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# 2013 Warmwater Fisheries Survey of Lake Tapps, Pierce County, Washington

Warmwater Fish Enhancement

by Kenneth Behen and Stephen Caromile

*Washington Department of*
*FISH AND WILDLIFE*
*Fish Program*
*Fish Management Division*

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# Abstract

Lake Tapps, Pierce County, Washington was surveyed by the Washington Department of Fish and Wildlife's Warmwater Enhancement Program from October 21 – 23, 2013 to assess the warmwater fish community (e.g. growth rates, condition, age, size structure) and the zooplankton populations (e.g. density, size structure) to evaluate the current fishery and its zooplankton forage base in order to develop management considerations. Two three-person crews utilized boat electrofishers, gill nets, fyke nets and zooplankton nets to accomplish study objectives. The Lake Tapps fish assemblage was primarily composed of small forage species, with Largescale Suckers *Catostomus macrocheilus*, representing the majority (57%) of the biomass. Proportional stock densities and relative stock densities of Smallmouth Bass *Micropterus dolomieu*, Largemouth Bass *M. salmoides*, Brown Bullhead *Ameiurus nebulosus* and Tiger Muskie *Esox masquinongy* x *E. lucius* suggest opportunities exist in Lake Tapps for anglers to catch large fish. Overall, growth rates, condition factors and age classes were below national and state averages. Lake Tapps zooplankton total lengths and densities were on average smaller and less densely distributed than zooplankton populations from American Lake, Banks Lake and Lake Roosevelt. Patterns of Lake Tapps zooplankton total lengths and densities, in conjunction with the fish assemblage structure, are indicative of an overgrazed zooplankton population. We postulate that additional competition for preferred prey (e.g. *Daphnia* spp.) by stocked planktivores i.e., (salmonids) may result in cascading detriments on the warmwater fish assemblage.

We identified four management options to maintain a healthy fish community and provide successful angling opportunities for Lake Tapps:

1. Explore options to improve primary productivity by decreasing the frequency of drawdowns and depth reductions, decrease removal of aquatic macrophyte habitat, decrease input of cold, nutrient poor glacial runoff, and increase residency time of Lake Tapps waters.
2. Continue to stock Tiger Muskie at the current rate to continue the reduction of overcrowding by Largescale Sucker, continue beneficial predatory trophic effects, and provided increased opportunity for anglers.
3. Expand promotion of the Smallmouth Bass and Tiger Muskie fisheries, as they represent unique angling opportunities within the region, in addition to increased promotion of underexploited populations such as Brown Bullhead and Rock Bass.
4. Identify funding to stock Tapps Lake with 20-30 catchable (2.5 fish per pound) size rainbow trout per surface acre (50,000 – 80,000 fish) annually for three years and evaluate angler participation (anglers days directed at rainbow trout), success (catch/harvest per hour), and fish growth and condition. Based on the cost of $2.32 per pound of fish as currently charged by Trout Lodge, total approximate costs will range from $46,000 to $74,000 for 50,00 to 80,000 fish respectively.

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# Introduction

Lake Tapps is a large reservoir located east of Tacoma, Washington, adjacent to the cities of Bonney Lake and Auburn, in Pierce County. Lake Tapps has a surface area of approximately 971 hectares with an average and maximum depth of 7.6 and 26 meters respectively (Figure 1). The current lake was created in 1911, as a reservoir for hydropower generation, by flooding four smaller lakes (which included the original Lake Tapps) with water diverted from the nearby White River, along a 13 kilometer diversion canal located in the southeast portion of the reservoir. After flooding, a complex series of islands and peninsulas were formed, creating nearly 72 kilometers of shoreline, most of which is highly developed by private residences, concrete bulkheads, docks, bridges, parks and a golf course. A fish screen located approximately 6 kilometers below a diversion dam in the White River impedes movement of riverine salmonids into Lake Tapps (Cascade Water Alliance 2010). Operation of the power plant, located along the northwest shoreline, ceased in 2004 and in 2009 the lake was sold to the Cascade Water Alliance where it has been slated as a municipal water resource (Cascade Water Alliance 2010). As part of an agreement with homeowners, the Cascade Water Alliance maintains recreational water levels from April 15$^{th}$ to October 31$^{st}$, after which, water is drawn down for vegetation control, flood prevention, dike maintenance and to meet in-stream flow requirements in the White River (Mueller 1998; Cascade Water Alliance 2010). There are two public water access sites on the lake: Lake Tapps North Park, owned and operated by Pierce County Parks and Recreation Department, located along the north-east shoreline with shoreline access and a boat ramp: and Allan Yorke Park, owned and operated by the City of Bonney Lake, located along the western shore with dock access and a boat launch (Fish Washington, http://wdfw.wa.gov/fishing/washington/).

A survey of the lake Tapps fish assemblage was conducted in 1997 to assess the warmwater fish community. This original survey provided evidence of an unbalanced fish community; with below average growth rates and weight ratios observed among piscivorous game fish species, additionally, the biomass was dominated by Largescale Suckers *Catostomus macrocheilus* (Mueller 1998). Mueller (1998) also found that the forage fish community was likely suffering from overcrowding and interspecific competition of resources, which resulted in below-average growth and condition. Mueller (1998) determined that runoff from melting snow in the spring and early summer caused low water temperatures, low light penetration and fluctuating availability of aquatic macrophytes all of which negatively impacted the fish community. Mueller presented a number of management recommendations, including the introduction of Tiger Muskie *Esox masquinongy* x *E. lucius* to help reduce the overcrowding of soft-rayed forage fish.

Lake Tapps has experienced a long history of fish stocking, with the earliest hatchery records dating back to 1904. While originally stocked with warmwater game fish such as Yellow Perch *Perca flavescens* and black bass (not specified in historical record), the management emphasis thereafter switched towards salmonids and remained as such for most of the century. From 1918 to 1994 Lake Tapps was stocked with a number of salmonid species including; Rainbow Trout *Oncorhynchus mykiss*, Eastern Brook Trout *Salvelinus fontinalis*, Cutthroat Trout *Oncorhynchus clarki*, Coho Salmon *Oncorhynchus kisutch*, and Kokanee *Oncorhynchus nerka*. However, historical accounts of the Lake Tapps salmonid fisheries indicate that growth rates and catch rates were poor, and that stocking was inconsistent in terms of what species and size of fish were placed into the lake (Steve Jackson, personal communication, February 26, 2013). Poor performance of the Lake Tapps trout and Kokanee fisheries resulted in a management shift towards a warmwater emphasis and in 1994 trout stocking ceased. In 2000, the WDFW Warmwater Program began stocking Tiger Muskie to help manage soft-rayed fish species, enhance the overall warmwater fishery and to provide a unique angling experience in the region. Since 2000, nearly 11,000 age-1 Tiger Muskie have been planted into Lake Tapps (WDFW 2013). Lake Tapps now hosts an active warmwater sport fishery, with an increasing trend in bass and total catch reported among tournament records (Figure 2).

Recent interest has arisen to re-evaluate the current fisheries management plan for Lake Tapps. This study was developed to assess the warmwater fish community (e.g. growth rates, condition, age, size structure) and the zooplankton populations (e.g. density, size structure) to evaluate the current fishery and its zooplankton forage base in order to develop management considerations from our findings.

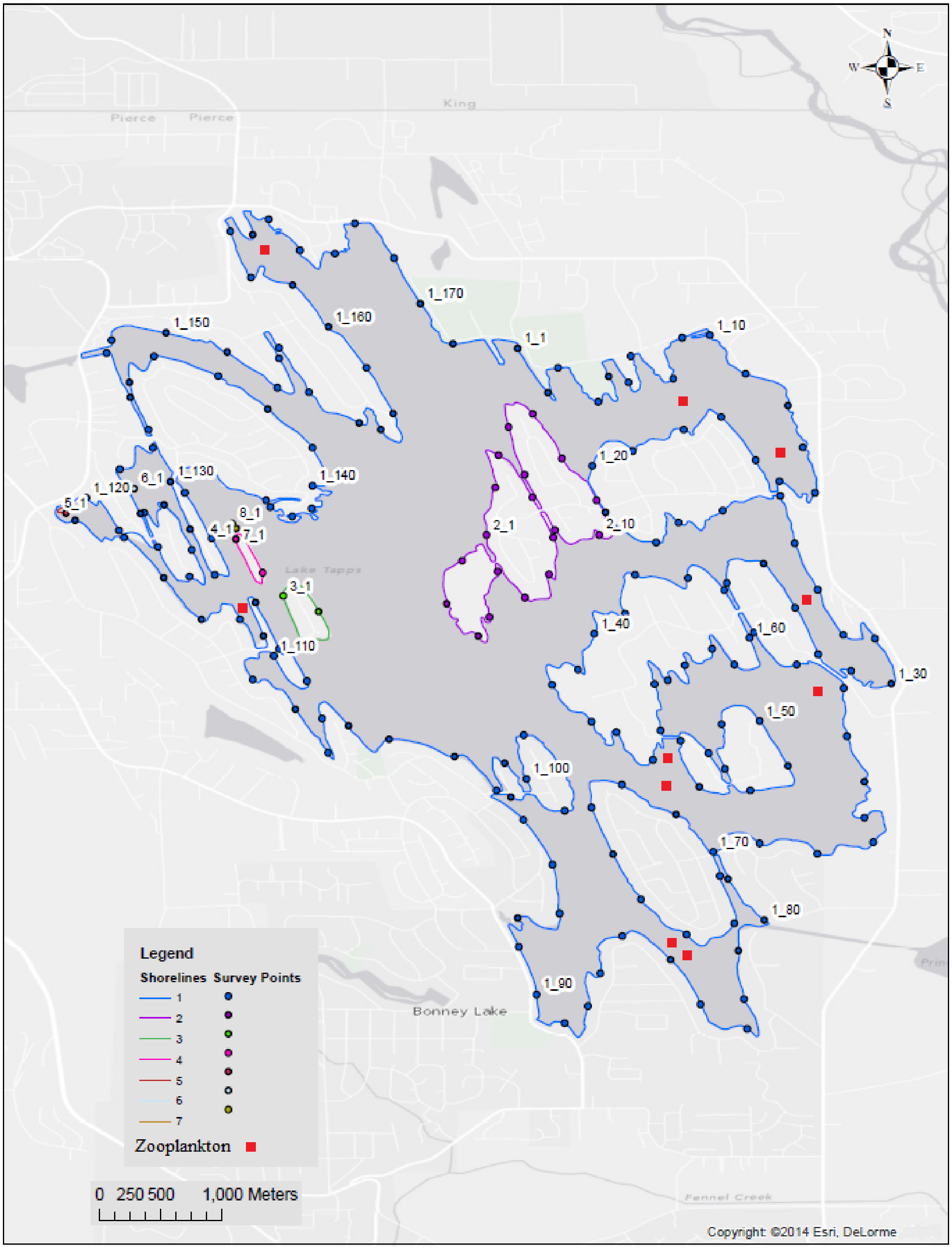


**Figure 1. Map of Lake Tapps, Pierce County, Washington.**

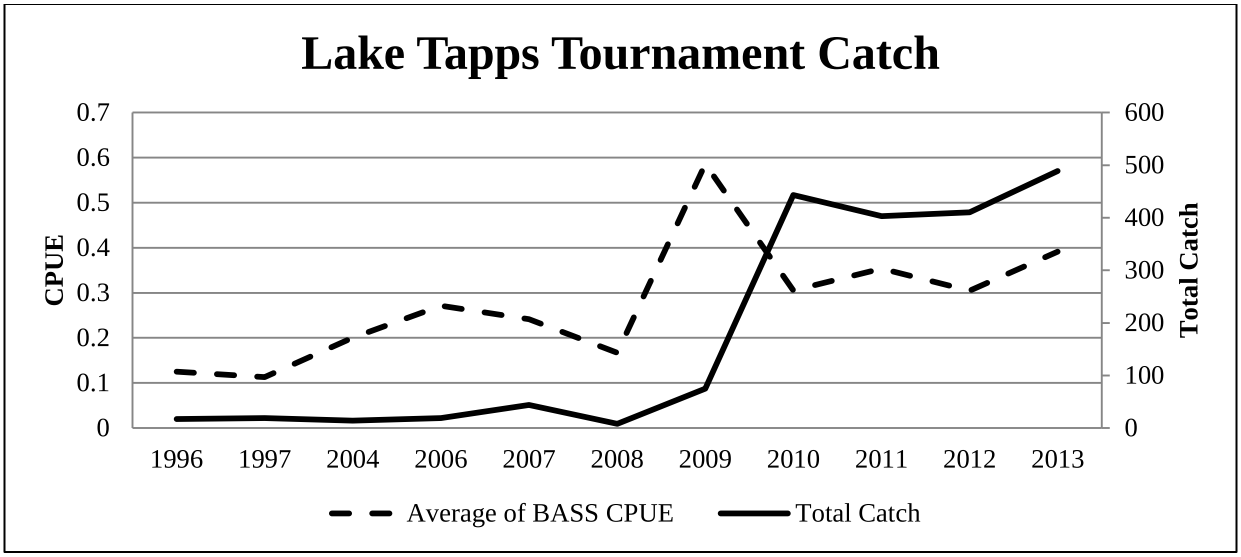


**Figure 2. Bass fishing tournament catch in Lake Tapps, Pierce County, Washington from 1996 to 2013, showing average angler CPUE as well as total yearly catch.**

# Methods

## Data Collection

Lake Tapps was surveyed from October 21st to 23rd, 2013 by two three-person crews using a standardized sampling protocol develop by Bonar et al. (2000). Fish were collected utilizing three sample 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. The electrofishing gear settings consisted of a pulsed DC current of 60 Hz at 2 -4 amp power, as close to peak efficiency as possible. Experimental gill nets (45.6 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 nets (modified hoop) 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 locations were selected from a map by dividing all available shoreline, including islands, into 400 m sections, numbering them consecutively and randomly selecting sites without replication. The number of randomly selected sampling locations were as follows: electrofishing – 30, gill netting – 16, fyke netting – 16. While electrofishing, boats were maneuvered slowly through the shallows for a total of 600 seconds of "pedal-down" time (Bonar et al. 2000). Gill nets were fished perpendicular to the shoreline with the small-mesh end tied off to the shore, and the large-mesh end anchored off shore. Fyke nets were fished perpendicular to the shoreline as well. The lead was tied off to the shore and the cod end was anchored off shore. The wings were anchored at approximately a 45° angle from the net lead. Fyke nets were fished with the hoops 0.3 – 0.5 m below the water surface, which sometimes required shortening the lead. Sampling commenced in the evening, after dark to maximize the type and number of fish captured.

