2000 Warmwater Fisheries Survey of Newman Lake, Spokane County, Washington

by

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Report No. FPT 04-02

March 2004

Acknowledgments

From the Washington Department of Fish and Wildlife (WDFW) we thank S. Jackson, J. Whalen, and C. Donley for reviewing this report and providing comments; Larry Phillips for his assistance with data collection; Teresa Nelson and Lucinda Morrow for aging scales; and Colleen Desselle for formatting the final report. Funding for this project was provided by the WDFW Warmwater Gamefish Enhancement Program.

Abstract

Newman Lake was surveyed by a 3-person investigation team September 18-20, 2000. Fish were sampled by boat electrofishing, gill netting, and fyke netting. Twelve fish species were collected. Yellow perch *Perca flavescens* (n=923), bluegill sunfish *Lepomis macrochirus* (n=237), and largemouth bass *Micropterus salmoides* (n=208) were the most abundant gamefish species observed during collection activities. A large proportion (39.5%) of the biomass was comprised of common carp *Cyprinus carpio.* Black crappie *Pomoxis nigromaculatus*, pumpkinseed sunfish *L. gibbosus*, yellow bullhead *Ameiurus natalis*, brown bullhead *A. nebulosus*, smallmouth bass *M. dolomieu*, tench *Tinca tinca*, tiger muskellunge *Esox lucius* x *E. masquinongy*, and rainbow trout *Oncorhynchus mykiss* were also collected. Newman Lake shows indications of having a prey-crowded fish community dominated by yellow perch and bluegill sunfish less than quality size. Although largemouth bass are also fairly abundant in the lake, most are small (<200 mm). The relatively low condition of bluegill sunfish, pumpkinseed sunfish, yellow perch, and smaller size largemouth bass indicates that largemouth bass are having to compete with their forage rather than prey upon them. The low stock density values and slow growth rates of yellow perch, bluegill sunfish, and pumpkinseed sunfish suggest that predation rates on those species by largemouth bass, smallmouth bass, and tiger muskellunge are insufficient to control stunting.

Due to measures taken by the Washington State Department of Ecology, including the operation of a hypolimnetic aerator and alum injection system by the Spokane County Division of Engineering and Roads, Newman Lake water quality has improved since the mid-1990s. Although late summer dissolved oxygen may drop below levels preferred by most fish species, the results of this survey suggest that those effects on fish populations in Newman Lake have been minimal, and water quality monitoring, the operation of the hypolimnetic aerator and alum injection system should continue. Future management considerations include increasing the annual stocking rate of tiger muskellunge, monitoring the response of fish populations to the recently imposed largemouth and smallmouth bass slot limit, conducting a creel survey to determine angler harvest and preferences, and determining what factors are limiting condition of adult black crappie in the lake. In addition, enhancement of the WDFW access site to include a boat dock and a fishing pier is recommended.

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Introduction

Newman Lake is located approximately 27 kilometers (km) east-northeast of Spokane, Washington, in Spokane County. Newman Lake has a surface area of approximately 486 hectares and has a maximum depth of about 9 meters (m) (Table 1). Newman Lake has one main, perennial inlet, Thompson Creek, as well as other smaller seasonal streams that flow into the north end of the lake (Figure 1). Because no natural outlet existed, one was constructed at the southeast end of the lake in the early 1900s and was used for log transportation. Later, a dam was erected in the outlet a short distance from the south shore, and the lake became impounded for irrigation use. In 1967, this practice ceased. In high runoff years, fish (including stocked fish) frequently escaped over and through the poorly kept outlet structure, ending up stranded in agricultural land, or in a sink area where they were eliminated by predation or lack of water. In the mid-1970s, a fish screen was installed to ensure the retention of fish stocked into the lake. The current goal of the Spokane County Division of Engineering and Roads is to maintain Newman Lake's water level at 2,125.6 feet of elevation during summer, and 2,123.9 feet of elevation during winter (Marianne Barrentine, Spokane County Division of Engineering and Roads, personal communication). Excess water from the outlet flows approximately three miles south into a natural depression. Recreational access at Newman Lake is available to the public at a Washington Department of Fish and Wildlife (WDFW) owned and maintained boat launch located on the southeast side of the lake. There is also a resort on the southeast shore and another on the southwest shore, which have boat launches that provide additional lake access. Recreational activities available at Newman Lake include fishing, swimming, water skiing, hiking, and camping. Newman Lake is open year-round under state fishing regulations with ice fishing available in the winter.

