# 1998 Warmwater Fish Survey of Vancouver Lake, Clark County

by

Stephen J. Caromile,
William R. Meyer and
Chad S. Jackson

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

**April 2000**

# Acknowledgments

We thank Steve Anderson, Chris Sergeant, and Stacie Kelsie for their efforts in the field, and the Inland Fisheries Investigations unit for the loan of the catfish traps. We also like to thank the owners of the Felita boat launch for allowing us free access to their boat launch and parking area. This project was funded by the Warmwater Enhancement Program, through a license surcharge, which is providing greater opportunity to fish for and catch warmwater fish in Washington. We also thank John Weinheimer for providing the commercial carp fishery information. Comments to the draft were provided by Steve Jackson and John Weinheimer.

# Abstract

The Vancouver Lake warmwater fish population was sampled during the fall of 1998. Vancouver Lake is a large lake, connected directly to the Columbia River through the Lake River to the north and the constructed flushing channel on the eastern shore. A total of 16 species of fish were encountered, mostly warmwater game fish with a few seasonal visitors. The lake has suffered from water quality problems, and during the 1970s, it was dredged, and a channel was created to aid in increasing the water turnover rate, effectively connecting both ends of the lake to the Columbia River. As there is direct access to the Columbia River, managing this lake as a closed system may prove difficult. It is of our opinion that it may be a more effective use of resources to increase the anglers access to the available resources through providing improved boat launch access, and fish habitat structure throughout the lake. Additionally, educating the public about the how–to's of common carp angling could possibly open up additional resources not commonly utilized by the public.

# Table of Contents

# List of Tables

# List of Figures

# Introduction and Background

Vancouver Lake is a 2,286–acre water body located in the city of Vancouver, Clark County. Historically, Vancouver Lake was connected directly to the Columbia River; water entered the southern end of the lake through Mulligan Slough, and exited through the Lake River at the north. Currently, the lake is more of a backwater cove off of the main stem Columbia River, and the lake level is tidally influenced (tidal exchange is roughly 0.3 meter). It is an extremely shallow lake, with a maximum depth of approximately 1.8 meters, and a mean depth of 0.6 meter. Because it is tied directly to the Columbia River, mean and maximum depths of the lake vary greatly throughout the year, depending upon flows and tides. Other sources of surface water inflow are from Burnt Bridge Creek and an unnamed tributary on the eastern shore.

During the mid–1970s, plans to increase the usage of Vancouver Lake were being developed and researched by the local and state governments. The shallow depth and high level of pollutants made the lake undesirable for recreation. The final restoration plan called for the dredging of approximately 6.5 million cubic meters of sediment, the construction of a flushing channel to aid in water exchange, and the construction of a city park along the western shore. A flushing channel, nearly a mile long, was created between the Columbia River and the lake, with flows being controlled by tide gates. The dredging consisted mainly of creating a channel along the western side of the lake; this was designed to allow greater directed movement of water from the flushing channel out through the lake river, greatly increasing the flushing rate of the lake as a whole. The restoration plan was completed by the mid 1980s, and was supported by the local, state, and federal governments.

Vancouver Lake suffers from a high amount of suspended solids, mostly colloidal material possibly stirred up by tidal, wind, and wave action in the shallow lake. The high turbidity, and low light penetration has resulted in low primary productivity, and few, if any, aquatic plants.

Shoreline development is minimal. The southern end flood plain is mostly agricultural and partially within the boundary of the state owned Vancouver Lake Wildlife Area . The western shore is mostly county park, and the eastern is undeveloped land bordered by railroad. Most of the surrounding land is fairly flat and low in elevation. It is assumed that much of this land floods during times of extreme high water in the Columbia River.

Vancouver Lake does receive a fairly large amount of fishing pressure, including a commercial fishery for common carp (*Cyprinus carpio*) during certain times of the year (John Weinheimer, WDFW, personal communication).

# Materials and Methods

## Data Collection

Vancouver Lake was surveyed by a four–person team during September 15-22, 1998. Fish were captured using five sampling techniques: electrofishing; gill netting; fyke netting; catfish traps; and beach seining. The electrofishing unit consisted of a Smith-Root SR-16s electrofishing boat, with a 5.0GPP pulsator unit. The boat was fished using a pulsed DC current of 120 cycles/sec at 3 - 4 amps power. 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 4–foot diameter hoops with two funnels, and an 8–foot cod end (¼ inch nylon delta mesh). Attached to the mouth of the net were two 25–foot wings, and a 100–foot 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 gill netting to fyke netting was 1:1:1. The standardized sample is 1800 seconds of electrofishing (3 sections), two gill net nights, and two 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 (Figure 1) by dividing the entire shoreline into 400–m sections, and numbering them consecutively. Nightly sampling locations were randomly chosen (without replication) utilizing a random numbers table (Zar 1984). While electrofishing, the boat was maneuvered through the shallows at a slow rate of speed (~18 m/minute, linear distance covered over time) for a total of 600 seconds of "pedal–down" time or until the end of the section was reached, whichever came first. We electrofished for a total of 3631 seconds, or roughly 6 standard sections. 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 off to shore, and the cod end was anchored off shore, with the wings anchored at approximately a 45° angle from the net lead. We set fyke nets so that the hoops were 1-2 feet below the water surface, this sometimes would require shortening the lead. A gill net was set overnight at one location on the lake whereas fyke nets were set overnight at two locations.

Due to the very shallow litoral zone, and hard, sandy bottom, a 15–m beach seine was set three times approximately 25-30 m from shore and pulled towards the shore. To target catfish (*Ictaluridae*) and bullheads (*Ameiuridae*), wooden slat traps, measuring 120 cm long x 40 cm in diameter, were baited and deployed in for a total of 32 trap nights.