With the exception of sculpin (Cottidae), all fish captured were identified to the species level measured to the nearest millimeter total length (mm TL) and weighed to the nearest gram (g). Scale samples for age and growth analysis were collected from at least five individuals of each warmwater game species per centimeter size class. Upon return to the lab, scale samples were mounted, pressed and aged according to Jearld (1983) and Fletcher et al. (1993). Fish that were not weighed in the field were assigned a weight using a length-weight regression.

# Data Analysis

## Species Composition

Species composition by weight (kg) and number were calculated as proportions of total catch, excluding young-of-the-year (YOY). The YOY were excluded to prevent inaccurate impressions of year class strength due to the high abundance of small fish, which often experience substantial mortality during their first winter (Chew 1974). Additionally, YOY were excluded to prevent distortions in analyses influenced by factors such as sample location, methodology, and specific timing of hatches (Fletcher et al. 1993).

## Catch Per Unit Effort

Catch-per-unit-effort (CPUE), by gear type, was determined for each fish species collected, i.e., (number of fish/hour electrofishing, number of fish/gill net-night, and number of fish/fyke net-night). Eighty percent confidence intervals (CI) were calculated for each mean CPUE by species and gear type. Each CI was calculated as,

$$\bar{x} \pm t(N-1) \times SE$$

Where *t*= Student's *t* test for confidence level with N-1 degrees of freedom (two tailed), N= sample size and, SE= standard error of the mean. Standardized CPUE allows for comparisons of catch rates between lakes or sampling dates on the same water.

## Length-Frequency

Length frequency histograms were created to evaluate the size structure of populations. Length frequency histograms were calculated as percent frequency captured by gear type and were limited to fish $\geq$ age 1.

## Stock-Density Indices

Proportional stock density (PSD) of each warmwater game fish species was determined following procedures outlined in Anderson and Neumann (1996). Relative stock density (RSD) of each warmwater fish species was determined using the five-cell model proposed by Gabelhouse (1984). Length categories were determined from percentages of world record lengths (Table 1.). Proportional stock density was calculated as the number of quality-length fish, divided by the number of stock-length fish, multiplied by 100. Relative stock density was calculated as the number of fish within the specified length category, divided by the total number of stock-length fish, multiplied by 100. Eighty percent confidence intervals for PSD and RSD were selected from tables in Gustafson (1998).

**Table 1. Minimum total length (mm) categories of warmwater fish used to calculate PSD and RSD values (Willis et al. 1993)**

| | | | Length Category | | |
|---|---|---|---|---|---|
| % World Record Length | 20 - 26 | 36 - 41 | 45 - 55 | 59 - 64 | 74 - 80 |
| **Species** | Stock | Quality | Preferred | Memorable | Trophy |
| Yellow Perch | 130 | 200 | 250 | 300 | 380 |
| Smallmouth Bass | 180 | 280 | 350 | 430 | 510 |
| Rock Bass | 100 | 180 | 230 | 280 | 330 |
| Common Carp | 280 | 410 | 610 | 710 | 910 |
| Tiger Muskie | 510 | 760 | 970 | 1070 | 1270 |
| Largemouth Bass | 200 | 300 | 380 | 510 | 630 |
| Bluegill | 80 | 150 | 200 | 250 | 300 |
| Black Crappie | 130 | 200 | 250 | 300 | 380 |
| Brown Bullhead | 130 | 200 | 280 | 360 | 430 |

## Age and Growth

Age and growth of warmwater fishes sampled were evaluated using the direct proportion method and Lee's modification of the direct proportional method (Carlander 1982; Fletcher et al. 1993). Using the direct proportional method, total length at annulus formation, $L_n$, was back-calculated as,

$$L_n = (A \times TL)/S$$

were *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 at capture. Using Lee's modification, $L_n$ was back-calculated as,

$$L_n = a + (TL - a)(A/S)$$

Where *a* is the species-specific standard intercept from a scale radius-fish length regression. Mean back-calculated lengths at age *n* for each species were presented for comparison of growth between year classes, and in comparison to Washington State averages (Fletcher et al. 1993).

## Relative Weight

The relative weight ($W_r$) index was calculated from all species to evaluate condition of fish in Lake Tapps (Anderson and Neumann 1996). The index was calculated as,

$$W_r = \frac{W}{W_s} \times 100$$

Where W is the weight (g) of an individual fish and $W_s$ is the standard weight of a fish of the same length calculated with the standard weight ($W_s$) equation (Anderson and Neumann 1996; Bister el al. 2000; Hyatt and Hulbert $2001_{a,b}$).

## Zooplankton

Zooplankton samples were collected at ten randomly selected locations throughout Lake Tapps (Figure 1) utilizing a 30 cm x 100 cm zooplankton net (62 µm mesh). Samples were collected along a vertical water column and followed the Large Lakes Research Team's (LLRT) protocol for zooplankton collection and analysis (Polacek et al. 2013). Field samples were first killed in 95% ethanol (EtOH), then preserved in 70% EtOH and taken to the LLRT laboratory for analysis. Subsamples were utilized among samples of high biotic richness. Whole samples were diluted, homogenously mixed and sampled using a Hensen Stemple spring-loaded pipette. All zooplankton were identified to the lowest possible taxonomic order (Pennak 1989), enumerated, and measured (up to 20 individuals) to the nearest 0.01 mm to calculate mean length. Estimates of zooplankton population density were calculated as number per cubic meter for inference of lake wide distribution and planktivorous fish grazing trends. Mean density and mean total length of October sampled Lake Tapps *Daphnia* spp. were compared to October sampled *Daphnia* spp. populations from American Lake, Banks Lake and Lake Roosevelt to detect differences between populations.

# Results

## Species Composition

A total of 1,186 individual fish representing 7 families and 11 species were collected from Lake Tapps (Table 2). Largescale Sucker, comprised the greatest proportion of biomass among gear types (58%), followed by Common Carp *Cyprinus carpio* (15%), Rock Bass *Ambloplites rupestris* (7%), Tiger Muskie (6%), and Smallmouth Bass *Micropterus dolomieu* (5%). Yellow Perch, Brown Bullhead *Ameiurus nebulosus*, Largemouth Bass *Micropterus salmoides*, Black Crappie *Pomoxis nigromaculatus*, sculpin, Bluegill *Lepomis macrochirus*, and Redside Shiner *Richardsonius balteatus* comprised < 6% of total biomass. Sport fish comprised the majority of fish sampled in terms of relative abundance (72%), but only accounted for 27% of total biomass sampled. Rock Bass comprised the largest proportion of catch, with 38% of total relative abundance followed by Largescale Sucker (21%), Yellow Perch (18%), sculpin (5%) and Brown Bullhead (5%). Smallmouth Bass, Bluegill, Largemouth Bass, Common Carp, Tiger Muskie and Redside Shiner comprised < 8% of total relative abundance.

**Table 2. Species composition by weight and number for fish species sampled from Lake Tapps, Pierce County, October 2013.**

| | **Species Composition** | | | | | |
|---|---|---|---|---|---|---|
| | by Weight | | by Number | | Size Range (mm TL) | |
| **Species** | (kg) | (%w) | (#) | (%n) | Min | Max |
| Largescale Sucker | 178.2 | 57.9 | 252 | 21.2 | 47 | 532 |
| Common Carp | 46.7 | 15.2 | 16 | 1.3 | 144 | 720 |
| Rock Bass | 22.1 | 7.2 | 451 | 38 | 80 | 214 |
| Tiger Muskie | 18.9 | 6.1 | 7 | 0.6 | 367 | 1010 |
| Smallmouth Bass | 15.6 | 5.1 | 45 | 3.8 | 152 | 450 |
| Brown Bullhead | 9.4 | 3.0 | 58 | 4.9 | 49 | 361 |
| Yellow Perch | 8.2 | 2.7 | 213 | 18 | 125 | 256 |
| Largemouth Bass | 6.6 | 2.2 | 4 | 0.3 | 220 | 550 |
| Black Crappie | 0.8 | 0.3 | 31 | 2.6 | 105 | 175 |
| Bluegill | 0.8 | 0.3 | 42 | 3.5 | 79 | 144 |
| Sculpin | 0.5 | 0.2 | 61 | 5.1 | 36 | 155 |
| Redside Shiner | 0.1 | 0.0 | 6 | 0.5 | 70 | 121 |

## Catch Per Unit Effort

Rock Bass and Yellow Perch were captured at the highest rates across all gear types. The greatest capture rates were observed while electrofishing, with Rock Bass, Largescale Sucker, sculpin and Yellow Perch representing the highest catch per unit effort (Table 3.).

**Table 3. Average catch per unit effort and 80% confidence intervals by gear type for fish species sampled from Lake Tapps, pierce County, October 2013.**

| | Electrofishing | | | Gill Netting | | | Fyke Netting | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | no. per hour | 80% CI | shock site | no. per hour | 80% CI | net nights | no. per hour | 80% CI | net nights |
| Yellow Perch | 10.3 | 5.1 | 30 | 1.6 | 0.6 | 16 | 8.5 | 6.4 | 16 |
| Smallmouth Bass | 6.2 | 1.8 | 30 | 0.9 | 0.4 | 16 | 0 | - | 16 |
| Rock Bass | 38.9 | 6.6 | 30 | 3.6 | 1.2 | 16 | 12.3 | 3.0 | 16 |
| Sculpin | 11.5 | 2.7 | 30 | 0.1 | 0.1 | 16 | 0.1 | 0.1 | 16 |
| Largescale Sucker | 25.9 | 5.5 | 30 | 7.6 | 1.3 | 16 | 0 | - | 16 |
| Common Carp | 1.0 | 0.5 | 30 | 0.6 | 0.2 | 16 | 0.1 | 0.1 | 16 |
| Tiger Muskie | 0.8 | 0.5 | 30 | 0.1 | 0.2 | 16 | 0.1 | 0.1 | 16 |
| Largemouth Bass | 0.8 | 0.6 | 30 | 0 | - | 16 | 0.0 | - | 16 |
| Bluegill | 4.0 | 2.9 | 30 | 0.4 | 0.3 | 16 | 1.0 | 0.4 | 16 |
| Black Crappie | 0.8 | 0.5 | 30 | 0.4 | 0.3 | 16 | 1.3 | 0.8 | 16 |
| Brown Bullhead | 2.2 | 1.1 | 30 | 0.6 | 0.3 | 16 | 2.3 | 1.4 | 16 |
| Redside Shiner | 0.2 | 0.3 | 30 | 0.3 | 0.2 | 16 | 0 | - | 16 |

## Stock Density

Sample sizes of stock length fish were only adequate to evaluate stock density indices of Rock Bass (electrofishing, gill and fyke netting) and Yellow Perch (fyke netting). Adequate sample size is defined as no less than 55 stock-length fish for accurate PSD estimates. Rock Bass PSDs were low ranging from 3 (gillnetting) to 13 (electrofishing, fyke netting). Yellow perch PSD's were low ranging from 2 (electrofishing) to 23 (gillnetting). Though few individuals were captured, Largemouth and Smallmouth Bass PSD estimates were high, with representatives present among all RSD categories except RSD-T. Additionally, Brown Bullhead PSD's were high across all gear types with RSD-M present among fyke net surveys (Table 4).