Newman Lake was first extensively studied in 1974 (Funk et al. 1976). This study showed that the lake was rich in dissolved nutrients, evidenced by large blue-green algae blooms, and had poor water quality conditions, including near anoxic conditions near the bottom of the lake by late summer. In 1985-86, as part of Phase I of the Clean Lakes Restoration Project (United States Environmental Protection Agency 2000), Newman Lake was surveyed again and was found to have conditions similar to those that existed in 1974, as well as problems with turbidity and poor transparency (Thomas et al. 1994). In addition, Funk and Moore (1988) reported that about half of the nutrients in Newman Lake were from external sources and half were from internal cycling. By 1995, as part of Phase II of the Clean Lakes Restoration Project, several measures had been implemented to control these problems. Methods used to help control nutrient input included stream bank fencing, septic system management, ordinance development, and public education. In 1992, a hypolimnetic aerator was installed to increase the dissolved oxygen concentration (Doke et al. 1995). In 1997, an alum injection system was installed in conjunction with the aerator (Moore et al. 1998). Alum, or aluminum sulfate, is used to reduce the amount of phosphorous in the water and, in turn, control algae which relies on phosphorous to live and grow (Goldman and Horne 1983).

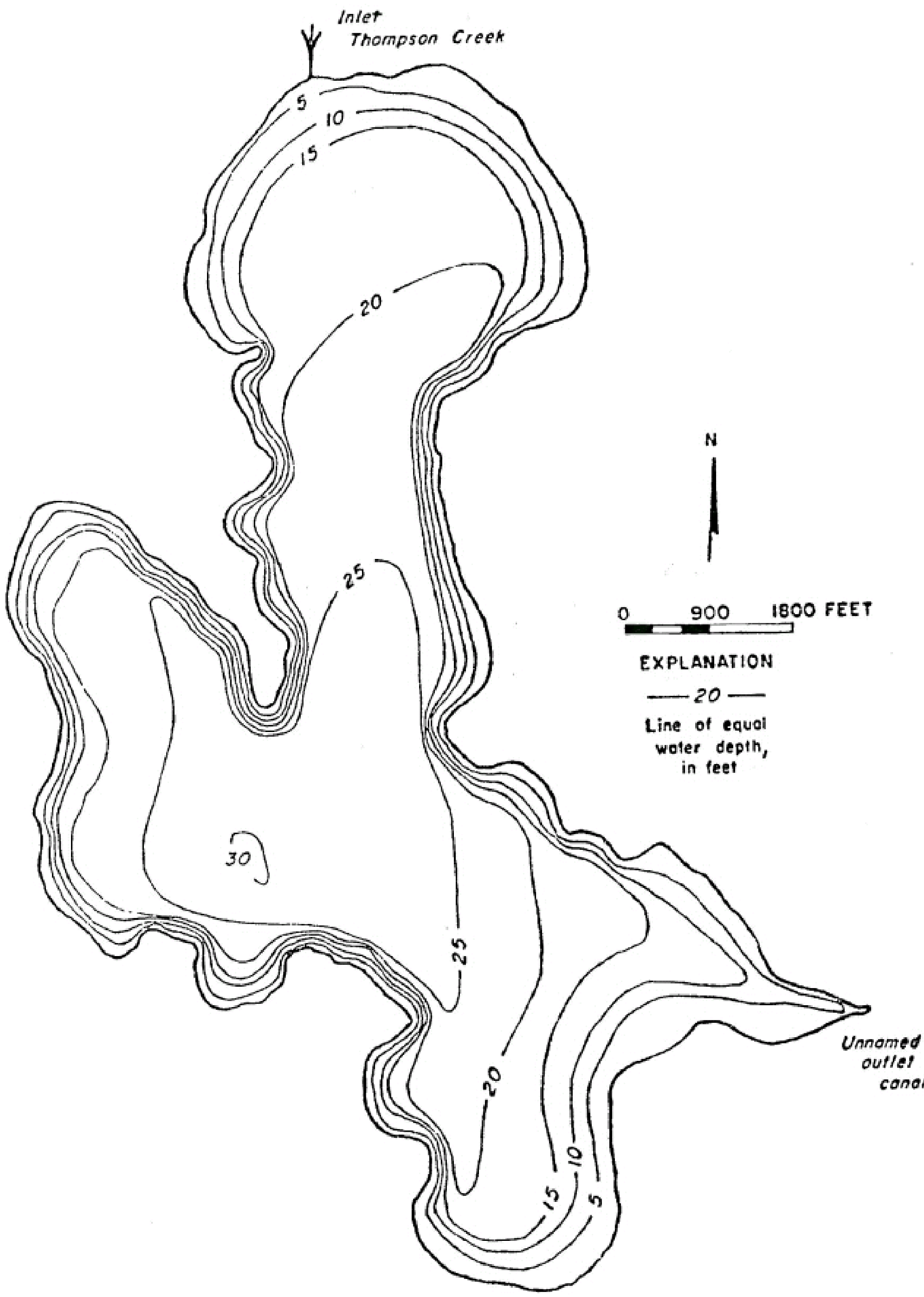

Figure 1. Bathymetric map of Newman Lake, Spokane County, Washington.

Table 1. Physical parameters of Newman Lake, Spokane County (Washington State Department of Game 1951).