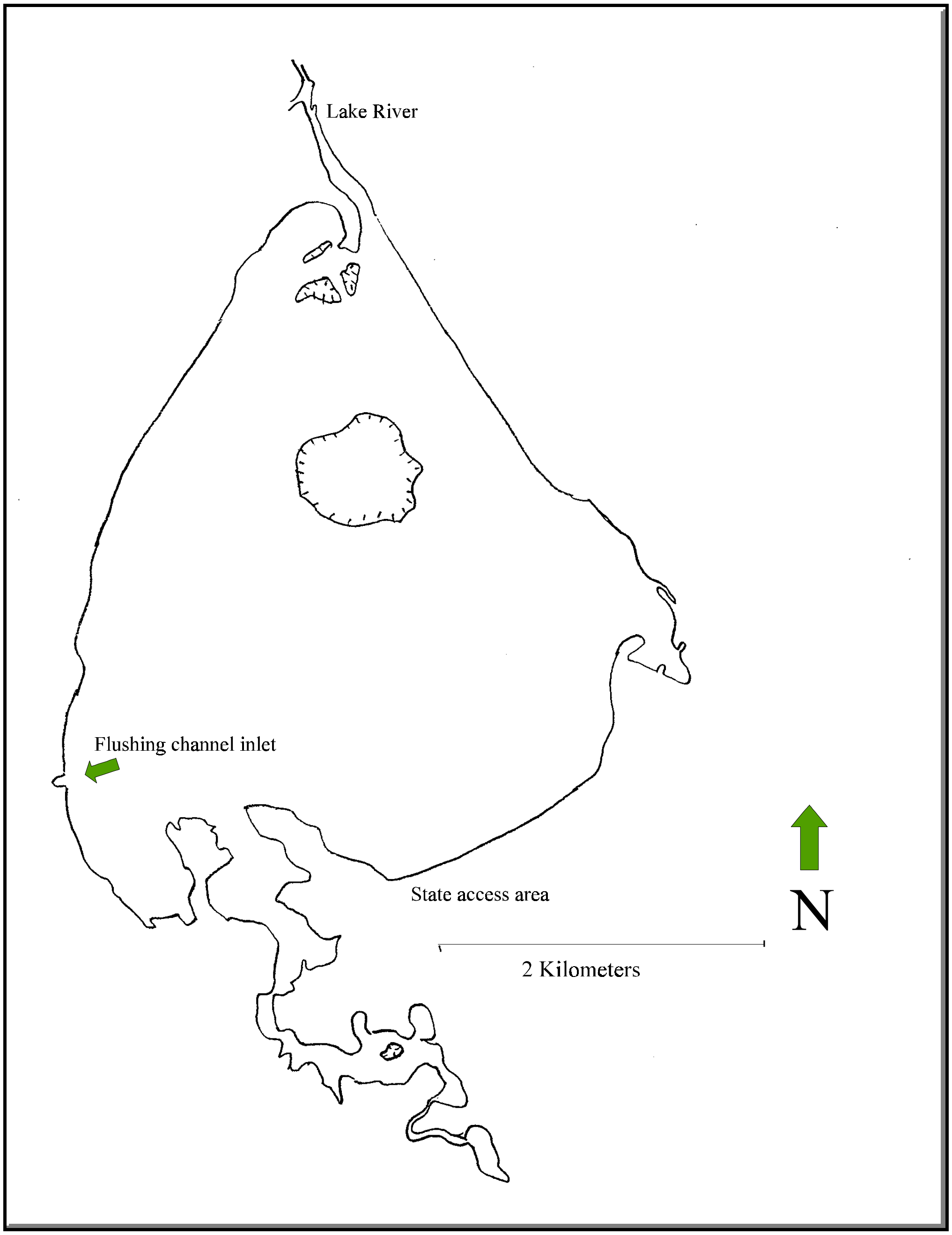


**Figure 1**. Map of Vancouver Lake, Clark County, traced from USGS Vancouver, WA - OR quadrangle.

With the exception of sculpin (*Cottidae*), all fish captured were identified to the species level. Each fish was measured to the nearest millimeter (mm) and assigned to a 10 mm size class based on total length (TL). For example, a fish measuring 156 mm TL was assigned to the 150 mm size class for that species, and 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 (YOY) or small juveniles (<100 mm TL) of a given species, then a sub-sample (N ~100 fish) were measured, and the remainder were just counted.  The frequency distribution of the sub–sample was then applied to the total number collected.  At least 10 fish from each size class were weighed to the nearest gram (g); in some instances, multiple small fish were weighed together to get an average weight. Scales were taken from five individuals per size class, mounted, pressed, and aged using the Fraser-Lee method.  However, members of the bullhead family (*Ictaluridae*), and non–game fish like carp (*Cyprinidae*), were not usually aged.

# 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). Percentage of the aggregate biomass for each species provided useful information regarding the balance and productivity of the community (Swingle 1950, Bennett 1962). Only 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 yellow perch (*Perca flavescens*) may suggest successful spawning during a given year, as indicated by a abundance of fish in the smallest size classes. However, most of these fish would be subject to natural attrition during their first winter, resulting in a different size distribution by the following year.

## Catch Per Unit of 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, by the total electrofishing time (seconds). 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, and is shown in Table 2.

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

## Length Frequency

A length frequency histogram was calculated for each species and gear type in the sample (Figures 1, 2, and 4). Length frequency histograms are constructed using individuals that are age 1 and older (determined by the aging process), and calculated as the number of individuals of a species in a given size class, divided by the total individuals of that species sampled. Plotting the histogram this way tends to flatten out large peaks created by an abundant size class, and makes the graph a little 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

Stock density indices are used to assess the size structure of fish populations. 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).

The indices calculated here are described by Gablehouse (1984) as the traditional approach. The 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 condition (plumpness or robustness) of fish in the lake. A $W_r$ value of 1.0 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 (ODFW 1997). Following Murphy and Willis (1991), the index was calculated as $W_r = W/W_s$ x 100, where $W$ is the weight (g) for an individual fish from the sample and $W_s$ is the standard weight of a fish of the same total length (mm). $W_s$ is calculated from a standard log weight - log length relationship defined for the species of interest. The parameters for the $W_s$ equations of many fish species, including the minimum length recommendations for their application, are listed in Anderson and Neumann (1996). For the species where data is available, the $W_r$ values from this study are compared to an average $W_r$ value calculated from lakes that have been surveyed across the state by the warmwater enhancement teams (Stephen Caromile, WDFW, unpublished data), and the national standard ($W_r$=100).

## Age and Growth

Age and growth of warmwater fishes were evaluated according to Fletcher et al. (1993). Total length at annulus formation, $L_n$, was back–calculated using the Fraser-Lee method. Intercepts for the *y* axis for each species were taken from Carlander (1982). Mean back–calculated lengths at each age for each species were presented in tabular form for easy comparison between year classes. Mean back–calculated lengths at each age for each species were compared to averages calculated from scale samples gathered at lakes sampled by the warmwater enhancement teams.

# Results and Discussion

## Habitat

Vancouver Lake is a very shallow lake, lacking complex habitat and vegetative cover. The littoral zone of the lake is wide and flat, much of it becoming exposed, muddy flats at low tide. Tidal action probably inhibits plant growth along the shore, while turbidity probably inhibits plant growth throughout the rest of the lake. The substrate is a uniformly hard sand and silt, with no gravel or rock bars, and only a few large woody structures in the lake. Overall, a near complete lack of complex habitat; providing no refuge for younger fish to escape predation and providing no habitat for insects to colonize and provide food.

## Species Composition and Relative Abundance

A total of 14 species of fish were encountered at Vancouver Lake, including: brown bullhead (*Ameiurus nebulosus*), channel catfish (*Ictalurus punctatus*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), goldfish (*Carassius auratus*), common carp (*Cyprinus carpio*), northern pike-minnow (*Ptychocheilus oregonensis*), American shad (*Alosa sapidissima*), mosquito fish (*Gambusia affinis*), largescale sucker (*Catostomus macrocheilus*), and unidentified sculpin (Cottidae). Additionally, starry flounder (*Platichthys stellatus*), and white sturgeon (*Acipenser transmontanus*) were captured in August, 1999, during a fish capture operation taking crappie for our warmwater hatchery. Because of their direct connection, Vancouver Lake probably contains, at some level, most of the species that inhabit the Columbia River.

Electrofishing proved difficult in Vancouver Lake due to the poor visibility and shallow depth. The shoreline was too shallow to maneuver a boat; at times we were as much as 100 m from shore, and still in water around 0.5 m deep. Because of the poor visibility and inefficient electrofishing method, catch per unit of effort (CPUE) will be biased towards the low side; so values in Tables 1 and 2 should be considered conservative.

Although common carp probably account for the highest biomass in Vancouver Lake, our sampling effort has shown biomass to be dominated by brown bullhead (Table 1). Average CPUE of common carp (Table 2) was among the lowest for all species, but carp are notoriously hard to net, and move quickly out of the electrical field when electrofishing. As well, our largest gill net mesh is near the bottom end of the size range to capture larger carp. Brown bullhead, white crappie and black crappie provided the highest catch rates, respectively, for electrofishing, and fyke netting proved to be the best method to sample crappie (species combined). Gill netting proved to be most efficient for the more pelagic species like American shad. It is also possible that the gill net provided “structure” which attracted white crappie; due to the tidal action, the gill net had to be set off shore, anchored at both ends.

Stock density indices (Table 3) indicate that although there are plenty of stock sized fish available (for all species) in Vancouver Lake, there are few fish that attain a size larger than stock size. Largemouth bass are an exception. Though the sample size of bass stock sized and above was small, a wide range of sizes were encountered (Table 1), and the population appears to be in balance (Table 3).

**Table 1.** Species composition (excluding young–of–year) by weight (kg), and number of fish captured at Vancouver Lake (Mason County) during the fall 1998 warmwater fish survey.

| | Species Composition | | | | | |
|---|---|---|---|---|---|---|
| | by Weight | | by Number | | Size Range (mm TL) | |
| **Species** | **(kg)** | **(%w)** | **(#)** | **(%n)** | **Min** | **Max** |
| Brown bullhead | 28.7 | 32.1 | 338 | 28.3 | 101 | 290 |
| White crappie | 20.0 | 22.4 | 422 | 35.3 | 48 | 193 |
| Common carp | 12.3 | 13.8 | 19 | 1.6 | 230 | 457 |
| Largemouth bass | 8.2 | 9.2 | 22 | 1.8 | 64 | 640 |
| Black crappie | 7.6 | 8.5 | 182 | 15.2 | 65 | 234 |
| American shad | 6.6 | 7.4 | 106 | 8.9 | 91 | 264 |
| Goldfish | 3.4 | 3.8 | 26 | 2.2 | 100 | 272 |
| Yellow perch | 1.1 | 1.2 | 35 | 2.9 | 80 | 180 |
| Bluegill | 0.8 | 0.9 | 29 | 2.4 | 30 | 183 |
| Northern pike-minnow | 0.5 | 0.5 | 3 | 0.3 | 25 | 280 |
| Pumpkinseed | 0.2 | 0.2 | 13 | 1.1 | 37 | 121 |
| Sculpin | >0.1 | >0.1 | 1 | 0.1 | 91 | 91 |
| Total | 89.3 | | 1196 | | | |

**Table 2.** Average catch per unit of effort (number of fish caught/hour electrofishing, and number of fish caught/ night for nets) for fish sampled in Vancouver Lake during the fall 1998 survey.