## 1997 Lake Tapps Comparison

Sample sizes of all fish species were inadequate in the 1997 survey for meaningful statistical comparisons of size and condition, with the exception of Largescale Sucker (Mueller 1998). Largescale Sucker populations showed significant differences in both size and weight with average length ($P < 0.001$, $T = -4.3$) and weight ($P < 0.001$, $T = -7.4$) greater among 2013 survey data.

**Table 4. Stock density indices (PSD and RSD) and 80% confidence intervals by gear type, for fish species sampled from Lake Tapps, Pierce County, October 2013.**

| | | Quality | | Preferred | | Memorable | | Trophy | |
|---|---|---|---|---|---|---|---|---|---|
| **Species** | **# Stock Length** | **PSD** | **80% CI** | **RSD-P** | **80% CI** | **RSD-M** | **80% CI** | **RSD-T** | **80% CI** |
| **Electrofishing** | - | - | - | - | - | - | - | - | - |
| Yellow Perch | 48 | 2 | 3 | 2 | 3 | 0 | - | 0 | - |
| Smallmouth Bass | 21 | 24 | 12 | 14 | 10 | 5 | 6 | 0 | - |
| Rock Bass | 163 | 13 | 3 | 0 | 0 | 0 | - | 0 | - |
| Common Carp | 3 | 67 | 35 | 67 | 35 | 33 | 35 | 0 | - |
| Tiger Muskie | 4 | 50 | 32 | 0 | 0 | 0 | - | 0 | - |
| Largemouth Bass | 4 | 50 | 32 | 50 | 32 | 25 | 28 | 0 | - |
| Bluegill | 20 | 0 | 0 | 0 | 0 | 0 | - | 0 | - |
| Black Crappie | 1 | 0 | 0 | 0 | 0 | 0 | - | 0 | - |
| Brown Bullhead | 10 | 70 | 19 | 30 | 19 | 0 | - | 0 | - |
| **Gillnetting** | - | - | - | - | - | - | - | - | - |
| Yellow Perch | 25 | 28 | 12 | 0 | 0 | 0 | - | 0 | - |
| Smallmouth Bass | 14 | 86 | 12 | 86 | 12 | 0 | - | 0 | - |
| Rock Bass | 58 | 3 | 3 | 0 | 0 | 0 | - | 0 | - |
| Common Carp | 8 | 75 | 20 | 75 | 20 | 13 | 15 | 0 | - |
| Tiger Muskie | 2 | 50 | 45 | 50 | 45 | 0 | - | 0 | - |
| Bluegill | 6 | 0 | 0 | 0 | 0 | 0 | - | 0 | - |
| Black Crappie | 4 | 0 | 0 | 0 | 0 | 0 | - | 0 | - |
| Brown Bullhead | 9 | 67 | 20 | 0 | 0 | 0 | - | 0 | - |
| **Fyke** | - | - | - | - | - | - | - | - | - |
| Yellow Perch | 114 | 3 | 2 | 0 | 0 | 0 | - | 0 | - |
| Rock Bass | 133 | 13 | 4 | 0 | 0 | 0 | - | 0 | - |
| Common Carp | 1 | 100 | 0 | 100 | 0 | 0 | - | 0 | - |
| Bluegill | 15 | 0 | 0 | 0 | 0 | 0 | - | 0 | - |
| Black Crappie | 6 | 0 | 0 | 0 | 0 | 0 | - | 0 | - |
| Brown Bullhead | 22 | 82 | 11 | 45 | 14 | 5 | 6 | 0 | - |

## Zooplankton

Among zooplankton surveys three taxa were identified to genus including, *Ceriodaphnia* spp., *Daphnia* spp., and *Holopedium* spp. Remaining zooplankton were grouped by lowest possible taxonomic order and included rotifera, copepoda, bosmonidae, chydoridae, and sididae. Due to their abundance and small size among all samples, rotifers were not enumerated. Organisms in the order Cladocera were grouped for analysis. *Daphnia* spp. were included among the Cladoceran grouping, but were segregated for comparative analysis of *Daphnia* spp. populations in American Lake, Banks Lake and Lake Roosevelt. Among samples, copepods were most abundant and demonstrated the greatest density ($m^3$; Table 5). Zooplankton lengths varied and were generally small; average length of copepods and Cladocerans were 0.78 mm (Figure 3) and 0.72 mm (Figure 4) respectively. Of the Cladocerans captured, *Daphnia* spp. were the largest with average length 0.91 (Figure 5). Lake Tapps *Daphnia* spp. were smaller than American

Lake (P< 0.001, T= 5.7) Banks Lake (P< 0.001, T= 5.3) and Lake Roosevelt (P< 0.001, T= 16.7) *Daphnia* spp. and were less densely distributed than American Lake (P< 0.001, T= 4.7) and Banks Lake (P< 0.05, T= 2.9) populations (Table 6).

**Table 5. Density per cubic meter of zooplankton sampled from Lake Tapps, Pierce County, October 2013.**

| Site | Copepod Density ($m^3$) | *Cladoceran Density ($m^3$) | *Daphnia* spp. Density ($m^3$) |
|---|---|---|---|
| (1) 1_33 | 2,321 | 374 | 240 |
| (2) 47 | 19,778 | 619 | 335 |
| (3) 1_76 | 6,531 | 1,061 | 66 |
| (4) 1_164 | 11,289 | 1,097 | 321 |
| (5) 1_18 | 9,824 | 3,520 | 1,779 |
| (6) 63 | 9,725 | 659 | 96 |
| (7) 46 | 7,651 | 1,263 | 445 |
| (8) 1_16 | 7,574 | 2,110 | 654 |
| (9) 1_114 | 14,164 | 5,858 | 5,154 |
| (10) 1_86 | 6,399 | 1,426 | 0 |
| | | | |
| **Average** | 9,526 | 1,799 | 909 |
| **CI 80%** | 2,102 | 739 | 690 |

*Cladoceran densities include *Daphnia* spp.

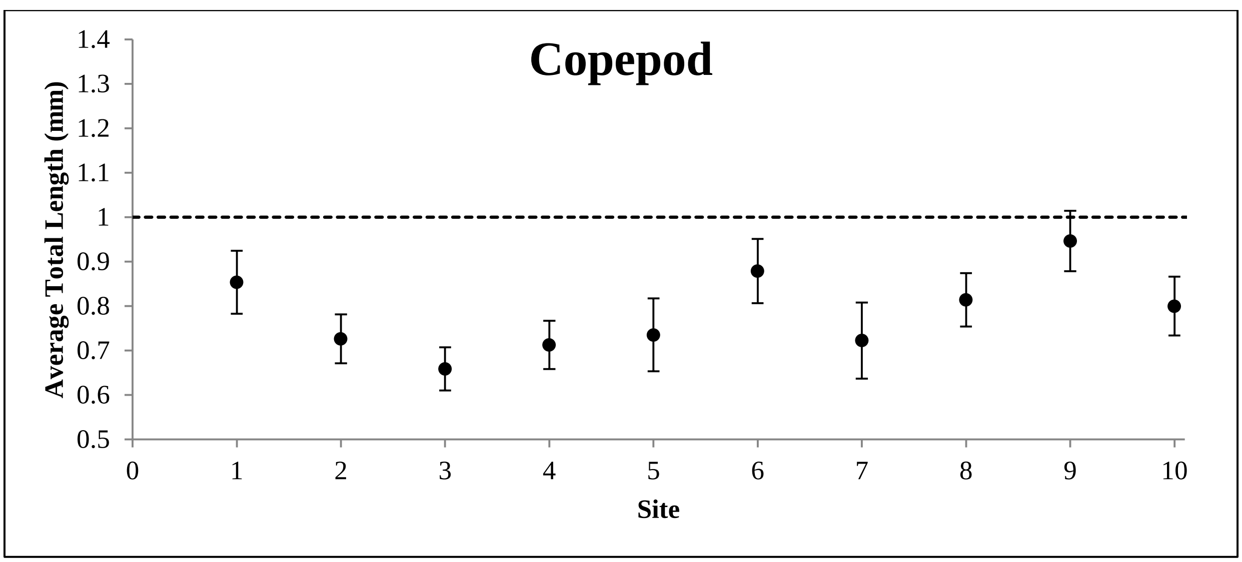


**Figure 3. Average body length (TL ± 80%CI) by site for Copepods in Lake Tapps, October 2013. Total lengths below the dashed line are indicative of an overgrazed zooplankton population (Mills and Schiavone 1987).**

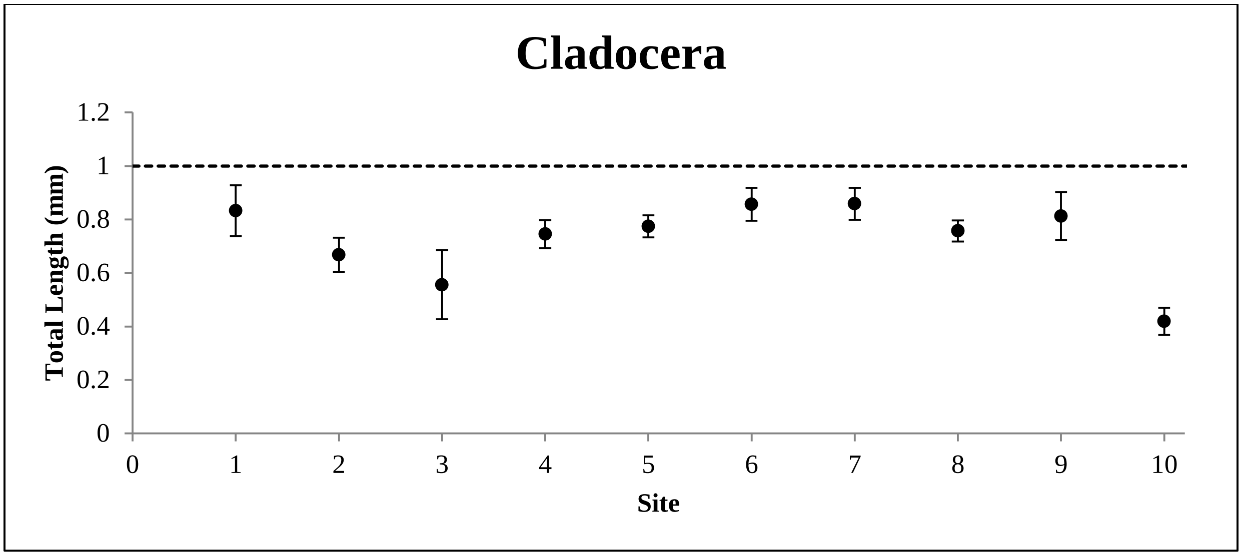


**Figure 4. Average body length (TL ± 80%CI) by site for Cladocera in Lake Tapps, October 2013. Total lengths below the dashed line are indicative of an overgrazed zooplankton population (Mills and Schiavone 1987).**

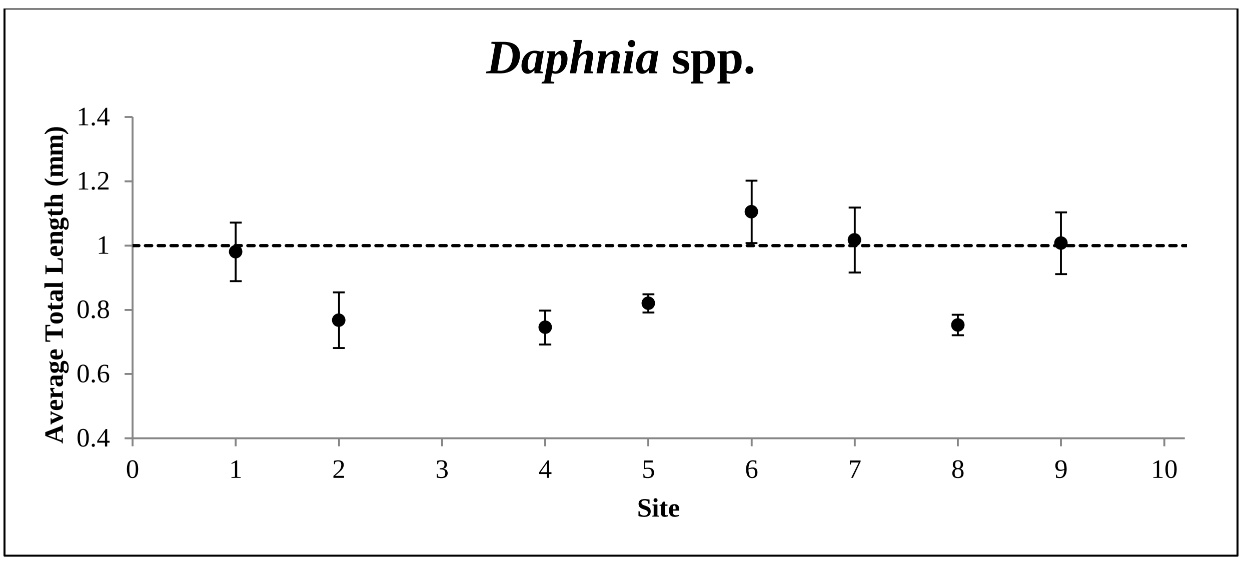


**Figure 5. Average body length (TL ± 80%CI) by site for *Daphnia* spp. in Lake Tapps, October 2013. Total lengths below the dashed line are indicative of an overgrazed zooplankton population (Mills and Schiavone 1987).**