Physical Parameters	Newman Lake (Spokane County)
Surface Area (ha)	486.0
Shoreline Length (km)	15.6
Maximum Depth (meters)	9.1
Mean Depth (meters)	5.8
Volume (m^3)	28,370,500.0
Shoreline Development (D_L)	2.0

In the late 1800s, Newman Lake supported a commercial lake whitefish *Coregonus clupeaformis* fishery due to the abundance of this species in the lake. In the 1890s, carp *Cyprinus carpio* became established in the lake from unknown sources. Spiny-rayed fish were also introduced during that time, but soon became stunted due to overcrowding. Since the late 1940s, Newman Lake has been managed primarily as a trout fishery. In 1948, an annual stocking of rainbow trout *Oncorhynchus mykiss* fingerlings began. In the 1960s, up to 100,000 rainbow fingerlings were planted annually. In the 1970s, stocking of these fingerlings decreased to approximately 65,000 annually, and eventually halted due to extensive fish loss through the outlet structure. Stocking resumed once a new structure and fish screens were installed. Currently, annual rainbow trout stocking is much lower than in earlier decades. In 1999, only 10,000 catchable rainbow trout were stocked (WDFW 1999). In 2000 and 2001, Newman Lake was selected to receive 10,000 catchable rainbow trout as well as 3,000 triploid rainbow trout in 2000 and 3,750 triploid rainbow trout in 2001 (WDFW 2000, WDFW 2001). Triploid rainbow trout are sterile and channel energy into growth rather than reproduction, which allows them to potentially reach large sizes. Triploid trout are stocked weighing an average of 1.5 pounds and have the potential to reach trophy size if not harvested soon after stocking.

In 1992, regional fisheries biologists chose Newman Lake for tiger muskellunge *Esox lucius* x *E. masquinongy* stocking in order to enhance fishing opportunity and diversity, to help control overcrowding of abundant panfish species, and to limit the amount of non-game fish within the lake. The initial stocking occurred during the fall of 1992 with 679 tiger muskellunge (Table 2). As of 2000, a total of 6,478 tiger muskellunge have been stocked in Newman Lake.

Table 2. Tiger muskellunge stocked in Newman Lake, Spokane County, Washington since 1992.

Year	Number	Size (inches)
1992	679	7-9
1994	2,250	12
1994	200	14
1995	955	8-9
1997	1,000	13
1998	500	13-14
1999	400	13-14
2000	400	12-16
2000	94	18

Under current statewide WDFW angling regulations, the following rules apply on Newman Lake: largemouth bass *Micropterus salmoides* and smallmouth bass *M. dolomieu* anglers may retain bass less than 12 inches or greater than 17 inches, with no more than one over 17 inches (daily bag limit of 5 fish); only tiger muskellunge over 36 inches may be kept (daily limit of 1 fish); a combination of five trout (no minimum length) may be retained. There is no minimum length or bag limit on black crappie *Pomoxis nigromaculatus*, bluegill sunfish *Lepomis macrochirus*, pumpkinseed sunfish *L. gibbosus*, yellow perch *Perca flavescens*, brown bullhead *Ameiurus nebulosus*, yellow bullhead *A. natalis*, carp, or tench *Tinca tinca*.

Newman Lake was identified by regional fisheries biologists as a body of water to be surveyed under the Warmwater Fish Enhancement Program. To evaluate warmwater fish populations, and to identify ways to improve the quality of fishing, personnel from the WDFW Warmwater Enhancement Program conducted a fisheries survey on Newman Lake during September 2000. This report is intended to assist regional fisheries biologists in identifying management options which could improve the quality of warmwater angling in Newman Lake.

Materials and Methods

Newman Lake was surveyed by a 3-person team on September 18 - 20, 2000. All fish were collected using a boat electrofisher, gill nets, and fyke nets. The electrofishing unit consisted of a Smith-Root GPP electrofishing boat, using a DC current of 120 cycles/sec at 3 to 4 amps power. Experimental gill nets (45.7 m x 2.4 m) consisted of variable size [13, 19, 25, and 51 millimeter (mm) stretched] monofilament mesh. Fyke nets were constructed of a main trap (4.7 m long and 1.2 m in diameter with five aluminum hoops), a single 30.3 m lead, and two 15.2 m wings. All netting material was constructed of 6.35 mm nylon mesh.

Sampling locations were selected by dividing the shoreline into 400 m sections determined from a map. The number of randomly selected sampling locations were as follows: electrofishing - 12, gill netting - 8, and fyke netting - 8. Electrofishing occurred in shallow water (depth range: 0.2 - 1.5 m), adjacent to the shoreline at a rate of approximately 18.3 m/minute for 600 second intervals (Bonar et al. 2000). Gill nets were set perpendicular to the shoreline with the small-mesh end attached on or near the shore, and the large-mesh end anchored offshore. Fyke nets were set perpendicular to the shoreline with the wings extended at 70^{o} angles from the lead. Gill nets and fyke nets were set overnight prior to electrofishing and were pulled the following morning (1 net night each). All sampling was conducted during night-time hours when fish are most numerous along the shoreline, thus maximizing the efficiency of each gear type. Sampling at night can be more effective because some fish species seek shelter during the day and move freely at night (Helfman 1983).