| | Electrofishing | | | Gill Netting | | | Fyke Netting | | |
|---|---|---|---|---|---|---|---|---|---|
| **Species** | **# / hour** | **80% CI** | **Shock Sites** | **# / GN night** | **80% CI** | **# Nights** | **# / FN night** | **80% CI** | **# Nights** |
| Brown bullhead | 52.0 | 43.5 | 6 | 73 | 0 | 1 | 65.0 | 49.6 | 3 |
| White crappie | 28.9 | 29.8 | 6 | 126 | 0 | 1 | 59.0 | 46.8 | 3 |
| Common carp | 6.9 | 3.6 | 6 | 4 | 0 | 1 | 0 | -- | 3 |
| Largemouth bass | 10.0 | 7.1 | 6 | 0 | -- | 1 | 0 | -- | 3 |
| Black crappie | 27.9 | 14.4 | 6 | 0 | -- | 1 | 43.7 | 36.0 | 3 |
| American shad | 2.0 | 1.6 | 6 | 103 | 0 | 1 | 0 | -- | 3 |
| Goldfish | 21.0 | 22.4 | 6 | 2 | 0 | 1 | 0.7 | 0.9 | 3 |
| Yellow perch | 11.0 | 3.7 | 6 | 7 | 0 | 1 | 0 | -- | 3 |
| Bluegill | 17.9 | 8.7 | 6 | 0 | -- | 1 | 1.3 | 1.1 | 3 |
| Northern pike-minnow | 0 | -- | 6 | 3 | 0 | 1 | 0 | -- | 3 |
| Pumpkinseed | 4.0 | 2.6 | 6 | 0 | -- | 1 | 0 | -- | 3 |
| Sculpin | 0 | -- | 6 | 0 | -- | 1 | 0.3 | 0.4 | 3 |

**Table 3.** Stock density indices by gear type and length categories for the fish population at Vancouver Lake (Clark County) during the fall 1998 warmwater fish survey.

| | | Quality | | Preferred | | Memorable | | Trophy | |
|---|---|---|---|---|---|---|---|---|---|
| | **# Stock Length** | **PSD** | **80% CI** | **RSD-P** | **80% CI** | **RSD-M** | **80% CI** | **RSD-T** | **80% CI** |
| **Electrofishing** | | | | | | | | | |
| Brown bullhead | 51 | 4 | 4 | 0 | -- | 0 | -- | 0 | -- |
| Black crappie | 25 | 4 | 5 | 0 | -- | 0 | -- | 0 | -- |
| Bluegill | 18 | 11 | 10 | 0 | -- | 0 | -- | 0 | -- |
| Common carp | 7 | 71 | 22 | 0 | -- | 0 | -- | 0 | -- |
| Largemouth bass | 10 | 80 | 16 | 30 | 19 | 10 | 12 | 10 | 12 |
| Pumpkinseed | 4 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |
| White crappie | 29 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |
| Yellow perch | 11 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |
| **Gill Netting** | | | | | | | | | |
| Brown bullhead | 73 | 1 | 2 | 0 | -- | 0 | -- | 0 | -- |
| Common carp | 4 | 75 | 28 | 0 | -- | 0 | -- | 0 | -- |
| White crappie | 125 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |
| Yellow perch | 7 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |
| **Fyke Netting** | | | | | | | | | |
| Brown bullhead | 195 | 6 | 2 | 0 | -- | 0 | -- | 0 | -- |
| Black crappie | 126 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |
| White crappie | 176 | 0 | -- | 0 | -- | 0 | -- | 0 | -- |

## Summary By Species

### Brown Bullhead (*Ameiurus nebulosus*)

Brown bullhead comprised the highest biomass in Vancouver Lake, and were the second most abundant by number (Table 1). The length frequency distribution in Figure 2 shows that all gear types sampled the same size distribution of bullhead, indicating that we probably have an accurate representation of the population. Though spines were not collected for age verification, it seems that the brown bullhead population is dominated by only one or two age classes. Although this is common for many species, the sharp drop off on either side seems to suggest that prey availability or some other environmental factor is limiting the growth and size distribution. An agreed to relative weight calculation is not currently available to determine the condition of these fish.

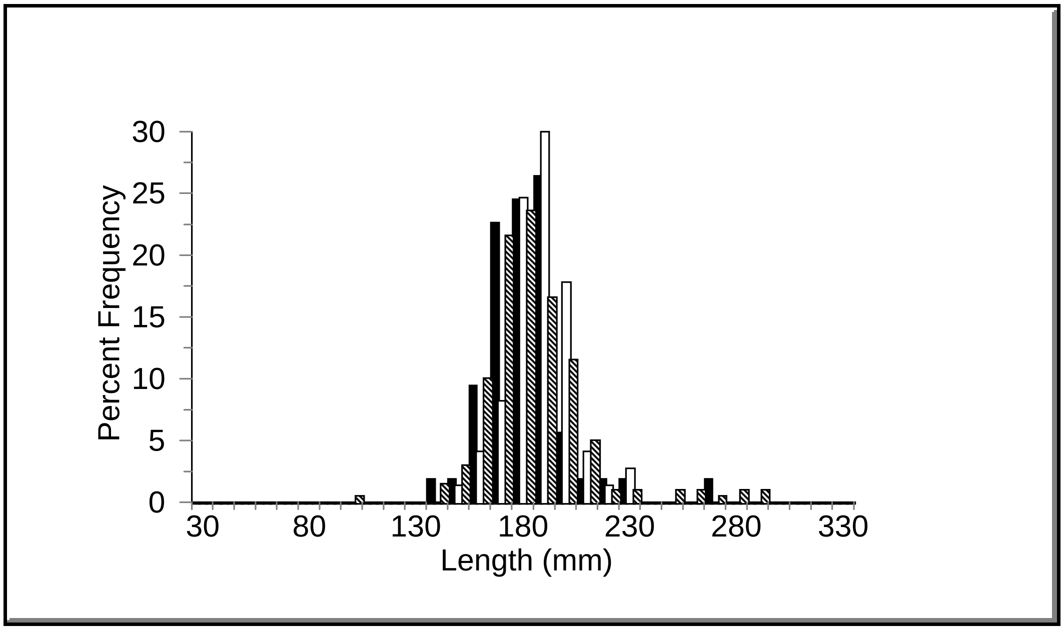


**Figure 2**. Length frequency distribution of brown bullhead from electrofishing (dark bars), gill netting (light bars) and fyke netting (hatched bars) from the fall 1998 survey of Vancouver Lake.

## White Crappie (*Pomoxis annularis*)

Gill netting and fyke netting, respectively, proved to be the most efficient methods for capturing white crappie in Vancouver Lake (Table 2). Though many crappie of stock size were captured, there were none in our sample that exceeded that size (Table 3 and Figure 3). All gear types appear to be capturing the same size classes of fish, as well.

Our sampling did not turn up any large, older white crappie. Table 4 shows the back–calculated length at age for white crappie we sampled in Vancouver Lake. Because we have no historical growth data for white crappie, historical data for black crappie is assumed here when making comparisons. Growth appears to be fast initially, and then dropping off to below average after the first year. This is also reflected in the relative weight graph (Figure 4) that shows the smaller size classes having a higher relative weight, which then drops off as size increases. This may suggest that prey for the larger sized fish is limiting.

**Table 4.** Age and growth of white crappie captured at Vancouver Lake during the fall 1998 survey. Table data represents mean back–calculated lengths at annulus formation using the Fraser-Lee method.

| | | Mean Length (mm) at Age | | |
|---|---|---|---|---|
| **Year Class** | **n** | **I** | **II** | **III** |
| 1997 | 10 | 63 | | |
| 1996 | 18 | 72 | 127 | |
| 1995 | 11 | 72 | 104 | 137 |
| Fraser-Lee | | 70 | 118 | 137 |
| Direct Proportion | | 48 | 106 | 130 |
| State Average (DP) | | | | |

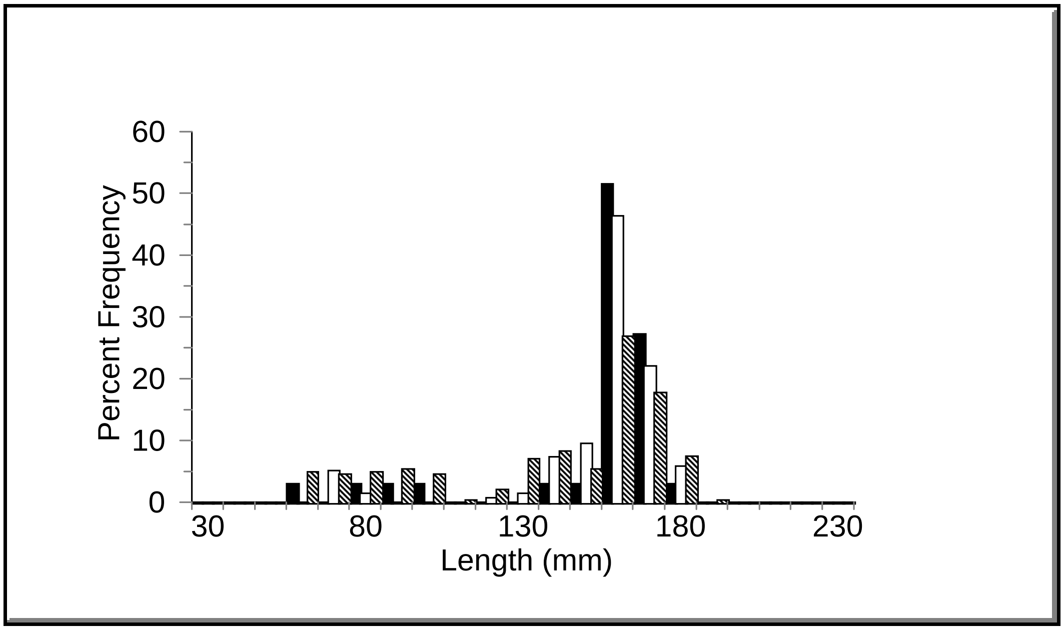


**Figure 3**. Length frequency distribution of white crappie from electrofishing (dark bars), gill netting (light bars) and fyke netting (hatched bars) from the fall 1998 survey of Vancouver Lake.