**Table 6. Average total length (mm) and density ($m^3$) with 80% confidence intervals for zooplankton population from Lake Tapps, American Lake, Banks Lake and Lake Roosevelt. Lake Tapps zooplankton were significantly smaller and less densely distributed than comparative water bodies, with a single exception.**

| Water Body | Total Length (mm) | | Density ($m^3$) | |
|---|---|---|---|---|
| | Mean | 80% CI | Mean | 80% CI |
| Lake Tapps | 0.91 | 0.03 | 909 | 690 |
| American Lake | 1.07 | 0.02 | 7,863 | 1,786 |
| Banks Lake | 1.06 | 0.02 | 4,309 | 573 |
| Lake Roosevelt | 1.47 | 0.03 | 670* | 205 |

*not significantly different than Lake Tapps

## Brown Bullhead

A total of 56 Brown Bullhead were sampled during this survey. Brown Bullhead total length ranged from 85 to 381 mm (Table 2; Figure 6). Brown Bullhead weight ratios were on average below the national 75th percentile (Average $W_r$= 81.3, SD= 12.4; Figure 7). Age and growth data were not collected for Brown Bullhead.

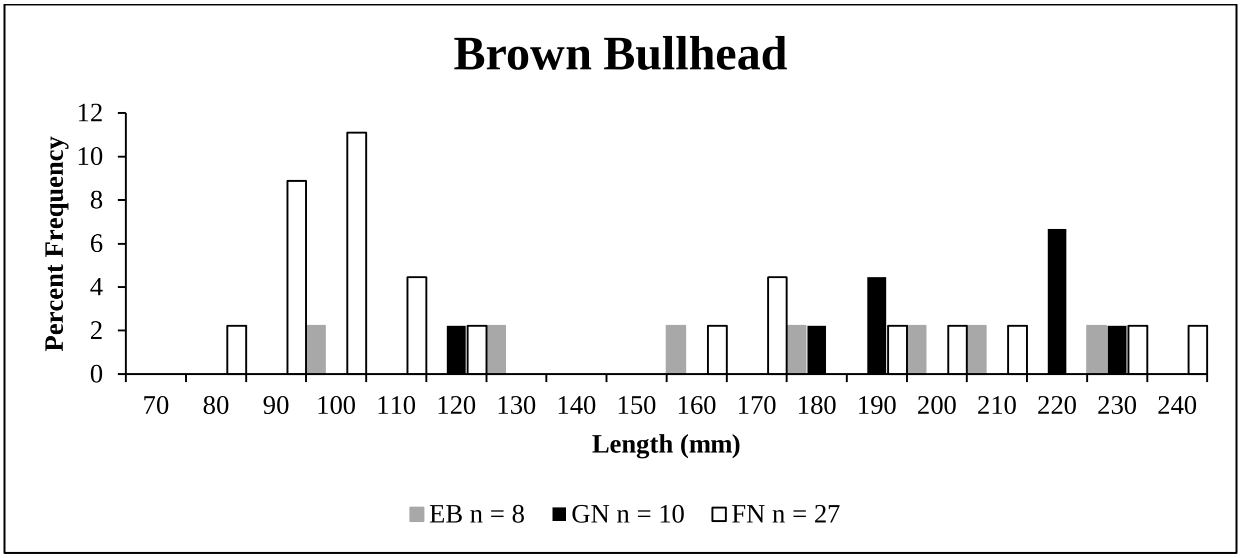


**Figure 6. Length frequency distribution of Brown Bullhead, observed in Lake Tapps, Pierce County, October 2013.**

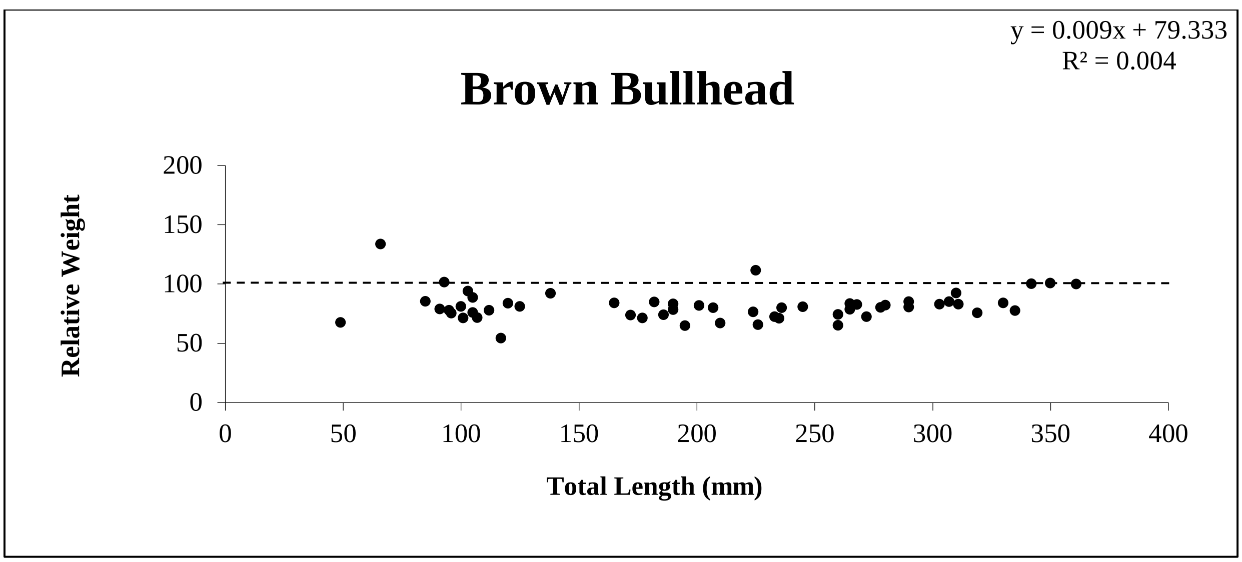


**Figure 7. Relative weights of Brown Bullhead, observed in Lake Tapps, Pierce County, October 2013, as compared to the national 75th percentile, $W_r$= 100 (dashed line).**

## Tiger Muskie

A total of 7 Tiger Muskie were sampled during this survey. Tiger Muskie total length ranged from 367 to 1010 mm (Table 2; Figure 8). Tiger Muskie weight ratios were below the national 75$^{th}$ percentile (Average $W_r$= 75.4, SD= 12.2; Figure 9). Tiger Muskie are stocked into Washington lakes as age-1 fish, and are typically tagged to aid in year class identification, however no age data were collected from Tiger Muskie during this sample period.

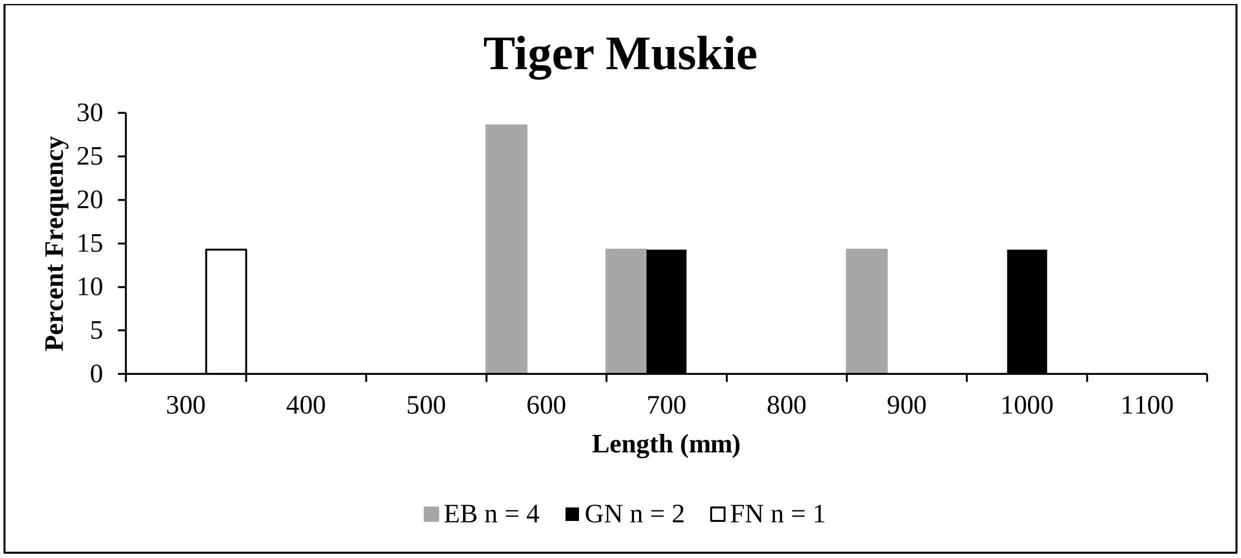


**Figure 8. Length frequency distribution of Tiger Muskie, observed in Lake Tapps, Pierce County, October 2013**

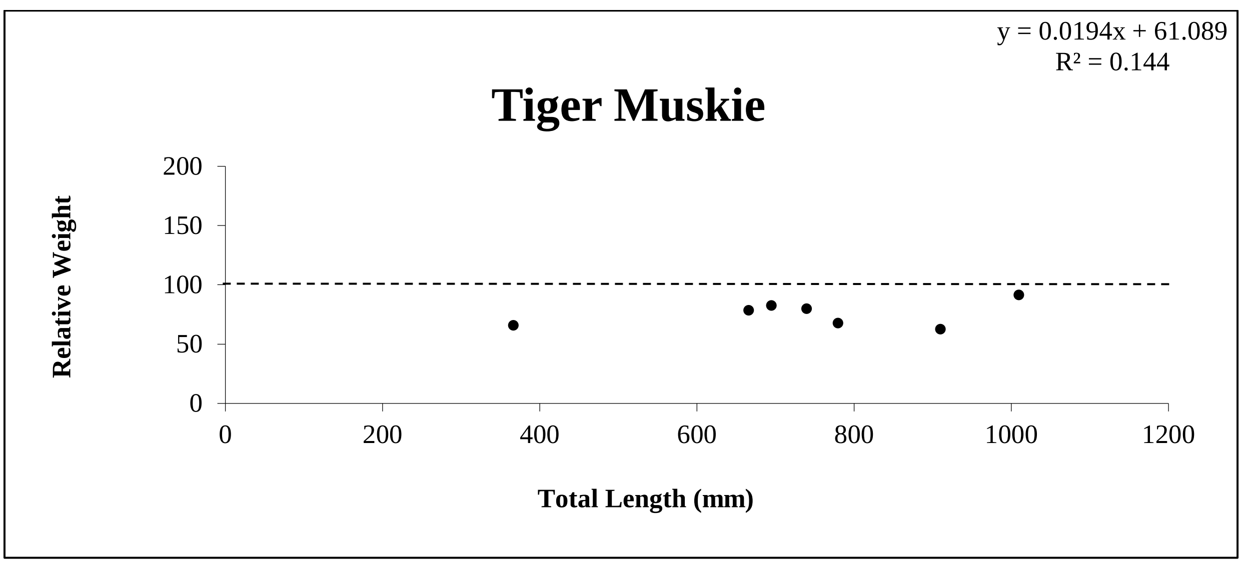


**Figure 9. Relative weights of Tiger Muskie observed in Lake Tapps, Pierce County, October 2013, as compared to the national 75th percentile, Wr= 100 (dashed line).**

## Rock Bass

A total of 451 Rock Bass were sampled during this survey. Rock Bass total length ranged from 80 to 214 mm (Table 2; Figure 10). The age of Rock Bass sampled ranged from one to six years (Table 7). Rock Bass weight ratios were on average below the national 75$^{th}$ percentile (Average $W_r$= 78.4, SD= 10.8; Figure11).