All fish were identified to species, measured in millimeters to total length (TL), and weighed to the nearest gram (g). Total length data were used to construct length-frequency histograms and to evaluate the size structure of the warmwater gamefish. Scales were collected from largemouth bass, smallmouth bass, tiger muskellunge, pumpkinseed sunfish, black crappie, bluegill sunfish, and yellow perch to analyze age and growth. The above species were assigned to a 10 mm size group based on total length, and scale samples were collected from five fish in each size group (Bonar et al. 2000). Scale samples were mounted on adhesive data cards, pressed onto acetate slides using a Carver® laboratory press, and aged according to Jearld (1983) and Fletcher et al. (1993).

Water chemistry data were collected from the area of greatest depth on three separate occasions. The first on June 27, 2000 (1015 hours), the second on July 28, 2000 (1246 hours), and the third on August 24, 2000 (1123 hours). A Hydrolab® probe and digital recorder was used to collect information on dissolved oxygen (milligrams per liter)(mg/l), temperature (degrees Celsius)(EC), pH, conductivity (micro-siemens per centimeter)(FS/cm), and turbidity (nephelometric turbidity units)(NTU). Water clarity was measured using a Secchi disc.

Species composition, by weight (kg) and number, was determined from fish captured. Fish less than one year old, i.e., young-of-the-year, were excluded from all analyses. Including young-of-the-year fish in the calculation of species composition can give a false impression of year class strength due to the abundance of small fish, which can suffer extensive mortality during the first winter (Chew 1974). In addition, eliminating young-of-the-year fish prevents distortions in analyses that may have occurred due to sampling location, method, and specific timing of hatches (Fletcher et al. 1993).

Catch per unit effort (CPUE) of each sampling gear was determined for each warmwater fish species collected. The CPUE of electrofishing was determined by dividing the number of fish captured by the total amount of time that was electrofished. Similarly, CPUE of gill netting and fyke netting was determined by dividing the number of fish captured by the total time the nets were deployed. Standardized CPUE allows for comparisons of catch rates between different lakes or sampling dates on the same water.

Relative weight (W_r) was used to evaluate the condition of fish in Newman Lake. As presented by Anderson and Neumann (1996), a W_r of 100 generally indicates that the fish is in a condition similar to the national average for that species and length. The index is defined as $W_r = W/W_s \times 100$, where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same total length (mm). Standard weight (W_s) was derived from a standard weight-length ($\log_{10}$) relationship which was defined for each species of interest (Anderson and Neumann 1996, Bister et al. 2000). Minimum lengths were used for each species as the variability can be significant for young-of-the-year fish. Relative weights less than 50 were also excluded from our analyses as we suspected unreliable weight measurements.

Age and growth of warmwater gamefish in Newman Lake were evaluated using procedures described by Fletcher et al. (1993). All samples were evaluated using both the direct proportion method (Fletcher et al.1993) and Lee's modification of the direct proportion method (Carlander 1982). Mean back-calculated lengths-at-age for all warmwater gamefish species were then compared to those of Eastern Washington and/or statewide averages (Fletcher et al.1993).

The proportional stock density (PSD) of each warmwater gamefish species was determined following procedures outlined in Anderson and Neumann (1996). Proportional stock density uses two measurements, stock length and quality length, to provide useful information about the proportion of various size fish in a population. Stock length is defined as the minimum size of a fish which provides recreational value or the approximate length when fish reach maturity (Table 3). Quality length is defined as the minimum size of a fish that most anglers like to catch or begin keeping. PSD is calculated using the number of quality size fish, divided by the number of stock size fish, multiplied by 100. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Stock length was 20-26 percent of world record length, whereas quality length was 36-41 percent of world record length.
Relative stock density (RSD) of each warmwater gamefish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality lengths, the Gabelhouse model adds preferred, memorable, and trophy categories (Table 3). Preferred length

(RSD-P) is defined as the minimum size of fish anglers would prefer to catch. Memorable length (RSD-M) refers to the minimum size fish anglers remember catching and trophy length (RSD-T) refers to the minimum size fish worthy of acknowledgment. Preferred, memorable, and trophy length fish were also based on percentages of world record lengths. Preferred length is 45-55 percent of world record length, memorable length is 59-64 percent of world record length, and trophy length is 74-80 percent of world record length. Relative stock density differs from PSD in that it is more sensitive to changes in year-class strength. Relative stock density is 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 PSDs and RSDs are provided as an estimate of statistical precision and were calculated using normal approximation (Conover 1980; Gustafson 1988).

Table 3. Minimum total length (mm) categories of warmwater fish species used to calculate PSD and RSD values (Anderson and Neumann 1996; Bister et al. 2000). Numbers in parenthesis represent percentages of world record lengths (Gabelhouse 1984).