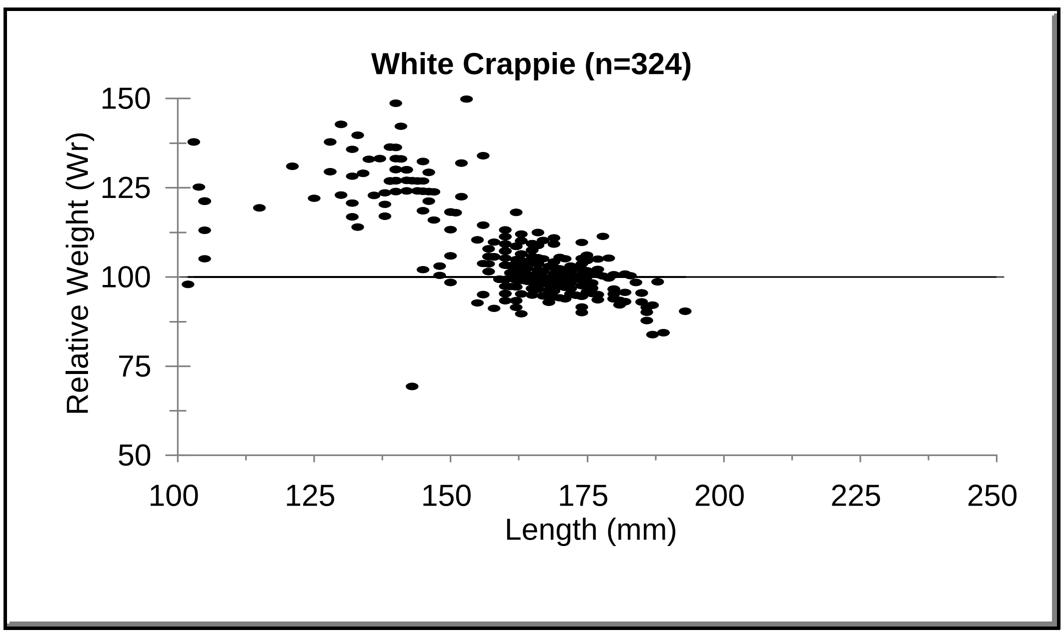


**Figure 4.** The relationship between total length and relative weight (Wr) for white crappie in Vancouver Lake, Clark County, as compared to the national standard (horizontal line at 100).

## Common Carp (*Cyprinus carpio*)

As with any slow, backwater area, common carp are readily abundant; few carp were captured at Vancouver Lake, but many were seen. Common carp are strong swimmers and are able to swim away from the electrical field of our electrofishing unit, and are notoriously hard to get into a net. With that in mind, the estimates of carp abundance (by number and weight) should be viewed as extremely conservative. Common carp probably account for the highest biomass in Vancouver Lake.

A commercial fishery for common carp has existed in Vancouver Lake since the late 1960s. The fishery centers around religious holidays (Christmas, Easter, and 60 different Saints days), and the anglers harvest common carp mainly for their community to consume during these times. The anglers, who must register with the Department of Fish and Wildlife, are restricted to using trammel nets with a 7–inch inside mesh and a 12–inch outside mesh. The nets must be pulled every two hours, and no incidental catch is allowed. Yearly catch and effort statistics are nearly non–existent for this fishery, as catch has only been reported intermittently. Region 5 staff are currently working on building a better catch and effort database for this net fishery.

## Largemouth Bass (*Micropterus salmoides*)

There were few largemouth bass sampled at Vancouver Lake. The majority of those sampled were taken in the slough area close to the confluence with the Lake River. This area of the lake is a little deeper, and there is more woody debris (old pilings) that may be used as cover or congregating structure for prey species. The average length at age for largemouth bass in Vancouver Lake (Table 5) is higher than average for western Washington. Largemouth bass probably have access to a large number of high quality prey species in the area around the Lake River. Here, many different species of fish move in and out with the tide, as well as many aquatic invertebrates (shrimp). The relative weights (Figure 6) of sampled largemouth bass were higher than standard for all size classes, this shows that there is plenty of available prey for all size classes of bass.

Due to the low sample size, a useful length frequency histogram could not be created; but we did create one (Figure 5) just so one can graphically view the size range of the fishes sampled.

**Table 5.** Age and growth of largemouth bass captured at Vancouver Lake during the fall 1998 survey. Table data represents mean back–calculated lengths at annulus formation using the Fraser-Lee method.

| | | Mean Length (mm) at Age | | | | | |
|---|---|---|---|---|---|---|---|
| **Year Class** | **n** | **I** | **II** | **III** | **IV** | **V** | **VI** |
| 1997 | 2 | 58 | | | | | |
| 1996 | 2 | 81 | 151 | | | | |
| 1995 | 0 | - | - | - | | | |
| 1994 | 5 | 112 | 204 | 279 | 403 | | |
| 1993 | 1 | 70 | 131 | 177 | 253 | 371 | |
| 1992 | 1 | 64 | 97 | 165 | 194 | 319 | 408 |
| Fraser-Lee | | 88 | 172 | 248 | 352 | 345 | 408 |
| Direct Proportion | | 74 | 162 | 240 | 349 | 342 | 407 |
| State Average (DP) | | 60 | 146 | 222 | 261 | 289 | 319 |

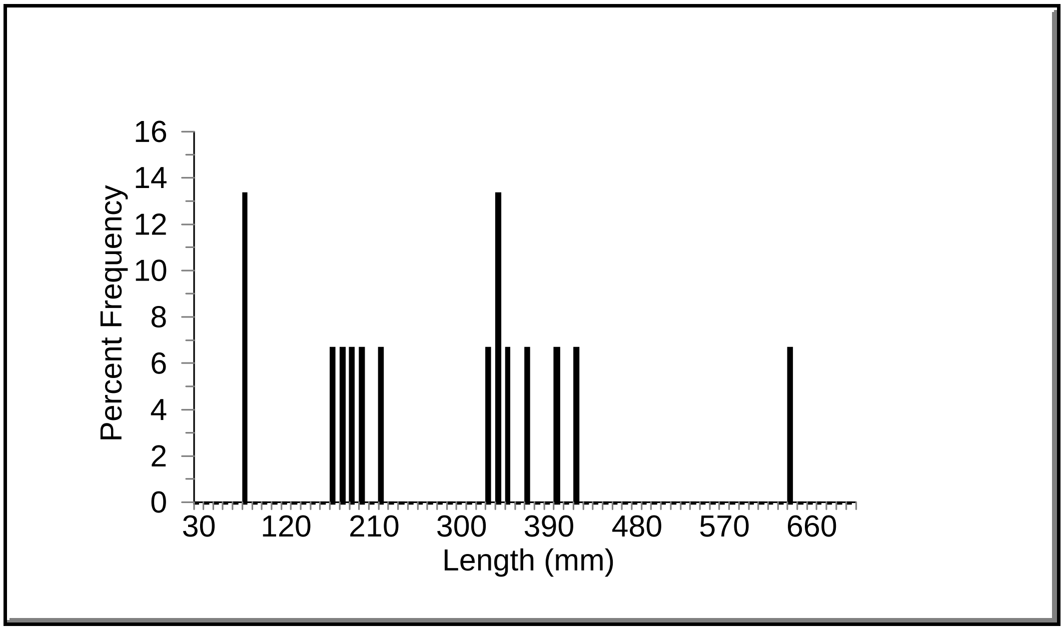


**Figure 5**. Length frequency distribution of largemouth bass from electrofishing for the fall 1998 survey of Vancouver Lake.