**Table 7. Back-calculated mean length at age (mm) of Rock Bass collected from Lake Tapps, Pierce County, Fall 2013. Unshaded values represent length at age calculated from the direct proportion method (Fletcher et al. 1999). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).**

| | | Mean Total Length (mm) at age | | | | | |
|---|---|---|---|---|---|---|---|
| Year Class | # Fish | 1 | 2 | 3 | 4 | 5 | 6 |
| 2012 | 28 | 34 | | | | | |
| | | 50 | | | | | |
| 2011 | 16 | 28 | 74 | | | | |
| | | 47 | 84 | | | | |
| 2010 | 28 | 28 | 71 | 122 | | | |
| | | 48 | 85 | 128 | | | |
| 2009 | 20 | 31 | 81 | 131 | 160 | | |
| | | 52 | 94 | 134 | 160 | | |
| 2008 | 12 | 26 | 72 | 122 | 156 | 182 | |
| | | 48 | 87 | 136 | 165 | 180 | |
| 2007 | 1 | 15 | 64 | 114 | 159 | 176 | 193 |
| | | 39 | 81 | 125 | 165 | 180 | 194 |
| Direct Proportion Mean | | 30 | 74 | 125 | 158 | 182 | 193 |
| Lee's Weighted Mean | | 49 | 87 | 131 | 162 | 180 | 194 |
| Direct Proportion State Average | | -- | -- | -- | -- | -- | -- |

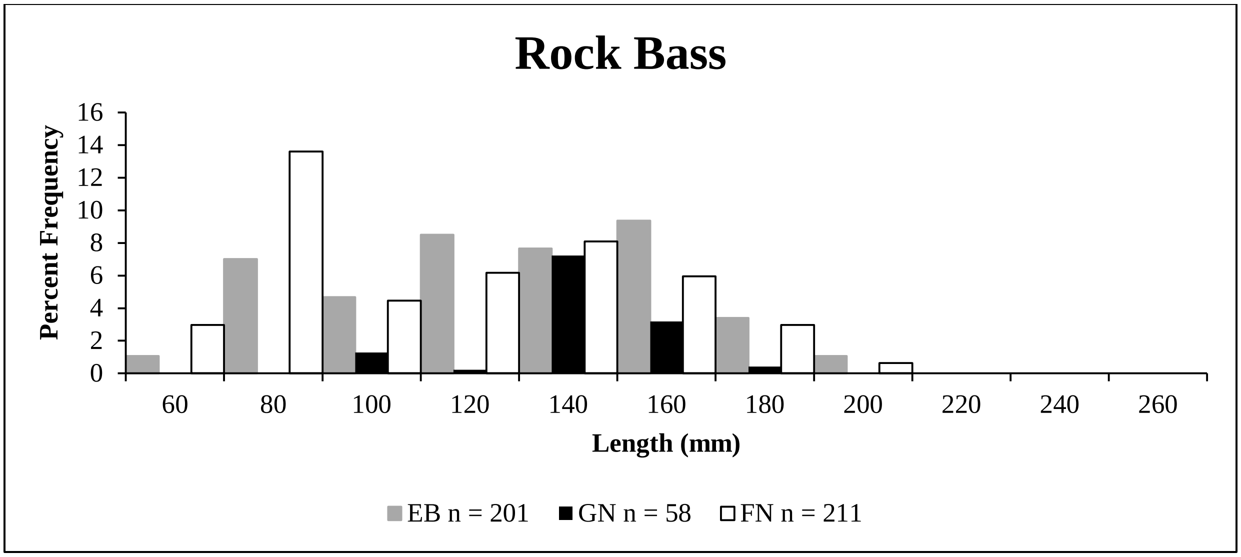


**Figure 10. Length frequency distribution of Rock Bass, observed in Lake Tapps, Pierce County, October 2013.**

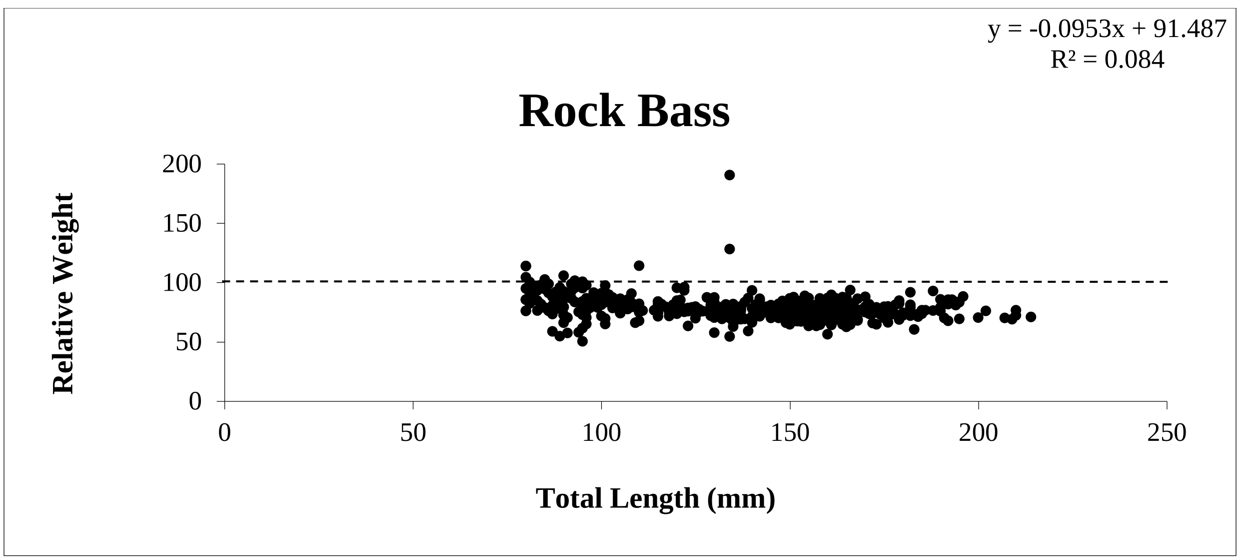


**Figure 11. Relative weights of Rock Bass observed in Lake Tapps, Pierce County, October 2013, as compared to the national 75th percentile, $W_r$= 100 (dashed line).**

## Bluegill

A total of 42 Bluegill sampled during this survey. Bluegill total length ranged from 79 to 144 mm (Table 2; Figure 12). The age of Bluegill ranged from one to two years (Table 8). Bluegill year-class strength was dominated by small young (age-1) fish (Table 8; Figure 12). Bluegill growth rates were below the Washington state average among all year classes (Fletcher et al. 1993). Bluegill weight ratios were on average below the nation 75$^{th}$ percentile (Average $W_r$= 86.5, SD= 12.2; Figure 13).

**Table 8. Back-calculated mean length at age (mm) of Bluegill collected from Lake Tapps, Pierce County, October 2013. Unshaded values represent length at age calculated from the direct proportion method (Fletcher et al. 1999). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).**

| | | Mean Total Length (mm) at Age | |
|---|---|---|---|
| Year Class | # Fish | 1 | 2 |
| 2012 | 31 | 16 | |
| | | 35 | |
| 2011 | 2 | 17 | 70 |
| | | 35 | 82 |
| Direct Proportion Mean | | 16 | 70 |
| Lee's Weighted Mean | | 35 | 82 |
| Direct Proportion State Average | | 37 | 97 |

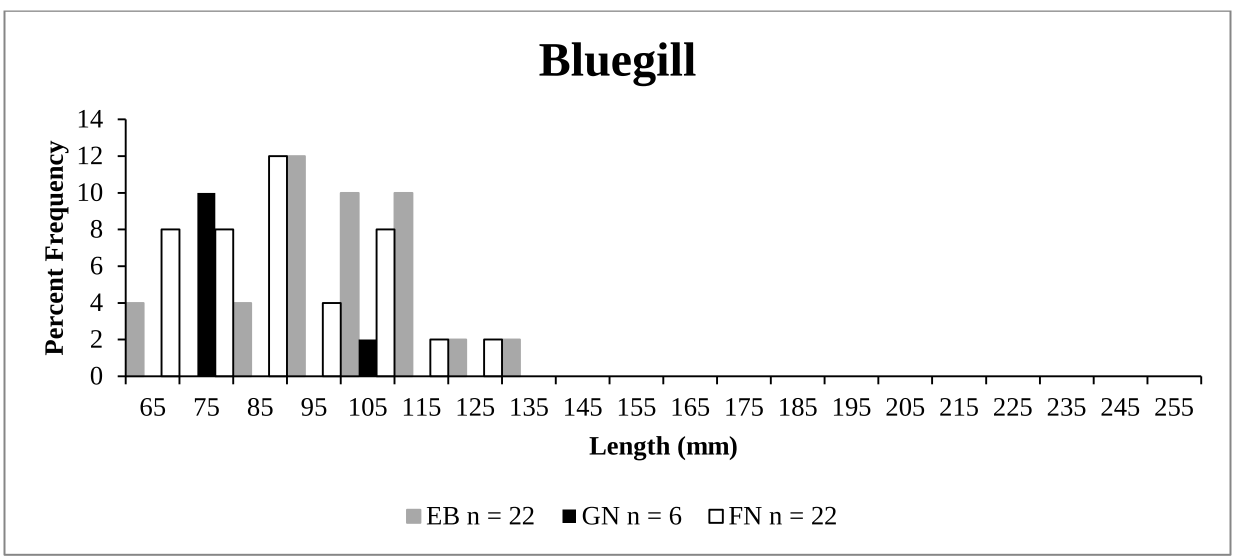


**Figure 12. Length frequency distribution of Bluegill, observed in Lake Tapps, Pierce County, October 2013.**

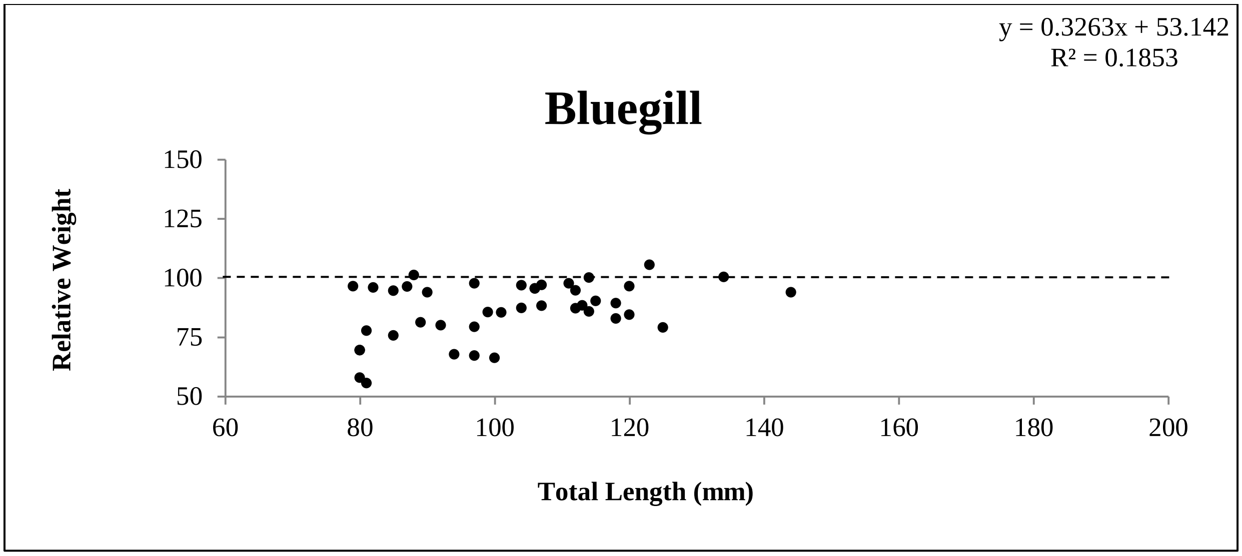


**Figure 13. Relative weights of Bluegill observed in Lake Tapps, Pierce County, Fall 2013, as compared to the national 75th percentile, $W_r$= 100 (dashed line).**

## Smallmouth Bass

A total of 45 Smallmouth Bass were sampled during this survey. Smallmouth Bass total length ranged from 152 to 450 mm (Table 2; Figure 14). The age of Smallmouth Bass ranged from one to six years (Table 9). Smallmouth Bass year-class strength varied by gear type, with large quantities of small, young fish observed in electrofishing samples and large older fish observed among gill net samples (Table 9; Figure 14). Smallmouth Bass growth rates were above the Washington state average at ages 3, 4, 5, and 6, but were below average at ages 1, and 2 (Fletcher et al. 1993). Among all size classes, weight ratios were on average below the national 75th percentile (Average $W_r$= 88.4, SD= 11.2; Figure 15).