	Standard Length Categories				
Species	**Stock (20-26%)**	**Quality (36-41%)**	**Preferred (45-55%)**	**Memorable (59-64%)**	**Trophy (74-80%)**
Black Crappie	130	200	250	300	380
Bluegill	80	150	200	250	300
Brown Bullhead	130	200	280	360	430
Largemouth Bass	200	300	380	510	630
Pumpkinseed	80	150	200	250	300
Smallmouth Bass	180	280	350	430	510
Yellow Bullhead	100	180	230	280	360
Yellow Perch	130	200	250	300	380

Results

Water Chemistry

Water chemistry data were collected on June 27 (1015 hours), July 28 (1246 hours), and August 24 (1123 hours), 2000. However, data from June were omitted because of equipment failure and/or unreliable readings. Overall, water temperatures and pH were higher in July than what was observed in August (Table 4). Water temperatures appeared more favorable for warmwater species than for salmonids. During August, pH was within the desired range of 6.5 to 9 for warmwater gamefish at all depths but was slightly higher than that range at most depths during July. Newman Lake was stratified between 2 and 4 meters in both July and August in terms of temperature and dissolved oxygen (Table 4). Despite favorable water temperatures, low dissolved oxygen levels restricted all fish species to the upper 2-3 meters of the lake during these months. Moore et al. (2001) reported that the low dissolved oxygen levels observed in the latter half of 2000 were a direct result of hypolimnetic oxygen demand and the breakdown of the aerator in July of that year. Trout may be more affected by these conditions than would warmwater species. Warmwater species are generally associated with the shallow littoral areas of a lake, which may remain oxygenated throughout the year due to wave action. Trout tend to inhabit the deeper, pelagic areas of the lake, which are subject to stratification and low oxygen conditions. Algal blooms may be responsible for the relatively low Secchi disk readings. Funk and Moore (1988) reported that low hypolimnetic dissolved oxygen concentrations in summer promote the release of large quantities of phosphorus from bottom sediments in Newman Lake and often results in algal blooms in mid to late summer.

Table 4. Water chemistry data collected from Newman Lake (Spokane County) on July 28 (1246 hours), and August 24, 2000 (1123 hours).

Date	Depth	Temp (ºC)	pH	DO (mg/l)	TDS	Conductivity	Secchi (m)
07/28/00	0	25.0	10.4	10.1	0.035	54.5	1.0
	2	22.6	9.9	7.3			
	4	19.7	9.4	1.2			
	6	16.9	9.1	0.4			
	7	16.0	8.7	0.3	0.036	57.1	
08/24/00	0	21.7	8.7	7.1	0.028	44.2	1.5
	2	20.8	8.5	5.3			
	4	19.7	8.5	2.2			
	6	17.5	8.5	0.4			
	7.3	16.7	9.1	0.4	0.039	60.9	

Species Composition

A total of twelve fish species were observed in September 2000 (Table 5). Warmwater gamefish comprised approximately 97 percent of the total fish captured. Yellow perch were the most abundant species (52.4%) encountered in the samples and contributed the second-highest proportion of biomass (13.1%). Although carp represented only 2 percent of the total number of fish sampled, they contributed more than three times the biomass (39.5%) of yellow perch. Rainbow trout were observed in low numbers, which may have been a result of sampling methods. Sampling methods were directed toward warmwater fish populations, which typically occupy littoral habitat. Our samples may under represent species, such as rainbow trout, that typically occupy pelagic habitat in the lake.

Table 5. Species composition (excluding young-of-the-year) by weight (kg) and by number of fish collected from Newman Lake (Spokane County), September 2000.

	Species Composition					
	Weight		Number		Size Range (mm TL)	
Species	**kg**	**%**	**No.**	**%**	**Min.**	**Max.**
Carp	98.23	39.5	36	2.0	497	700
Yellow Perch	32.57	13.1	923	52.4	68	235
Tiger Muskellunge	27.92	11.2	11	0.6	485	889
Largemouth Bass	26.67	10.7	208	11.8	68	528
Black Crappie	14.50	5.8	103	5.8	116	319
Brown Bullhead	14.02	5.6	46	2.6	204	343
Yellow Bullhead	10.53	4.2	54	3.1	135	380
Bluegill	9.31	3.7	237	13.4	57	186
Tench	5.97	2.4	13	0.7	292	352
Smallmouth Bass	3.43	1.4	37	2.1	77	370
Pumpkinseed	3.14	1.3	94	5.3	66	140
Rainbow Trout	2.62	1.1	4	0.2	333	446

Catch Per Unit Effort (CPUE)

With the exception of brown bullhead and yellow bullhead, electrofishing captured more fish (stock length fish or larger) than did gill nets or fyke nets (Table 6). Catch rates of yellow perch were higher than any other species sampled by electrofishing, gill netting, or fyke netting. Brown bullhead and yellow bullhead were captured more effectively with fyke nets. Electrofishing catch rates for largemouth bass and yellow perch increased substantially when all fish (excluding young-of-the-year) were analyzed for CPUE (Table 7) compared to the analysis of only stock length fish (Table 6), indicating a high abundance of Age-1 largemouth bass and yellow perch in the population.