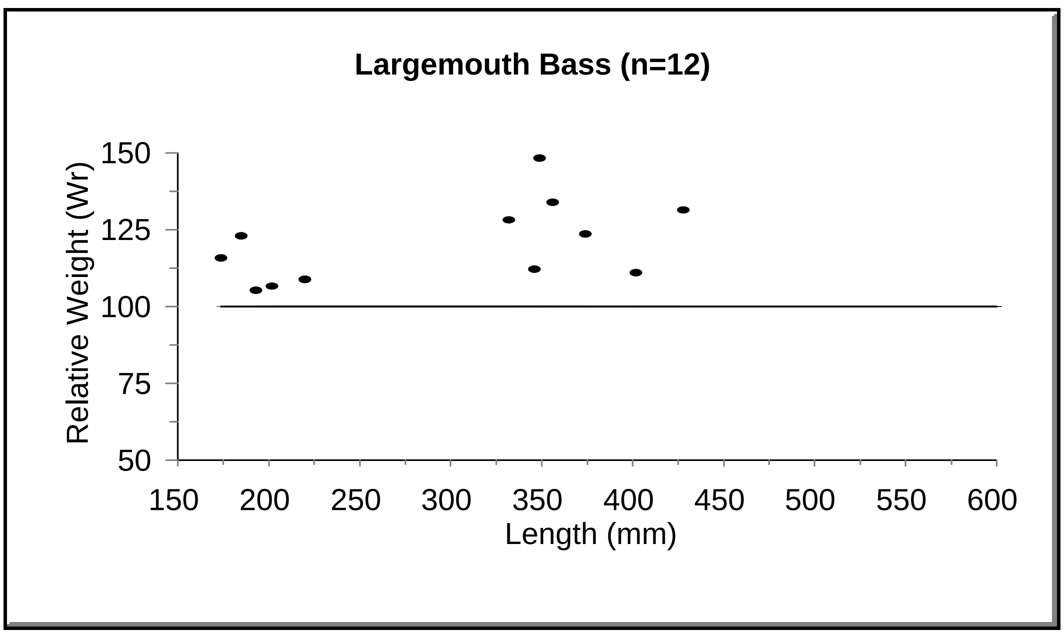


**Figure 6**. The relationship between total length and relative weight (Wr) for largemouth bass in Vancouver Lake, Clark County, as compared to the national standard (horizontal line at 100).

## Black Crappie (*Pomoxis nigromaculatus*)

Fewer black crappie were caught than white crappie. This makes sense in that white crappie are usually more adapted to murkier water conditions than are black crappie. But, looking at their back–calculated length at age (Table 6), it shows that black crappie in Vancouver Lake are growing at a faster pace than other populations in western Washington. As well, relative weights (Figure 8) of black crappie seem to show that there is an abundance of prey available.

Fyke netting and electrofishing proved to be the two most effective capture methods for black crappie, respectively (Table 2). The length frequency histogram (Figure 7) shows that both methods captured roughly the same size classes of fish, and again, our sample was mainly comprised of a few age classes.

**Table 6.** Age and growth of black crappie captured at Vancouver Lake during the fall 1998 survey. Table data represents mean back–calculated lengths at annulus formation using the Fraser-Lee method.

| | | Mean Length (mm) at Age | | |
|---|---|---|---|---|
| **Year Class** | **n** | **I** | **II** | **III** |
| 1997 | 1 | 68 | | |
| 1996 | 16 | 72 | 125 | |
| 1995 | 4 | 71 | 130 | 170 |
| Fraser-Lee | | 72 | 126 | 170 |
| Direct Proportion | | 49 | 118 | 166 |
| State Average (DP) | | 46 | 111 | 157 |

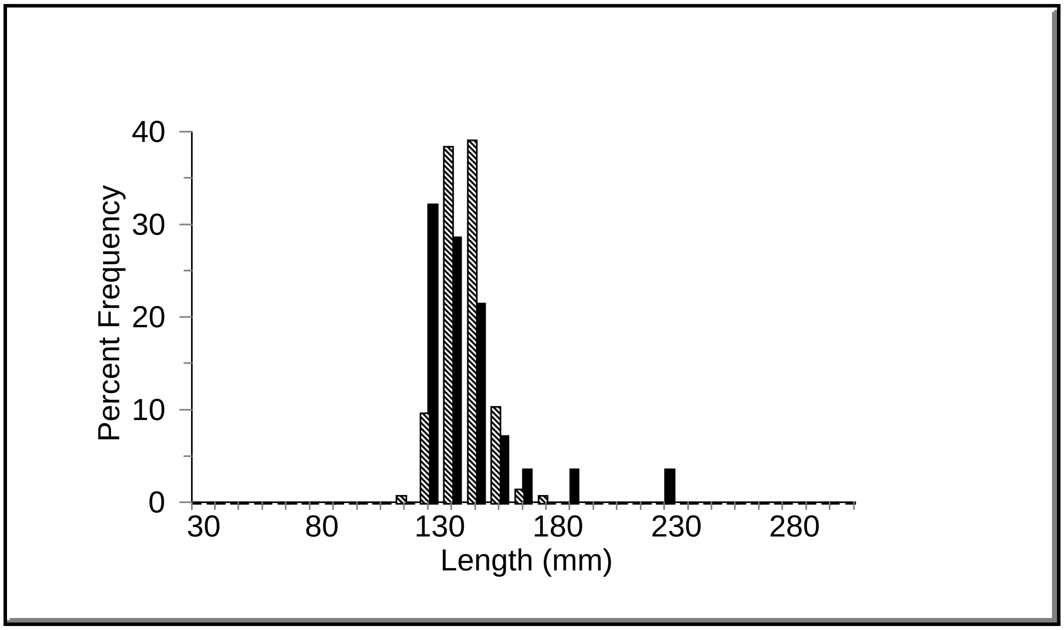


**Figure 7**. Length frequency distribution of black crappie from electrofishing (dark bars) and fyke netting (hatched bars) from the fall 1998 survey of Vancouver Lake.

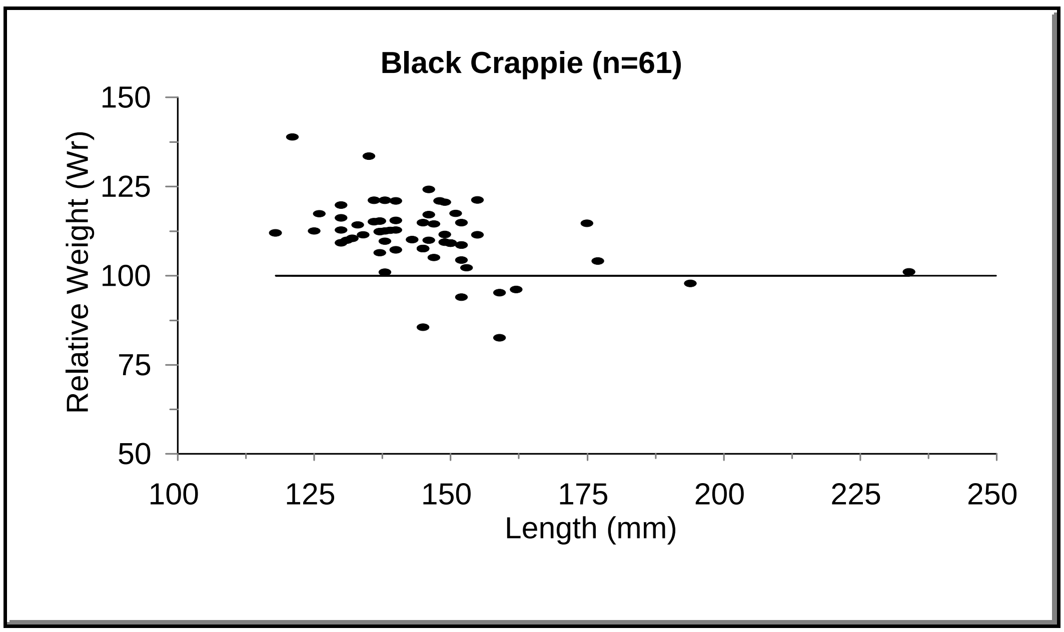


**Figure 8**. The relationship between total length and relative weight (Wr) for black crappie in Vancouver Lake, Clark County, as compared to the national standard (horizontal line at 100).

## Yellow Perch (*Perca flavescens*)

Yellow perch are not very abundant in Vancouver Lake. Perch usually prefer to have vegetation for spawning purposes as well as habitat for their young. Vancouver Lake is totally lacking in vegetative cover. The average length at age (Table 7) shows that growth is slower than the already slow average growth for western Washington. Relative weights (Figure 9) also show that available prey for all size classes of perch may be limiting. Perch are primarily insectivores, eating mainly aquatic invertebrates (insects and zooplankton), but as they grow larger, they may include small fish in their diets.

The length frequency distribution (Figure 10) shows that electrofishing and gill netting sampled the same size classes. This bimodal distribution is found frequently when sampling yellow perch populations as yellow perch tend to loosely school with other perch that are closely related in size.