**Table 9. Back-calculated mean length at age (mm) of Smallmouth Bass collected from Lake Tapps, Pierce County, October 2013. Unshaded values represent length at age calculated from the direct proportion method (Fletcher et al. 1999). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).**

| | | Mean Total Length (mm) at Age | | | | | |
|---|---|---|---|---|---|---|---|
| Year Class | # Fish | 1 | 2 | 3 | 4 | 5 | 6 |
| 2012 | 24 | 68 | | | | | |
| | | 90 | | | | | |
| 2011 | 5 | 59 | 153 | | | | |
| | | 86 | 168 | | | | |
| 2010 | 2 | 40 | 136 | 236 | | | |
| | | 70 | 154 | 242 | | | |
| 2009 | 1 | 62 | 152 | 248 | 315 | | |
| | | 91 | 172 | 258 | 319 | | |
| 2008 | 6 | 57 | 143 | 228 | 253 | 357 | |
| | | 87 | 165 | 243 | 266 | 266 | |
| 2007 | 5 | 52 | 134 | 217 | 280 | 335 | 380 |
| | | 82 | 157 | 234 | 291 | 291 | 383 |
| Direct Proportion Mean | | 62 | 143 | 227 | 269 | 347 | 380 |
| Lee's Weighted Mean | | 87 | 163 | 240 | 281 | 351 | 383 |
| Direct Proportion State Average | | 70 | 146 | 212 | 268 | 334 | 356 |

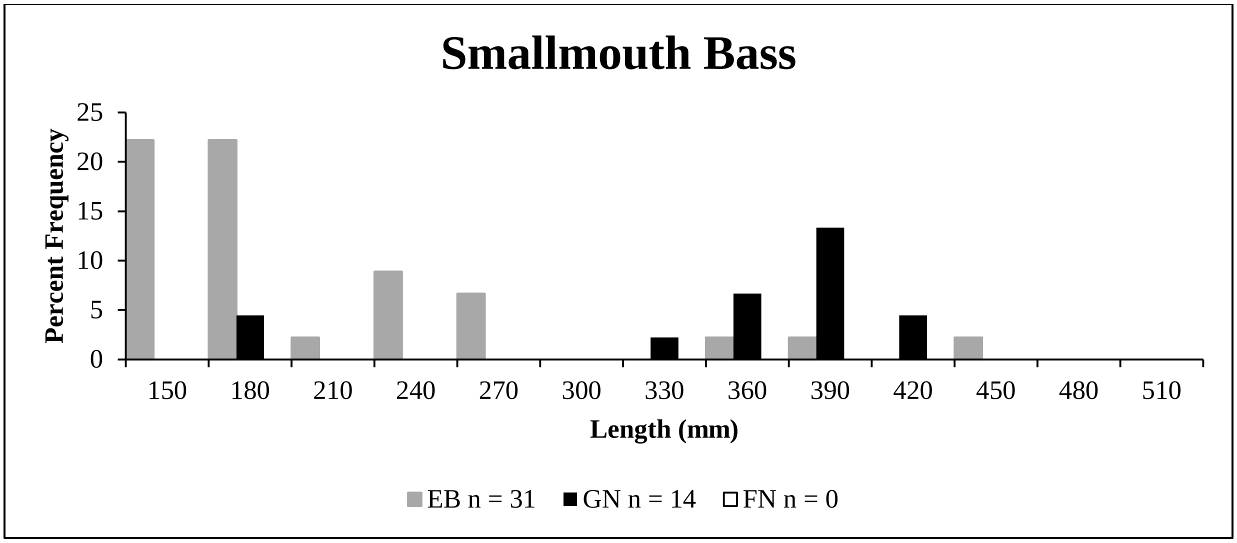


**Figure 14. Length frequency distribution of Smallmouth Bass, observed in Lake Tapps, Pierce County, October 2013.**

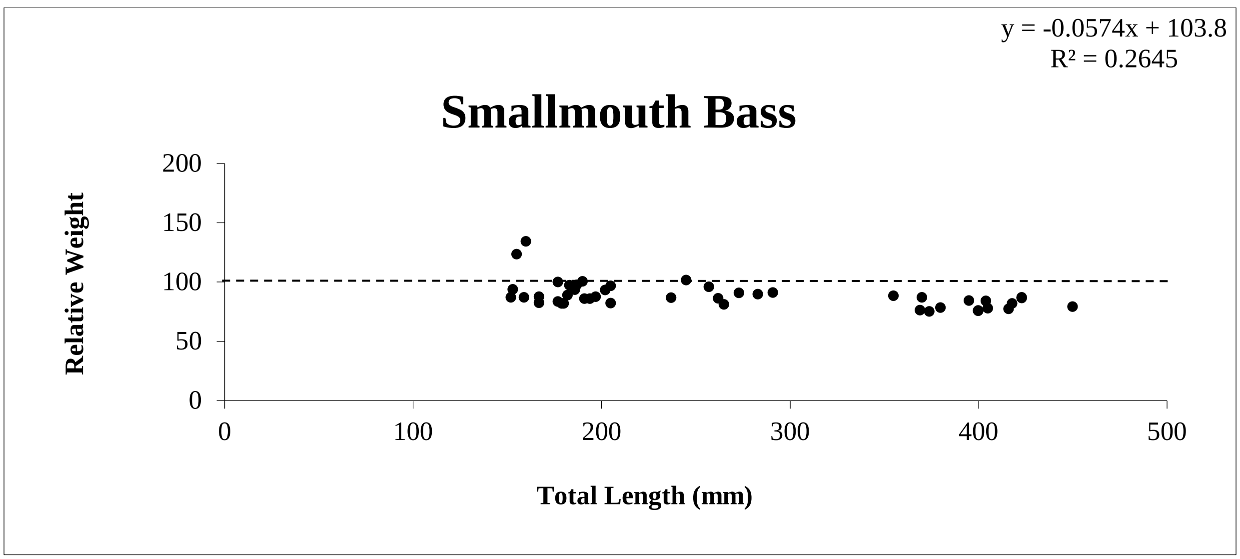


**Figure 15. Relative weights of Smallmouth Bass observed in Lake Tapps, Pierce County, October 2013, as compared to the national 75th percentile, $W_r$= 100 (dashed line).**

## Largemouth Bass

A total of four Largemouth Bass were sampled during this survey. Largemouth Bass total length ranged from 220 to 550 mm (Table 2). Age of fish captured were two (n= 2) and four (n= 2) years. Four year old Largemouth Bass were above the national 75th percentile ($W_r$= 131.6, SD= 11.6) and the 2 year olds below the national average ($W_r$= 92.6, SD= 2.3).

## Black Crappie

A total of 31 Black Crappie were sampled during this survey. Black Crappie total length ranged from 105 to 175 mm (Table 2; Figure 16). The age of Black Crappie ranged from one to two years (Table 10). Black Crappie year-class structure was dominated by young (age-1) individuals (Table 10; Figure 16). Black Crappie growth rates were below the Washington state average (Fletcher et al. 1993). Condition of Black Crappie varied, with observations above and below the national 75th percentile across all size classes ($W_r$= 96.1, SD= 11.0; Figure 17).

**Table 10. Back-calculated mean length at age (mm) of Black Crappie collected from Lake Tapps, Pierce County, October 2013. Unshaded values represent length at age calculated from the direct proportion method (Fletcher et al. 1999). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).**

| | | Mean Total Length (mm) at Age | |
|---|---|---|---|
| Year Class | # Fish | 1 | 2 |
| 2012 | 21 | 36 | |
| | | 61 | |
| 2011 | 1 | 30 | 79 |
| | | 58 | 96 |
| Direct Proportion Mean | | 36 | 79 |
| Lee's Weighted Mean | | 61 | 96 |
| Direct Proportion State Average | | 46 | 111 |

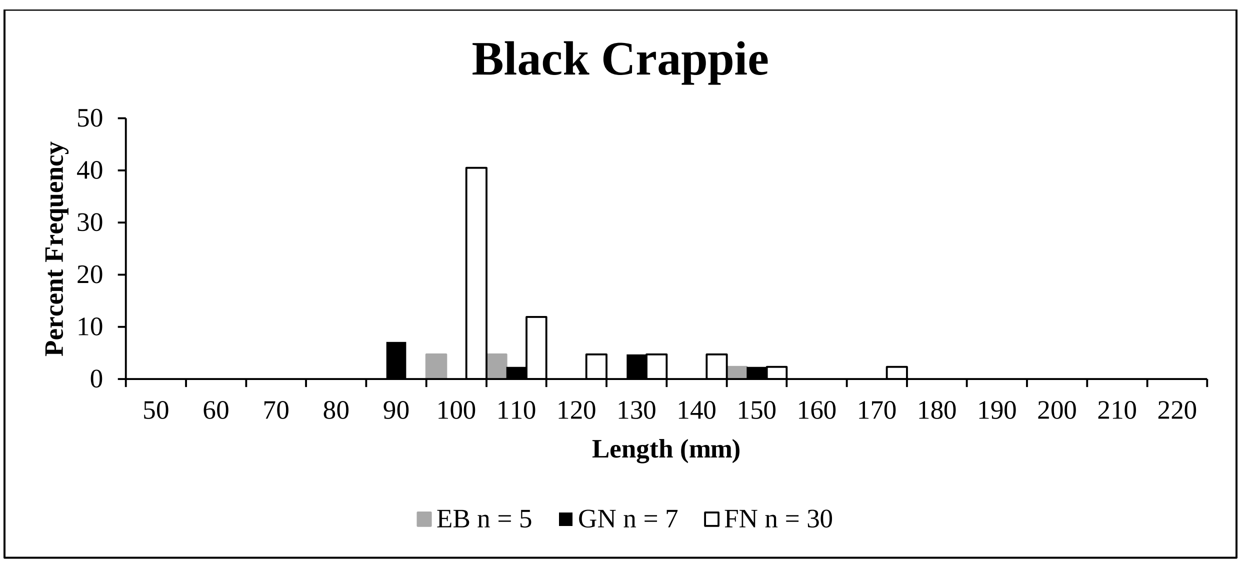


**Figure 16. Length frequency distribution of Black Crappie, observed in Lake Tapps, Pierce County, October 2013.**

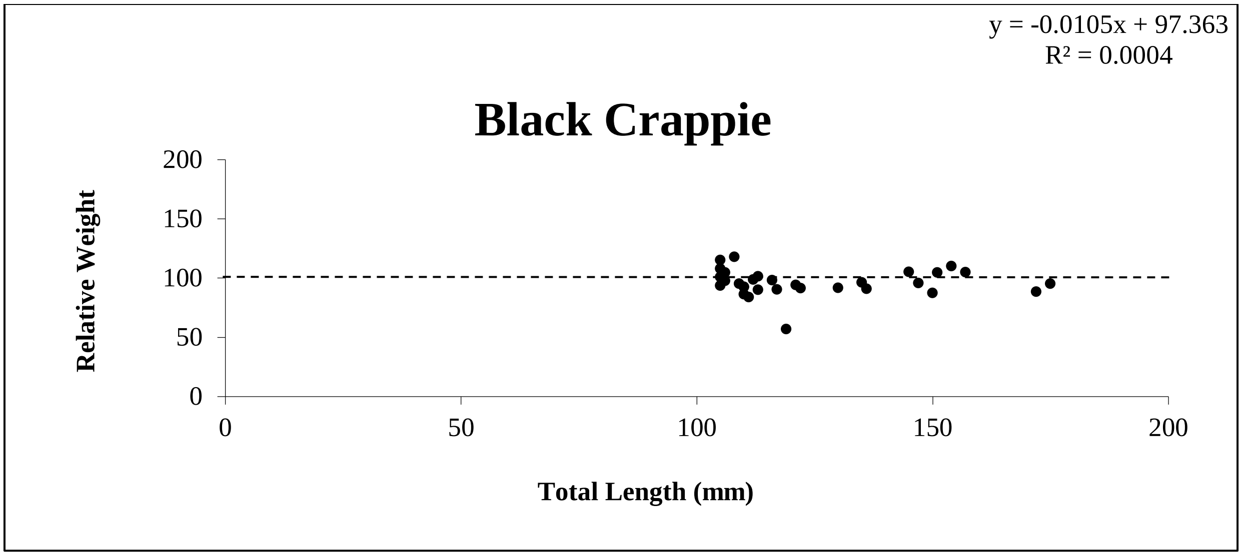


**Figure 17. Relative weights of Black Crappie observed in Lake Tapps, Pierce County, October 2013, as compared to the national 75th percentile, $W_r$= 100 (dashed line).**

## Yellow Perch

A total of 213 Yellow Perch were sampled during this survey. Yellow Perch ranged in total length from 125 to 256 mm (Table 2; Figure 18). Yellow Perch ages ranged from one to three years (Table 11). Yellow Perch year-class strength was dominated by small young (age-1) fish (Table 11; Figure 18). Yellow Perch growth rates were above the Washington state average (Fletcher et al. 1993). Yellow perch weight ratios were below the national 75th percentile ($W_r$= 76.3, SD= 9.1; Figure 19).