For some species, small sample size and broad confidence intervals limit the interpretation of CPUE data. However, for other species with larger sample sizes, data becomes easier to interpret. As the number of lakes sampled under the Warmwater Enhancement Program increases, this information will be valuable for comparison. Catch per unit effort data collected from Newman Lake in 2000 provides baseline information that can be used to monitor the effectiveness of future management techniques and/or fish population trends in the lake.

Table 6. Mean catch per unit effort (CPUE) by sampling method, including 80 percent confidence intervals, for stock length fish collected from Newman Lake (Spokane County) in September 2000.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
Species	**No./hour**	**No. Sites**	**No./Net Night**	**Net Nights**	**No./Night**	**Net Nights**
Brown Bullhead	2.50 ± 2.00	12	0.63 ± 0.34	8	4.50 ± 3.32	8
Black Crappie	32.00 ± 10.85	12	1.38 ± 0.42	8	2.50 ± 1.71	8
Bluegill	100.00 ± 37.84	12	3.50 ± 1.51	8	0.88 ± 0.95	8
Carp	10.00 ± 3.83	12	2.00 ± 0.73	8	0.00	8
Largemouth Bass	23.00 ± 5.08	12	0.13 ± 0.16	8	0.25 ± 0.32	8
Pumpkinseed	27.00 ± 8.22	12	1.50 ± 0.59	8	2.75 ± 2.18	8
Rainbow Trout	1.00 ± 0.86	12	0.25 ± 0.21	8	0.00	8
Smallmouth Bass	5.50 ± 3.06	12	0.13 ± 0.16	8	0.00	8
Tiger Muskellunge	4.50 ± 2.14	12	0.25 ± 0.21	8	0.00	8
Tench	3.00 ± 1.50	12	0.00	8	0.88 ± 0.61	8
Yellow Bullhead	0.00	12	3.25 ± 1.56	8	3.50 ± 2.66	8
Yellow Perch	261.50 ± 111.10	12	10.25 ± 5.20	8	13.63 ± 15.67	8

Table 7. Mean catch per unit effort (CPUE) by sampling method, including 80 percent confidence intervals, for all fish (excluding young-of-the-year) collected from Newman Lake (Spokane County) in September 2000.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
Species	No./hour	No. Sites	No./Net Night	Net Nights	No./Night	Net Nights
Brown Bullhead	2.50 ± 2.00	12	0.63 ± 0.34	8	4.50 ± 3.32	8
Black Crappie	35.50 ± 10.93	12	1.50 ± 0.42	8	2.50 ± 1.71	8
Bluegill	101.00 ± 37.63	12	3.50 ± 1.51	8	0.88 ± 0.95	8
Carp	10.00 ± 3.83	12	2.00 ± 0.73	8	0.00	8
Largemouth Bass	86.00 ± 18.29	12	1.63 ± 0.72	8	3.00 ± 2.61	8
Pumpkinseed	29.00 ± 8.61	12	1.50 ± 0.59	8	3.00 ± 2.11	8
Rainbow Trout	1.00 ± 0.86	12	0.25 ± 0.21	8	0.00	8
Smallmouth Bass	18.50 ± 16.27	12	0.13 ± 0.16	8	0.00	8
Tiger Muskellunge	4.50 ± 2.14	12	0.25 ± 0.21	8	0.00	8
Tench	3.00 ± 1.50	12	0.00	8	0.88 ± 0.61	8
Yellow Bullhead	0.00	12	3.25 ± 1.56	8	3.50 ± 2.66	8
Yellow Perch	362.00 ± 138.25	12	10.50 ± 5.30	8	14.38 ± 15.95	8

Stock Density Indices

Sample sizes of stock-length fish were adequate for evaluating stock density indices for black crappie and bluegill captured by electrofishing, and yellow perch captured by gill netting (Table 8). Bonar et al. (2000) reported that a minimum sample size of 55 stock length fish is required for a sound PSD estimate. Although the sample size of stock-length largemouth bass and pumpkinseed were lower than desired, PSD analyses may provide some insight into the size structure of these species in Newman Lake.

The PSD for black crappie captured by electrofishing was 58 (± 8). Of the 64 stock-length or larger black crappie collected by electrofishing, only a small proportion (2±2) were larger than quality size (200 mm)(Table 8). This may be due to the overall slow growth rates of black crappie in Washington State (Phillips and Divens 2000) and/or angler harvest. The low PSD of yellow perch, bluegill, and pumpkinseed suggests that these populations are dominated by small individuals and that recruitment of these species to quality size or larger is low. The PSD of largemouth bass captured by electrofishing was 30 (±9). Largemouth bass were represented in all RSD categories except RSD-T (Trophy); however, the broad confidence intervals limit the interpretation of these analyses.

Table 8. Traditional stock density indices, including 80% confidence intervals, of fish collected from Newman Lake (Spokane County) in September, 2000.