**Table 7.** Age and growth of yellow perch captured at Vancouver Lake during the fall 1998 survey. Table data represents mean back–calculated lengths at annulus formation using the Fraser-Lee method.

| | | Mean Length (mm) at Age | | |
|---|---|---|---|---|
| **Year Class** | **n** | **I** | **II** | **III** |
| 1997 | 16 | 81 | | |
| 1996 | 8 | 91 | 134 | |
| 1995 | 6 | 72 | 98 | 142 |
| Fraser-Lee | | 82 | 119 | 142 |
| Direct Proportion | | 68 | 109 | 137 |
| State Average (DP) | | 60 | 120 | 152 |

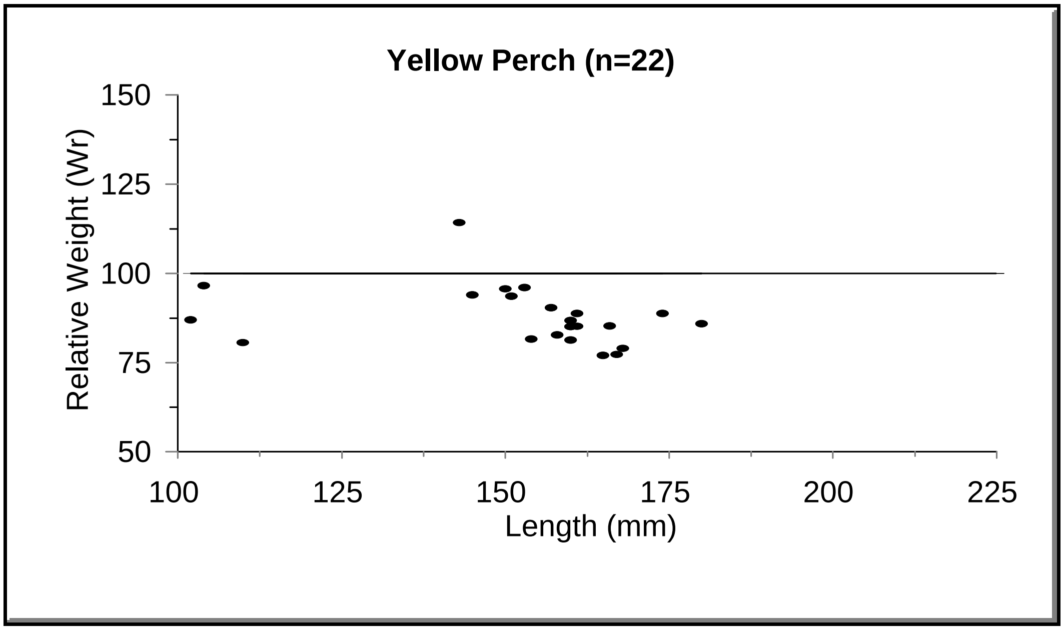


**Figure 9**. The relationship between total length and relative weight (Wr) for yellow perch in Vancouver Lake, Clark County, as compared to the national standard (horizontal line at 100).

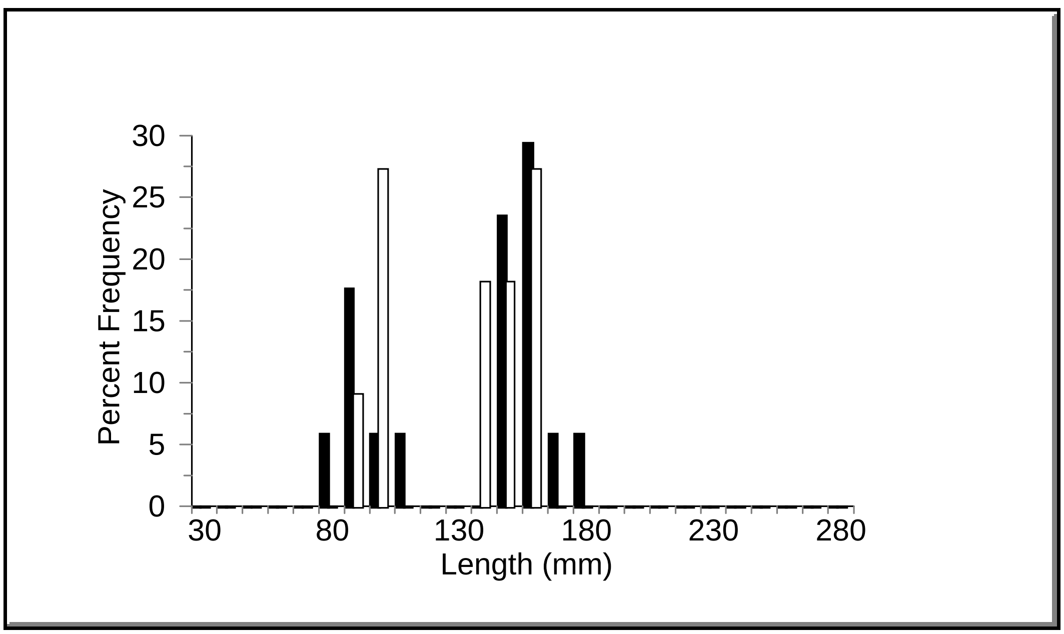


**Figure 10**. Length frequency distribution of yellow perch from electrofishing (dark bars) and gill netting (light bars) from the fall 1998 survey of Vancouver Lake.

## Bluegill (*Lepomis macrochirus*)

Bluegill were not a common occurrence in Vancouver Lake. Overall growth (Table 8) of bluegill starts off slower than the average bluegill population in western Washington, but older fish tend to grow a little faster. This can also be seen in the relative weight calculations (Figure 11). Relative weights, in general, are above the national standard of 100, but the younger fish are a little more variable and may average at, or a little below 100. The overall suggestion is that prey is not really a limiting factor on growth for bluegill during the summer and early fall months.

The sample size of bluegill was not large enough to calculate a length frequency histogram that would give one enough information for comparison purposes, nor would it give a good representation of the size distribution of the population. A length frequency histogram is included here (Figure 12) only to give a pictorial representation of the size range of captured individuals.

**Table 8.** Age and growth of bluegill captured at Vancouver Lake during the fall 1998 survey. Table data represents mean back–calculated lengths at annulus formation using the Fraser-Lee method.

| | | **Mean Length (mm) at Age** | | | |
|---|---|---|---|---|---|
| **Year Class** | **n** | **I** | **II** | **III** | **IV** |
| 1997 | 2 | 38 | | | |
| 1996 | 6 | 46 | 89 | | |
| 1995 | 1 | 51 | 121 | 139 | |
| 1994 | 1 | 45 | 84 | 136 | 166 |
| Fraser-Lee | | 45 | 92 | 138 | 166 |
| Direct Proportion | | 30 | 86 | 134 | 164 |
| State Average (DP) | | 37 | 97 | 132 | 148 |

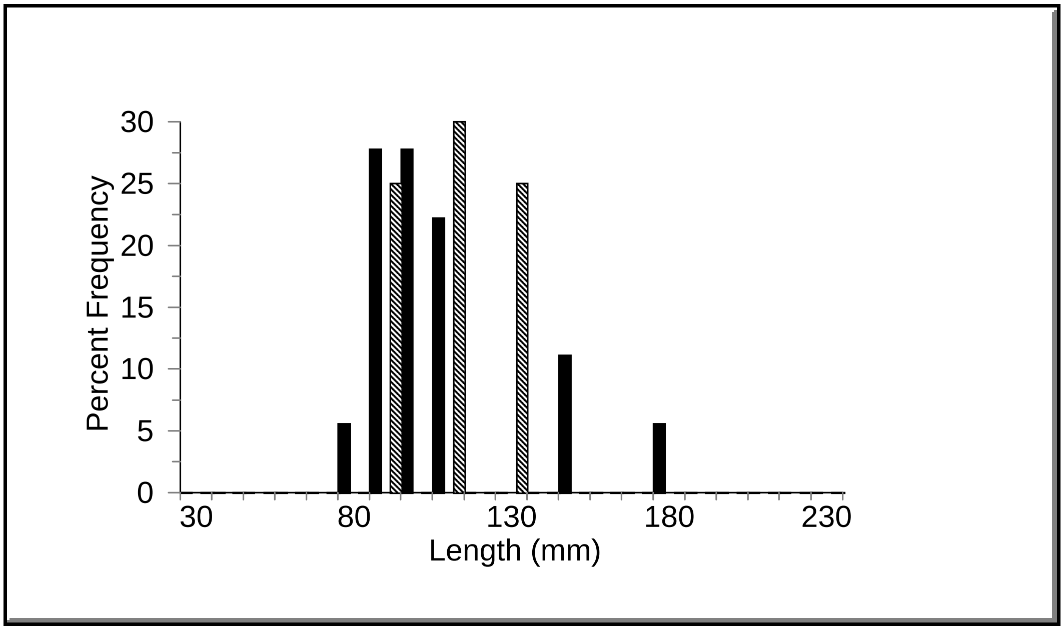


**Figure 11**. Length frequency distribution of bluegill from electrofishing (dark bars) and fyke netting (hatched bars) from the fall 1998 survey of Vancouver Lake.