**Table 11. Back-calculated mean length at age (mm) of Yellow Perch collected from Lake Tapps, Pierce County, October 2013. Unshaded values represent length at age calculated from the direct proportion method (Fletcher et al. 1999). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).**

| | | Mean Total Length (mm) at Age | | |
|---|---|---|---|---|
| Year Class | # Fish | 1 | 2 | 3 |
| 2012 | 45 | 102 | | |
| | | 112 | | |
| 2011 | 12 | 59 | 160 | |
| | | 81 | 168 | |
| 2010 | 1 | 50 | 169 | 234 |
| | | 74 | 179 | 237 |
| Direct Proportion Mean | | 92 | 161 | 235 |
| Lee's Weighted Mean | | 105 | 169 | 237 |
| Direct Proportion State Average | | 60 | 120 | 152 |

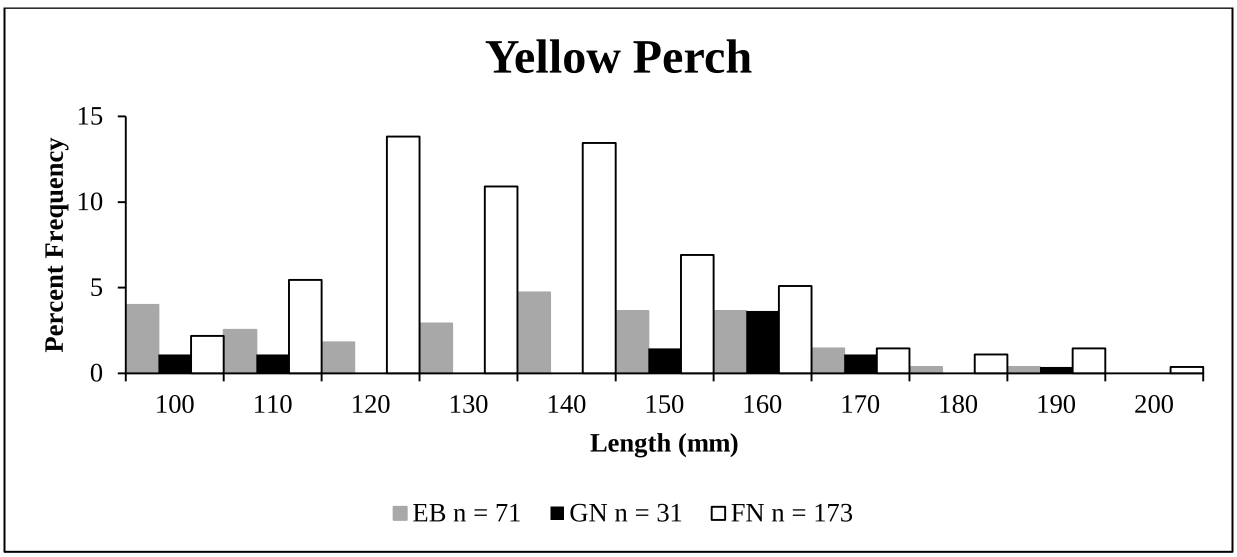


**Figure 18. Length frequency distribution of Yellow Perch, observed in Lake Tapps, Pierce County, October 2013.**

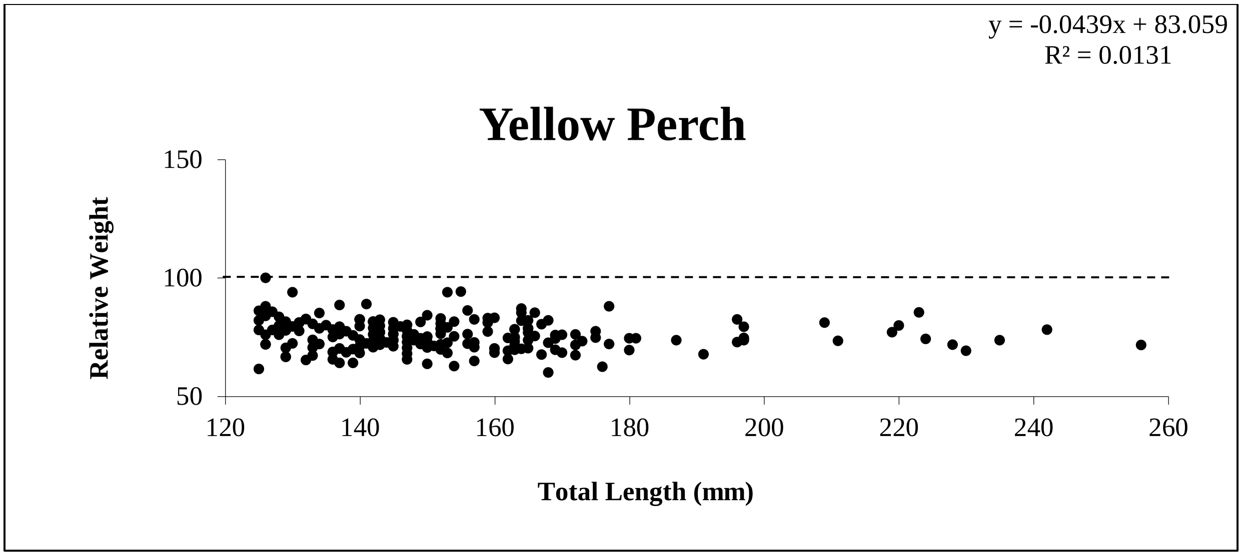


**Figure 19. Relative weights of Yellow Perch observed in Lake Tapps, Pierce County, October 2013, as compared to the national 75th percentile, $W_r$= 100 (dashed line).**

## Other Fish

In addition to the fish listed above, the Lake Tapps assemblage included Largescale Sucker, Common Carp, Redside Shiner and unidentified species of sculpin. Combined, these fish represented nearly 73.3% of the total biomass and 28.1% of the total relative abundance. No age or growth data were collected for these fish.

# Discussion

The Lake Tapps fish community is dominated by small, young forage species. Yellow Perch, Rock Bass and Largescale Sucker comprised the majority of the forage fish base within the lake, with sparse large predatory fish i.e., (Largemouth Bass, Smallmouth Bass, Tiger Muskie). Balanced fish populations demonstrate predator-prey ratios such that, small fish are sufficiently culled from the population by predation and natural mortality to reduce intraspecific competition and foster recruitment into harvestable sizes (Swingle 1950). Large quantities of small, young and poorly conditioned fish indicate that the Lake Tapps fish community is likely unbalanced, and may benefit from increased predation and harvest of these species (Swingle 1950; Anderson 1973; Mills and Schiavone 1987). Several environmental factors interact in Lake Tapps which influence population structure and dynamics including: perpetually low water temperature and high turbidity due to glacial silt input as well as varying habitat availability due to winter draw down (LeRoy Heman et al. 1969; Rogers and Bergersen 1995; Mueller 1998). Additionally it is also likely that inter- and intraspecific competition plays a strong role in shaping the fish community (Mills and Schiavone 1982; Elinor and Hadley 1979). Effects of these factors were observed among Lake Tapps fish as growth rates, condition and age ranges were generally below national and state averages with few exceptions. While generally considered forage for larger predatory species, studies of Rock Bass populations have found substantial overlap in diet and habitat preferences with Smallmouth Bass at varying life stages (George and Hadley 1979; Probst et al. 1984). As such, the densities of Rock Bass observed in Lake Tapps may represent substantial competition for consumers of YOY fish. Additionally, winter water level drawdowns have been shown to vary in their effect on fish, with increased competition for resources and preferential habitat observed among planktivores, as well as increased predation (LeRoy Heman et al. 1969; Rogers and Bergersen 1995). Low PSD estimates of forage species indicate that recruitment into quality size or larger is low, however PSD estimates of some sport fish indicate that opportunities exist in Lake Tapps to catch very large Smallmouth Bass, Largemouth Bass, Bullhead and Tiger Muskie (Table 1).

Comparative analysis between survey years was limited due to disparities in standardized sample techniques in addition to inadequate sample sizes from 1997 survey data. Descriptive comparisons of assemblage composition demonstrate few, but meaningful differences, in both species composition and population structure. The 1997 Lake Tapps survey included captures of 3 species of salmonids that were not observed in the 2013 survey, including Mountain Whitefish *Prosopium williamsoni*, Kokanee and Cutthroat Trout. These salmonids comprised 19.1% of the total biomass and 17% of the total relative abundance in 1997. A number of warmwater game species were absent in 1997 including Largemouth Bass, Brown Bullhead and Tiger Muskie which comprised 11.3% of total biomass and 5.8% total relative abundance in 2013. Hatchery records indicate that the most recent stocking of Rainbow Trout and Kokanee occurred in 1994 (48,000 fish) and 1992 (53,000 fish) respectively, therefore it is unlikely that salmonids captured during the 1997 survey were a product of such releases. Rather, it is likely that, given the presence of Mountain Whitefish and Cutthroat Trout, that these fish were the product of entrainment from the White River. Furthermore, the screen placed below the diversion dam on the White River was removed, and then replaced in 1996, when it had gone without maintenance for decades prior, increasing the likelihood of fish bypassing the screen. Lack of detection of Largemouth Bass and Brown Bullhead in the 1997 survey was likely due to a smaller sample effort and lack of fyke samples in 1997, as well as small population size, as evidenced with the small sample size of Largemouth Bass in 2013. Efficacy studies of gear bias have found that in comparison to electrofishing and gillnetting, hoop nets and fyke nets are more effective at capturing benthic species like catfish, so not surprisingly the greatest catch rates of Brown Bullhead in the 2013 survey occurred in fyke net samples (Buckmeir and Schlechte 2009). Tiger Muskie were first stocked into Lake Tapps in 2000, so none were captured in 1997.

Species composition and population structures observed from the 1997 and 2013 surveys reflect the transitional effects of the earlier management decision to cease trout and Kokanee stocking and emphasize warmwater angling opportunities, such as Tiger Muskie. In addition to providing a trophy angling opportunity, Tiger Muskie were stocked into Lake Tapps to improve the state of the overall warmwater fishery by reducing the abundance of Largescale Suckers. Introductions of large apex predatory fish have been positively correlated with increases in proportional and relative stock densities of warmwater sport-fish (Bennett 1962; Noble 1981; Wahl and Stein 1988; Boxrucker 1992; Bolding et al. 1997). We found evidence to support the contention that these efforts have been preliminarily successful, with changes in Largescale Sucker population structure observed between surveys; Largescale Sucker captured in 2013 were on average greater in length and weight than those captured in 1997, which may have been a result of increased predation of smaller individuals. As well as high PSD and RSD estimates observed for four game species in 2013.

A host of biological and environmental factors contribute to the population structure of zooplankton communities including; primary productivity, physical properties of habitat, and predation by planktivorous fish (Mills and Schiavone 1987; Radwan and Popio 1989; Brett and Goldman 1996; Hambright and Hall 1992; Jackson et al. 2001). These factors interact along a dynamic spatio-temporal cascade of trophic effects which shape each population into predictable patterns of size and abundance, commonly utilized to infer stability and structure of a fishery (Mills and Schiavone 1982; DeVries and Stein 1992). The size and abundance of zooplankton along these trophic cascades are often used to infer fish population structure, as a measure of the degree of grazing (Mills and Schiavone 1982). *Daphnia* spp., which typically comprise the largest proportion of planktivorous fish diets, have shown to be good indicator organisms in such studies, where populations of average total length greater than 1 mm TL are indicative of a balanced system, and total lengths less than 1 mm TL are indicative of an overgrazed population (Mills and Schiavone 1982; Burgess et al. 2008). Zooplankton size and densities, in conjunction with fish length frequency distributions, observed in Lake Tapps in October 2013 are indicative of an overgrazed zooplankton population (Mills and Schiavone 1982). High abundance of <1 mm TL zooplankton and small, young planktivores in Lake Tapps are consistent with patterns of overgrazing of the zooplankton community.

Currently, the fisheries management plan of Lake Tapps is centered on enhancing and promoting the warmwater fish community. However having a greater understanding of how stocked salmonids might impact the fish community will allow managers to assess future potential for salmonid fisheries in Lake Tapps. It is difficult to predict how the warmwater fish community and corresponding trophic interactions may react to stocking large quantities of trout, because as omnivores, trout vary in their prey selection under different feeding opportunities. When compared to other warmwater communities that cohabitate with stocked salmonids the average size and density of Lake Tapps zooplankton were significantly smaller and less densely distributed than zooplankton from American Lake, Banks Lake and Lake Roosevelt (Polacek 2009, 2013; Knudson et al. 2014). Therefore it is possible that the introduction of large quantities of planktivorous salmonids into Lake Tapps will add grazers to an already overgrazed system. Furthermore, Galbraith (1967) demonstrated that substantial overlap of *Daphnia* spp. size selectivity occurs between Yellow Perch and Rainbow Trout, so introductions of small trout may increase competition among zooplankton consumers. Increased competition for shared prey items (e.g. *Daphnia* spp.), has been shown to negatively impact both fish growth and condition (Persson 1983; Mittelbach 1988; Welker et al. 1994; Ward et al. 2006). Zooplankton communities are highly variable, and are often in a dynamic state of cascade, as such, a single survey of the population may not be an accurate representation of the true nature of their distribution and size structure. Further study of the Lake Tapps zooplankton population will increase the degree of certainty for which current and future management decisions can be based.