Species	# Stock Length L	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Black Crappie	64	58 ± 8	2 ± 2	0	0
Bluegill	200	14 ± 3	0	0	0
Largemouth Bass	46	30 ± 9	13 ± 6	2 ± 3	0
Pumpkinseed	54	0	0	0	0
Smallmouth Bass	11	36 ± 19	27 ± 17	0	0
Yellow Perch	523	0	0	0	0
		Gill Netting			
Black Crappie	11	36 ± 19	27 ± 17	27 ± 17	0
Bluegill	28	0	0	0	0
Pumpkinseed	12	0	0	0	0
Yellow Perch	82	4 ± 3	0	0	0
		Fyke Netting			
Black Crappie	20	70 ± 13	25 ± 12	5 ± 6	0
Pumpkinseed	22	0	0	0	0
Yellow Perch	109	0	0	0	0

Largemouth Bass

Largemouth bass sampled from Newman Lake ranged in length from 68 to 528 mm (Table 5; Figure 2). The age of largemouth bass sampled ranged from one to eleven years (Table 9). Largemouth bass year-class strength appeared variable (Table 9; Figure 2). This may have been an artifact of limited sampling as few fish older than 4 years of age were observed (Table 9). Growth rates of largemouth bass sampled in Newman Lake were lower than largemouth bass populations sampled in other Washington lakes (Fletcher et al.1993) at ages one to four and age 10, but were higher at all other ages (Table 9). Condition of largemouth bass was at or below the national average for fish less than 250 mm, while most fish greater than 325 mm were at or above the national average (Figure 3). Slow growth and low condition of largemouth bass less than quality length may be a result of interspecific competition for food and/or space. Largemouth bass larger than quality size likely have adequate forage in this fish community, whereas the smaller bass are forced to compete with the highly abundant yellow perch, bluegill, and pumpkinseed for available resources.

Table 9. Baclk-calculated mean length at age (mm) of largemouth bass collected at Newman Lake (Spokane County) during September 2000. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). 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**	**7**	**8**	**9**	**10**	**11**
1999	28	56										
		68										
1998	18	49	117									
		65	126									
1997	5	42	192	298								
		59	201	301								
1996	2	55	143	284	339							
		72	156	289	341							
1995	2	55	111	153	296	353						
		72	126	165	301	355						
1994	1	39	88	180	304	338	357					
		56	104	190	307	340	357					
1993	0	--	--	--	--	--	--	--				
		--	--	--	--	--	--	--				
1992	1	57	92	154	220	321	375	396	416			
		75	107	167	230	326	378	398	417			
1991	0	--	--	--	--	--	--	--	--	--		
		--	--	--	--	--	--	--	--	--		
1990	2	58	112	148	184	307	372	402	429	451	473	
		76	127	162	197	314	376	406	431	453	473	
1989	2	39	93	153	213	291	350	405	437	459	477	493
		57	110	166	224	300	356	409	440	461	478	493
Overall Mean		50	119	196	259	322	363	401	427	455	475	493
Weighted Mean		67	137	228	266	326	367	406	432	457	476	493
WA State Average		60	146	222	261	289	319	368	396	440	485	472

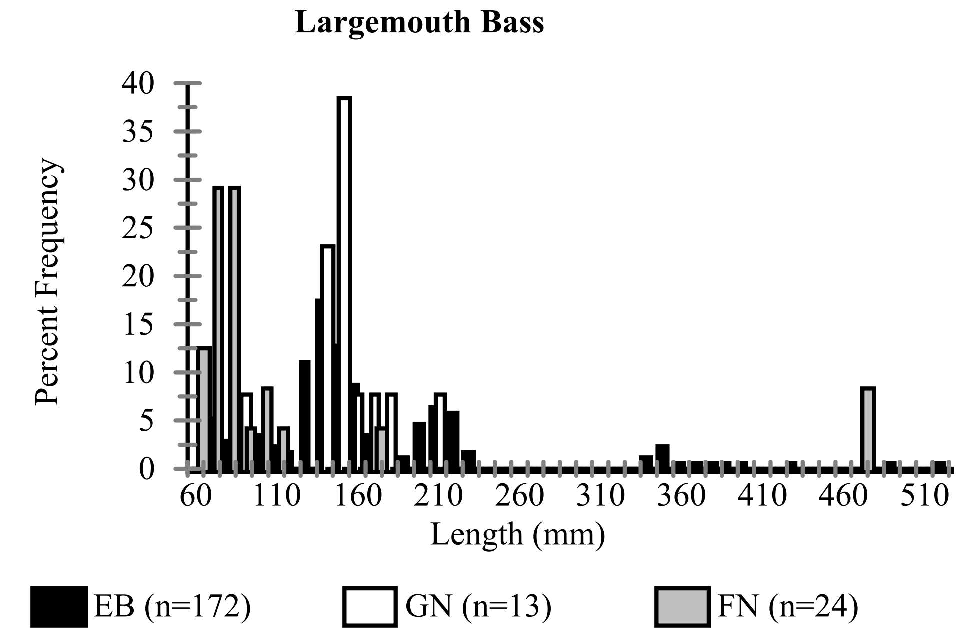

Figure 2. Length frequency distribution of largemouth bass, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