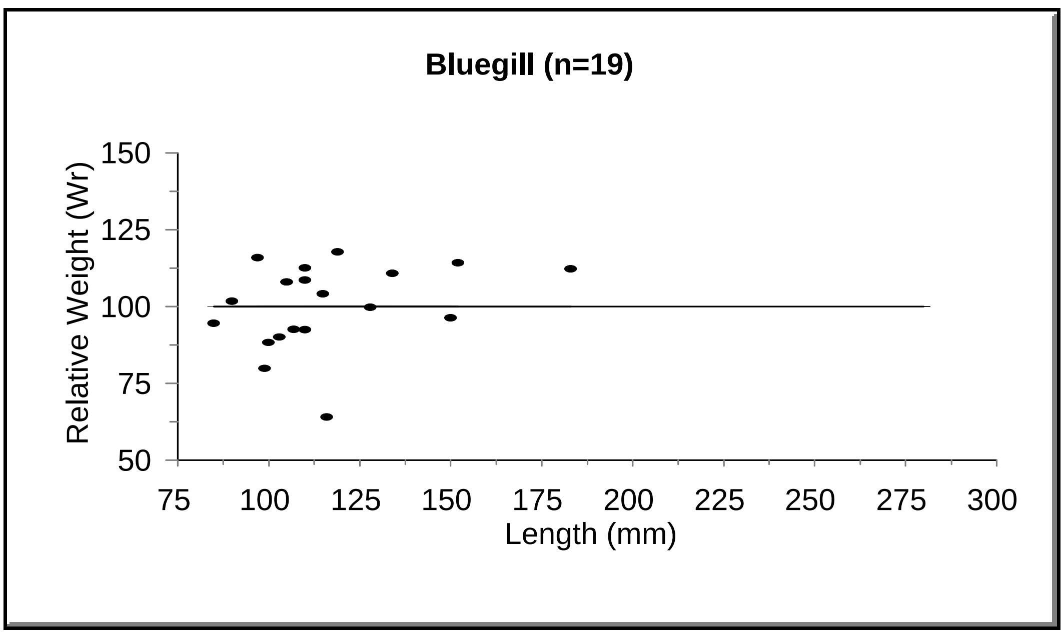


**Figure 12**. The relationship between total length and relative weight (Wr) for bluegill in Vancouver Lake, Clark County, as compared to the national standard (horizontal line at 100).

## Pumpkinseed (*Lepomis gibbosus*)

Pumpkinseed did not comprise much of the sample at Vancouver Lake. In many lakes that have the right characteristics, pumpkinseed can quickly overpopulate the lake, and cause a stunted population. The average length at age for pumpkinseed in Vancouver Lake (Table 9) does not show this. Calculating an average growth for pumpkinseed can sometimes be difficult because pumpkinseed may spawn numerous times throughout the year. Because of this, an average growth calculated on a small sample size like that above can give a false impression of the growth of the entire population, when in fact, you may be looking at individuals from only an early or late spawn; this will give an inaccurate representation of the "average". Relative weight calculations (Figure 13 ) show pumpkinseed to be right around the national standard of 100. This would suggest that prey is probably not limiting the growth of pumpkinseed during the summer and early fall months.

**Figure 14**. Age and growth of pumpkinseed sunfish captured at Vancouver Lake during the fall 1998 survey. Table data represents mean back-calculated lengths at annulus formation using the Fraser-Lee method.

| | | Mean Length (mm) at Age | | |
|---|---|---|---|---|
| **Year Class** | **n** | **I** | **II** | **III** |
| 1997 | 1 | 44 | | |
| 1996 | 3 | 59 | 87 | |
| 1995 | 1 | 58 | 80 | 90 |
| Fraser-Lee | | 56 | 86 | 90 |
| Direct Proportion | | 40 | 78 | 85 |
| State Average (DP) | | 24 | 72 | 102 |

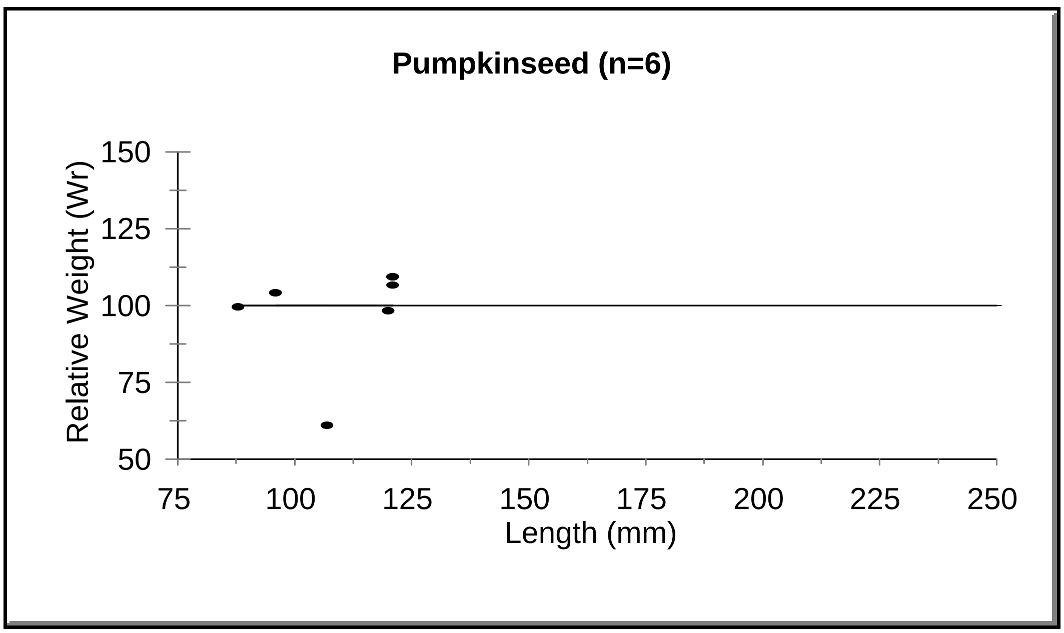


**Figure 13**. The relationship between total length and relative weight (Wr) for pumpkinseed in Vancouver Lake, Clark County, as compared to the national standard (horizontal line at 100).

## Other Species

### American Shad (*Alosa sapidissima*)

Juvenile American shad emigrating from the Columbia River system were captured during our fall sample, mostly with by gill netting. Shad, in general, have been an under–utilized resource in the Columbia River system that are beginning to find favor with sport anglers. American shad spawn in the mid– and upper Columbia River. They are broadcast spawners, with semi–buoyant eggs that float downstream as they develop and finally hatch. The young, like their parents, are filter feeders and consume zooplankton as they migrate back to the ocean. Those we sampled were probably pushed up into the lake through the Lake River by an incoming tide during their outmigration, and probably left with the outgoing tide. Adult shad probably also make quick visits into the lake in small numbers during their spawning run. Migrating juvenile American shad assumably provide high quality forage for bass during the summer when they are around, accounting for some bass growth.

### Goldfish (*Carassius auratus*)

Goldfish were not extremely abundant in our sample; the most efficient capture method was electrofishing (Table 2). Goldfish, like common carp, frequently overpopulate the lakes in which they reside. This does not seem to be the case in Vancouver Lake, yet. Goldfish are a schooling fish, and hence, there are some sampling sections where we would capture them, and some we would not. This accounts for the high 80 percent confidence interval (Table 2). More directed sampling, possibly in the pelagic area of the lake with gill nets, would have yielded a higher sample.

### Northern Pikeminnow (*Ptychocheilus oregonensis*)

Few northern pikeminnow were captured. Gill netting was the only method that captured adult fish, and a single juvenile specimen was sampled while beach seining. It is assumed that these fish are more abundant in the lake than noted here. A more directed sampling in the pelagic area of the lake probably would have yielded a better sample.

### Sculpin, (*Cottidae*)

Few sculpin were encountered during our sampling period, most likely due to the poor visibility and the fact that sculpin are a negatively buoyant fish.

## Largescale Sucker (*Catostomus macrocheilus*)

Largescale sucker are the most abundant species in western Washington. Largescale sucker provide little or no sport value to the anglers of Washington; their use as a food fish here has not been documented either.

## Mosquito Fish (*Gambusia affinis*)

Mosquito fish are a species that was introduced for their supposed effectiveness at controlling mosquito larvae, and are stocked in Washington by local mosquito control boards. Washington Department of Fish and Wildlife has guidelines for the use and stocking of mosquito fish that are designed to limit who may stock these fish and where they may be stocked. Approval and permits are required for the stocking of any fish species into any water body in the state.

The few individuals we encountered were captured while beach seining along the southern shore.

## Channel Catfish (*Ictalurus punctatus*)

The majority of our sampling was directed towards the capture of catfish. Specifically, we were tasked to find out if, and to what extent, channel catfish were spawning in Vancouver Lake. In general, channel catfish do not spawn successfully in a strict lake environment; their spawning locations are usually associated with flowing water. It is possible that the tidal action of Vancouver Lake provides enough flow to encourage channel catfish to spawn successfully. Also, holes or depressions in the bank are usually utilized by channel catfish for spawning. The clay banks along the eastern shore of the lake, and within the Lake River, are full of beaver holes that would provide suitable nesting habitat for breeding channel catfish.