# Management Considerations

It is likely that a number of environmental factors contribute to the unbalanced conditions of the Lake Tapps fish community. However the strongest detriment to the Lake Tapps aquatic community is likely glacial runoff from the White River, which introduces a large amount of cold, nutrient poor, turbid water into the lake. Coupled with short water residency and habitat removal during winter drawdowns, primary productivity, fish growth and fish condition appear strongly affected. While some of these factors are the product of management plans and legal agreements and may be difficult to alter, efforts which increase primary productivity in Lake Tapps, such as increased duration of water residency, decreased frequency of drawdowns, reduction of cold water input and retention of habitat availability i.e., (aquatic macrophytes) may substantially benefit the warmwater fish community (Schallenberg and Burns 2010).

Despite the aforementioned physical limiters, anecdotal evidence from popular literature (fishing forums, magazine articles, etc.) as well as trends in fishing tournament data report that the Lake Tapps fish community experiences a high degree of angler use and success. Also, anglers have a strong interest in the unique opportunities at Lake Tapps to catch both Smallmouth Bass and Tiger Muskie. Efforts to ground truth anecdotal evidence via creel census surveys will provide managers with estimates of angler pressure, harvest rates, species preferences and overall satisfaction, which are critical aspects of informed management decisions. Furthermore, creel census surveys can aid in identifying species that may be underexploited such as Brown Bullhead and Rock Bass. Increased angler effort and harvest of underexploited species like Rock Bass will aid in decreasing intra and interspecific competition and may aid in increasing the below-average growth rates and weight ratios observed in Lake Tapps fish.

Lake Tapps was intermittently stocked with Rainbow Trout and /or Kokanee for nearly 80 years. While historical accounts of the Lake Tapps salmonid fisheries report poor growth rates and low catch rates, little information is available regarding the overall success of these programs. Recently, participants of these fisheries have indicated they are once again interested in these types of opportunities. Although, objectives of this study did not include an evaluation of the potential success or failure of stocked trout, we found evidence which suggests the introduction of a large quantity of planktivores, such as Rainbow Trout fry or fingerlings (put-grow-and-take), may substantially increase competition for limited food resources. Alternatively, a put-and-take stocking regime, with catchable-sized Rainbow Trout, may be less detrimental to the warmwater fish community. Stocked catchable-size trout require no growth to become eligible for harvest, and they are typically removed quickly from the system. The ability of the existing plankton community to support trout is unknown, primarily because it is unknown if the zooplankton communities observed in Lake Tapps were definitively the product of overgrazing, or were the product of poor environmental conditions. Therefore, if approved, a trout stocking program will be considered experimental and will require an evaluation to determine success or failure.

The following management options aim to maintain a healthy fish community and provide successful angling opportunities for Lake Tapps:

1. Explore options to improve primary productivity by decreasing the frequency of drawdowns and depth reductions, decreasing removal of aquatic macrophyte habitat, decrease input of cold, nutrient poor glacial runoff, and increasing residency time of Lake Tapps waters.

2. Continue to stock Tiger Muskie at the current rate to continue the reduction of overcrowding by Largescale Sucker, continue beneficial predatory trophic effects, and provided increased opportunity for anglers.

3. Expand promotion of the Smallmouth Bass and Tiger Muskie fisheries, as they represent unique angling opportunities within the region, in addition to increased promotion of underexploited populations such as Brown Bullhead and Rock Bass**.**

4. Identify funding to stock Tapps Lake with 20-30 catchable (2.5 fish per pound) size rainbow trout per surface acre (50,000 – 80,000 fish) annually for three years and evaluate angler participation (anglers days directed at rainbow trout), success (catch/harvest per hour), and fish growth and condition. Based on the cost of $2.32 per pound of fish as currently charged by Trout Lodge, total approximate costs will range from $46,000 to $74,000 for 50,00 to 80,000 fish respectively.

These management considerations could be coupled with additional population monitoring, in order to assess efficacy of new management practices, and can include:

1. Conduct future repeated surveys of the Lake Tapps fish assemblage to monitor effects of stocked Tiger Muskie on the Lake Tapps forage base, to monitor the status of the warmwater fishery and serve as a point comparison to evaluate long term trends of the fish community.

2. Conduct creel surveys to estimate angler pressure, harvest, species preferences, and overall satisfaction, to couple with Lake Tapps warmwater assessments, to inform management decisions for the Lake Tapps fishery.

# Literature Cited


Anderson, R. O. 1973. Application of Theory and Research to Management of Warmwater Fish Populations. Transactions of the American Fisheries Society. 102:1, 164-171.

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, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

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

Bister, T. J., D. W. Willis, M. L. Brown, S. M. Jordan, R. M. Neumann, M. C. Quist, and C. S. Guy. 2000. Proposed Standard Weight ($W_s$) Equations and Standard Length categories for 18 Warmwater Nongame and Riverine Fish Species. North American Journal of Fisheries Management. 20, 570-574.

Brett, M. T., and C. R. Goldman. 1996. A Meta-analysis of the Freshwater Trophic Cascade. Proceedings of the National Academy of Sciences. 93, 7723-7726

Bolding, B., S. A. Bonar, M. Diveans, D. Fletcher, and E. Anderson. 1997. Stocking Walleye to Improve Growth and Reduce Abundance of Overcrowded Panfish in a Small Impoundment. Washington Department of Fish and Wildlife, Research Report # RAD97-05, 27p.

Bonar, S. A., B. D. Bolding, and M. Divens. 2000. Standard Fish Sampling Guidelines for Washington State Pond and Lake Surveys. Report No. FPT 00-28, Washington Department of Fish and Wildlife, Olympia, Washington. 24pp.

Boxrucker, J. 1992. Results of Concomitant Predator and Prey Stockings as a Management Strategy in Combating Stunting in an Oklahoma Crappie Population. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 46, 327-336

Buckmeier D. L. and J. W. Schlechte. 2009. Capture Efficiency and Size Selectivity of Channel Catfish and Blue Catfish Sampling Gears. North American Journal of Fisheries Management. 29:2, 404-416.

Burgess, D., K. Simmons, R. Shipley, and T. Gish. 2008. Moses Lake Fishery Restoration Project; Factors Affecting the Recreational Fishery in Moses Lake Washington. 2003 Final Completion Report, Project No. 199502800, 68 electronic pages, (BPA Report DOE/BP-00029385-2).

Cascade Water Alliance. 2010. Lake Tapps Integrated Aquatic Vegetation Management Plan. Tetra Tech, Seattle, Washington.

Chew, R. L. 1974. Early life history of the Florida Largemouth Bass. Fishery Bulletin No.7. Florida Game and Freshwater Fish Commission. 76

Conover, W. J. 1980. Practical Nonparametric Statistics, 2nd edition. John Wiley and Sons, Inc., New York, New York.

DeVries, D. R., and R.A. Stein. 1992. Complex Interactions Between Fish and Zookplankton: Quantifying the Role of an Open-water Planktivore. Canadian Journal of Fisheries and Aquatic Sciences. 49, 1212-1217.

Fletcher, D., S. A. Bonar, B. D. Bolding, A. Bradbury, and S. Zeylmaker. 1993. Analyzing Warmwater Fish Populations in Washington State. Warmwater fish survey manual. Washington Department of Fish and Wildlife, Olympia, Washington. 164pp.

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

Galbraith, M. G. 1967. Size-selective Predation on Daphnia by Rainbow Trout and Yellow Perch. Transactions of the American Fisheries Society. 96:1, 1-10

George, E. L., W. F. Hadley. 1979. Food and Habitat Partitioning Between Rock Bass (Ambloplites rupestris) and Smallmouth Bass (Micropterus dolomieu) Young of the Year. Transactions of the American Fisheries Society. 108, 253-261.

Gustafson, K. A. 1988. Approximating Confidence Intervals for Indices of Fish Population Size Structure. North American Journal of Fisheries Management. 8, 139-141.

Hambright K. D., and R. O. Hall. 1992. Differential Zooplankton Feeding Behaviors, Selectivities, and Community Impacts of two Planktivorous Fishes. Environmental Biology of Fishes. 35:4, 401-411.

Hyatt, M. W., and W. A. Hubert. 2001a. Proposed Standard Weight Equations for Brook Trout. North American Journal of Fisheries Management. 21, 253–254.

Hyatt, M. W., and W. A. Hubert. 2001b. Proposed Standard Weight (*Ws*) Equation and Length Categorization Standards for Brown Trout (Salmo trutta) in Lentic Habitats. Journal of Freshwater Ecology. 16, 53–56.

Jackson D.A., P.R. Peres-Neto, and J.D. Olden. 2001. What Controls who is where in Freshwater Communities-the Roles of Biotic, Abiotic and Spatial factors. Canadian Journal of Fisheries and Aquatic Sciences. 58:1, 157-170.

Jerald, A., Jr. 1983. Age Determination. Pages 301-324 *in* L. A. Nielsen and D. L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Knudson, T., E. Kittel, A. Blake, J. Seibert, and P. B. Nichols. 2014. Lake Roosevelt Fisheries Evaluation Program: Annual Report. U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Portland.

LeRoy Heman, M., R. S. Campbell, and L. C. Redmond. 1969. Manipulation of Fish Populations Through Reservoir Drawdown. Transactions of the American Fisheries Society. 98:2, 293-304

Mills, E., and, A. J. Schiavone. 1982. Evaluation of Fish Communities Through Assessment of Zooplankton Populations and Measures of Lake Productivity. North American Journal of Fisheries Management. 2, 14-27.

Mittelbach, G. G. Competition Among Refuging Sunfishes and Effects of Fish Density on Littoral Zone Invertebrates. Ecology. 69:3, 614-623.

Mueller, K W. 1998. 1997 Lake Tapps Survey: The Warmwater Fish Community of a reservoir Managed for Hydropower. Washington Department of Fish and Wildlife Region 6, Olympia, Washington.

Noble, R. L. 1981. Management of Forage Fishes in Impoundments of the Southern United States. Transactions of the American Fisheries Society. 110, 738-750.

Pennak, R. W. 1989. Fresh-water invertebrates of the United States : Protozoa to Mollusca. 3rd Edition. New York. John Wiley and Sons Inc. 628p.

Persson, L. 1983. Effects of Intra- and Interspecific Competition on Dynamics and Size Structure of a Perch Perca fluviatilis and a Roach Rutilus rutilus Population. 41, 126-132

Polacek, M.P., K.N. Knuttgen, and R. Shipley. 2009. The Banks Lake Fishery Evaluation Project FY2008. Annual Report. Bonneville Power Administration, Project Number 2001-028-00, Portland, Oregon.

Polacek, M., K. Simmons, and D. Didrickson. 2013. Evaluations of Potential Limiting Factors for Kokanee in American Lake, Washington. Washington Department of Fish and Wildlife, Large Lakes Research Team.

Probst, W. E., C. F. Rabeni, W. G. Covington, and R. E. Marteney. 1984. Resource Use by Stream-Dwelling Rock Bass and Smallmouth Bass. Transactions of the American Fisheries Society. 113:3, 283-294.

Radwan, S. and, B. Popiolek. 1989. Percentage of Rotifers in Spring Zooplankton in Lakes of Different Trophy. Hydrbiologia. 186-187:1, 235-238

Rogers, K. B., E. P. Bergersen. 1995. Effects of a Fall Drawndown on Movement of Adult Northern Pike and Largemouth Bass. North American Journal of Fisheries Management. 15:3, 596-600

Schallenberg, M., C. Burns. 2010. Phytoplankton Biomass and Productivity in two Oligotrohpic Lakes of Short Hydraulic Residence Time. New Zealand Journal of Marine and Freshwater Research. 31:1, 119-134.

Swingle, H. S. 1950. Relationships and Dynamics of Balanced and Unbalanced Fish Populations. Agricultural Experiment Station of the Alabama Polytechnic Institute. 274, 74pp.

Wahl, D. H., and R. A Stein. 1988. Selective Predation by three esocids: the Roll of Prey Behavior and Morphology. Transaction of the American Fishery Society. 117, 142-151.

Ward, A. J. W., M. W. Webster, P. J. B. Hart. Intraspecific Food Competition in Fishes. Fish and Fisheries. 7:4, 231-261.

WDFW. 2013. Fish Stocking Report for 2013. Washington Department of Fish and Wildlife, Region 6, Olympia, Washington.

Welker, M. T., C. L. Pierce, D.H. Wahl. 1994. Growth and Survival of Larval Fishes: Roles of Competition and Zooplankton Abundance. Transactions of the American Fisheries Society. 123:5, 703-171.

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