were captured.

The causes for the variation described above are complex and difficult to isolate from a single survey; however, some inferences can be drawn from previous studies. For example, the conditions at Loomis Lake resemble those described by Swingle (1956) for populations experiencing inter- and intraspecific crowding. According to Swingle, crowding in warmwater fish populations results in slow growth (less food per individual) and reduced or inhibited reproduction. This was evident in the forage fish populations at Loomis Lake. Their size structure, growth patterns and $W_r$ values suggest that these fish were not able to find sufficient forage, possibly due to over-crowding and competition with other species, predominantly yellow perch and juvenile largemouth bass.

Disparate fishing pressure within a lake may cause an imbalanced fish community. Bennett (1962c) characterized underfished populations by high survival of all year classes, with small intermediate age fish (two to three years old) and few, harvestable size fish. Overfished populations were characterized by overabundant, slow-growing young fish (less than three years old) and few, large old fish. Additional research may show that the forage fish at Loomis Lake are subject to underfishing, while the large yellow perch and largemouth bass are being overfished.

Furthermore, an imbalanced community may result from increased aquatic macrophyte cover. For example, Hoyer and Canfield (1996) showed an inverse relationship between macrophyte abundance and growth of one and two year old largemouth bass. As macrophyte density increases, predator foraging efficiency decreases because of increased refuge available to prey.

The increased survival of prey leads to greater population density (crowding) and more competition among these fish (Olson et al. 1998 and references therein). Currently, Loomis Lake remains threatened by an invasion of submerged Eurasian watermilfoil and the spread of emergent burreed along the shore. The level of plant cover is one likely cause of the diminished growth and slightly crowded conditions observed during the late summer 1997. Lack of significant predation is another. Regardless, the fish community at Loomis Lake would probably benefit by reducing the macrophyte cover (Davies and Rwangano 1991; Olson et al. 1998), and increasing the predation of forage fish (Bennett 1962b; Masser *undated*).

## RECOMMENDATIONS

### *Support selective removal of nuisance aquatic plants*

The major goal of the Loomis Lake Integrated Aquatic Plant Management Plan (IAPMP) is to reduce the nuisance Eurasian watermilfoil and burreed without severely impacting other macrophytes (Envirovision *in review*). Prudent implementation of the plan may improve the quality of the warmwater fishery at the lake. For example, a recent study (Olson et al. 1998) showed that growth rates of certain age classes of largemouth bass and bluegill increased substantially by removing macrophytes from only 20% of the littoral zone. Given the current biomass or density of largemouth bass in Loomis Lake (Table 2; Figures 2 and 3), predation of forage fish should increase upon successful implementation of the IAPMP. Ostensibly, this would lead to improved densities and growth of predator and prey fish alike. However, removal of too much cover may shift the balance in the lake toward the predators by reducing prey refuge. The result would be an imbalanced fish community with abundant, small predators and few, large prey fish (Swingle 1956; Davies and Rwangano 1991). Loomis Lake should be surveyed within two years of implementing the IAPMP in order to reevaluate the balance of the fish community in the lake.

### *Control forage fish populations with 'super predator'*

Besides implementation of the IAPMP, the balance within Loomis Lake may be restored by stocking a sufficient number of 'super predators' to reduce the forage fish populations. This technique has been used with varied degrees of success for years (Bennet 1962a; Boxrucker 1992; WDFW 1996; Bolding et al. 1997 and references therein). For example, stocking walleye (*Stizostedion vitreum*) may improve the density and growth of forage fish, but once introduced, overproduction of the predator may lead to an imbalanced community (Bolding et al. 1997 and references therein). An alternative would be to stock a low number ($\leq$ 100) of sterile, yearling tiger musky (*Esox lucius* × *E. masquinongy*), which generally fare well irrespective of the forage base (Kohler and Kelly 1991). Moreover, tiger musky grow rapidly in Washington (WDFW 1996). Therefore, in addition to improving the balance by reducing forage fish populations, stocking tiger musky may also provide a trophy fishing opportunity at Loomis Lake (Storck and Newman 1992).

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## ACKNOWLEDGMENTS

I would like to thank John Pahutski and Steve Anderson of the Washington Department of Fish and Wildlife (WDFW) for their unfailing, invaluable assistance in the field and lab. Bill Zook (WDFW) provided technical assistance, encouragement and support, whereas Scott Bonar, Bruce Bolding, and Marc Divens (WDFW) provided helpful advice. I would also like to thank the staff at the department's Willapa Bay Field Station, especially Brett Dumbauld and Bruce Kauffman, who provided additional assistance in the field. This project was funded by the Warmwater Enhancement Program, through a licence surcharge, which is providing greater opportunities to fish for and catch warmwater fish in Washington.