Throughout all of the directed sampling, a single channel catfish was captured while beach seining along the southern shore, near the State owned access area. This individual, measuring 55 mm, most likely represented this years spawn. This may suggest that successful spawning is occurring in Vancouver Lake, or nearby in the Lake River. No adults were sampled.

## Starry Flounder (*Platichthys stellatus*)

A single starry flounder was captured during a fish transfer operation in August 1999. Like American shad, the starry flounder can be considered a freshwater visitor that moves in and out with the tide. Starry flounder can tolerate a wide range of salinities from full freshwater to full saltwater. The occurrence of these fish this high up in the Columbia River system is not all that uncommon.

### White Sturgeon (*Acipenser transmontanus*)

A single white sturgeon was captured during a fish transfer operation in August 1999. We have heard plenty of anecdotal reports about sturgeon being in Vancouver Lake, with little reason to doubt any of them. This was the only sturgeon that was identified by a biologist from the warmwater program.

# Management Options

## Fish Community

Because of its direct connection to the Columbia River, as well as the overall size of the lake, managing the fish community can prove difficult. In general, predator–prey interactions in lakes this size do not usually drive the population dynamics as they do in smaller lakes. Also, the constant immigration and emigration of fish from the lake does not allow for effective management of most species.

There is little doubt that Vancouver Lake plays a major role in the life history of many of the fishes in the lower Columbia River. Backwater areas can provide foraging or spawning areas for many species, as well as a resting place from the high flows of the river for others. A more effective use of our resources on this lake would be to increase anglers access to the available resources, and educate anglers as to how to best utilize these resources.

## Structure

Vancouver Lake is a large, shallow, body of water. The lake bottom is pretty uniform through dredging, and there is a startling lack of structure or vegetation for habitat. The wind, wave, and tidal action, combined with a colloidal substrate, have created a lake that is inhospitable to plant growth; mostly due to its apparent lack of light transmission. Because of the inability to sustain sufficient plant growth for cover, artificially placed structure (fallen trees, reefs, etc.) may help provide some relief from predation for small fishes, as well as concentrate fish for anglers.

## Access

Angler access to Vancouver Lake is excellent. With the majority of the land surrounding the lake being undeveloped, access for bank anglers is nearly 100%. The only problem being that anglers may not be able to get their lines out far enough to where the water is deep enough to fish. This is certainly the case along the state–owned access area, but less of a problem on the western shore by the city park. Boat access to Vancouver Lake is limited. Though the state–owned access area has an unimproved launch area, the gradient does not allow easy launching for boats on trailers. The overall depth at the launch area is 0.3-0.5 m for quite some distance away from shore. The result of this is that boaters must pay to launch their boats at a private boat ramp in the Lake River. If it is thought that there will be sufficient use, the boat launch area can be greatly improved, but costly dredging would be required for depths to be sufficient. Another option for boat launching would be to work cooperatively with the county to develop and maintain a boat launch at the existing county park. The gradient is more suitable, and the depth is enough to float a boat from a trailer.

## Fishery

This was just an initial survey to gather baseline population data. It is hard to make recommendations as how to manage a fishery without more data. This initial survey gave us a good idea of what species are present in the lake, and what people are most likely fishing for. Other data that would be beneficial to make decisions would be harvest and effort data. Without making any specific recommendations, we would like to point out a few areas that we will be focusing our future attention.

### Crappie Length Limit or Bag Limit

Black crappie and white crappie are two of the most abundant fish species in Vancouver Lake. Crappie fisheries are very important panfish fisheries where they exist, and are worth protecting. If we can determine how important crappie are to the anglers at Vancouver Lake, then the population may benefit from adding special length or creel limit regulations to alter the size structure of the population. Length limits can positively influence the size structure of a crappie population, as long as growth rates are high and natural mortality is low; though this is not a combination that happens too often.

Another common way of managing crappie populations is with a creel limit. Creel limits are useful when there is a sparse population, or when there is excessive angling pressure. But, you need to have an idea of how a population is exploited to know how a regulation will affect a population. This information is not currently available for Vancouver Lake.

### Special Common Carp Regulations

Common carp are an abundant fish in most large water bodies across the country. They are an abundant recreational resource that has yet to be utilized to its full extent across most of the country. Vancouver Lake is a perfect lake to try out experimental carp fishery regulations; carp are plentiful in the lake, and there is plenty of bank access. A booklet, or internet site, published with bait recipes, fishing techniques, fishing gear needs, as well as filleting or cooking tips could possibly help the public become more aware of the possibilities of carp angling.

# Literature Cited

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, MD.

Bennett, G. W. 1962. Management of Artificial Lakes and Ponds. Reinhold Publishing Corporation, New York, NY.

Bortleson, G. C., N.P. Dion, and J. B. McConnell. 1976. Reconnaissance Data on Lakes in Washington, Volume 4, Clark, Grays Harbor, Lewis, Pacific, Skamania, and Thurston Counties. State of Washington Department of Ecology, Water-Supply Bulletin 43, Vol. 4.

Carlander, K.D., 1982. Standard Intercepts for Calculating Lengths from Scale Measurements for Some Centrarchid and Percid Fishes. Transactions of the American Fisheries Society 111:332-336.

DeVries, D., and R. Frie. 1996. Determination of Age and Growth. Pages 483-512 *in* Murphy, B. R., and D. W. Willis (eds.), Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Fletcher, D., S. Bonar, B. Bolding, A. Bradbury, and S. Zeylmaker. 1993. Analyzing Warmwater Fish Populations in Washington State. Washington Department of Fish and Wildlife, Warmwater Fish Survey Manual, 173 p.

Gablehouse, D. W. 1984. A Length-Categorization System to Assess Fish Stocks. North American Journal of Fisheries Management 4:273-285.

Gablehouse, D. W. 1991. Seasonal Changes in Body Condition of White Crappies and Relations to Length and Growth in Melvern Reservoir, Kansas. North American Journal of Fisheries Management 11:50-56.

Gustafson, K. A. 1988. Approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8:139-141.

Guy, C. S., and D. W. Willis. 1991. Evaluation of Largemouth Bass - Yellow Perch Communities in Small South Dakota Impoundments. North American Journal of Fisheries Management 11:43-49.

Murphy, B. R., and D. W. Willis. 1991. Application of relative weight (*Wr*) to western warmwater fisheries. Pages 243-248 *in* Proceedings of the Warmwater Fisheries

Symposium I, June 4-8, 1991, Scottsdale, Arizona. USDA Forest Service, General Technical Report RM-207.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations Fisheries Research Board of Canada Bulletin 191.

Swingle, H. S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Auburn University, Alabama Agricultural Experiment Station Bulletin No 274, 74 p.

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

Willis, D. W., B. R. Murphy, C. S. Guy. 1993. Stock Density Indices: Development, Use, and Limitations. Reviews in Fisheries Science, 1(3):203-222.

Zar, J. H. 1984. Biostatistical Analysis, 2nd edition. Prentice-Hall, Englewood Cliffs, NJ.

# Appendix A

**Table A1.** Length categories that have been proposed for various fish species. Measurements are for total lengths (updated from Neumann and Anderson 1996).

| | Category | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stock | | Quality | | Preferred | | Memorable | | Trophy | |
| **Species** | **(in)** | **(cm)** | **(in)** | **(cm)** | **(in)** | **(cm)** | **(in)** | **(cm)** | **(in)** | **(cm)** |
| Black bullhead [a] | 6 | 15 | 9 | 23 | 12 | 30 | 15 | 38 | 18 | 46 |
| Black crappie | 5 | 13 | 8 | 20 | 10 | 25 | 12 | 30 | 15 | 38 |
| Bluegill [a] | 3 | 8 | 6 | 15 | 8 | 20 | 10 | 25 | 12 | 30 |
| Brook trout | 5 | 13 | 8 | 20 | | | | | | |
| Brown bullhead [a] | 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 |
| Flathead catfish | 11 | 28 | 16 | 41 | 24 | 61 | 28 | 71 | 36 | 91 |
| 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 catfish [a] | 8 | 20 | 13 | 33 | 17 | 43 | 21 | 53 | 26 | 66 |
| White crappie | 5 | 13 | 8 | 20 | 10 | 25 | 12 | 30 | 15 | 38 |
| Yellow bullhead | 4 | 10 | 7 | 18 | 9 | 23 | 11 | 28 | 14 | 36 |
| Yellow perch | 5 | 13 | 8 | 20 | 10 | 25 | 12 | 30 | 15 | 38 |

[a] As of this writing, these new, or updated length classifications have yet to go through the peer review process, but a proposal for their use will soon be in press (Timothy J. Bister, South Dakota State University, personal communication).