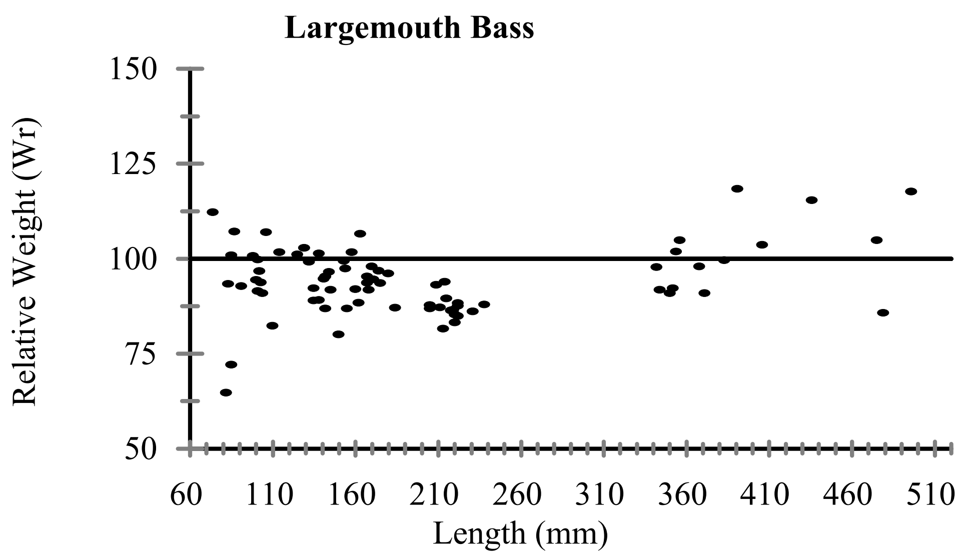

Figure 3. Relative weights of largemouth bass (n=79), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Smallmouth Bass

Smallmouth bass collected from Newman Lake ranged in length from 77 to 370 mm (Table 5; Figure 4). The age of smallmouth bass sampled ranged from one to four years (Table 10) and showed variable year-class strength (Table 10; Figure 4). When compared to other smallmouth bass populations sampled in Washington lakes (Fletcher et al. 1993), Newman Lake smallmouth bass growth rates were slower than average for fish ages one to three (Table 10). Growth of the single age four smallmouth bass sampled was higher than the Washington State average (Table 10). Overall, condition of smallmouth bass is lower than the national average (Figure 5), and when matched with slow growth rates, could indicate inter- and/or intraspecific competition for available food resources.

Table 10. Baclk-calculated mean length at age (mm) of smallmouth bass collected at Newman Lake (Spokane County) during September 2000. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). 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**
1999	17	47			
		69			
1998	14	56	104		
		81	120		
1997	1	41	142	207	
		72	161	218	
1996	1	46	89	199	288
		77	115	214	294
Overall Mean		48	112	203	288
Weighted Mean		74	122	216	294
Direct Proportion State Average		70	146	212	268

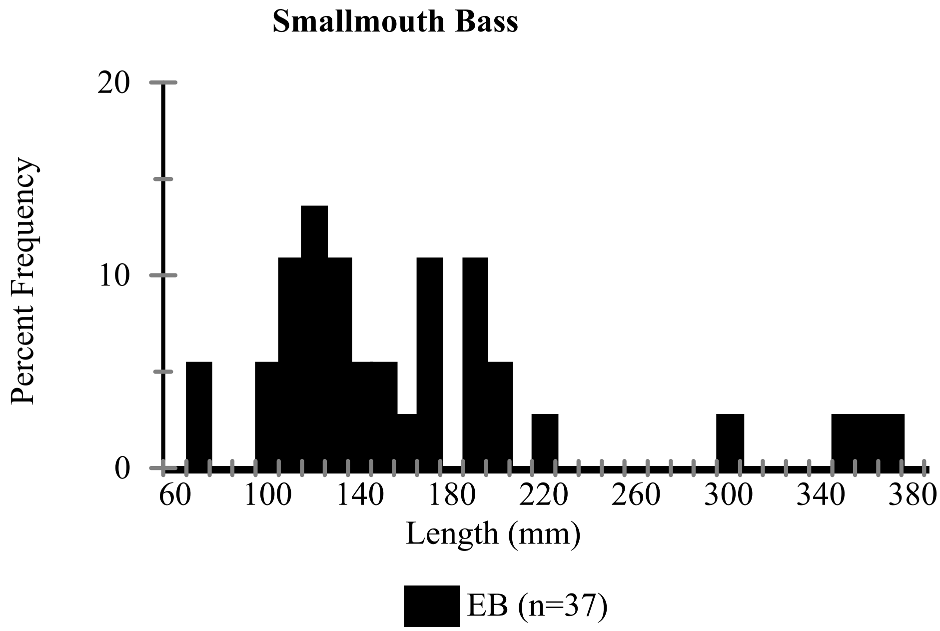

Figure 4. Length frequency distribution of smallmouth bass, excluding young-of-the-year, sampled by electrofishing (EB) at Newman Lake (Spokane County) during September 2000.

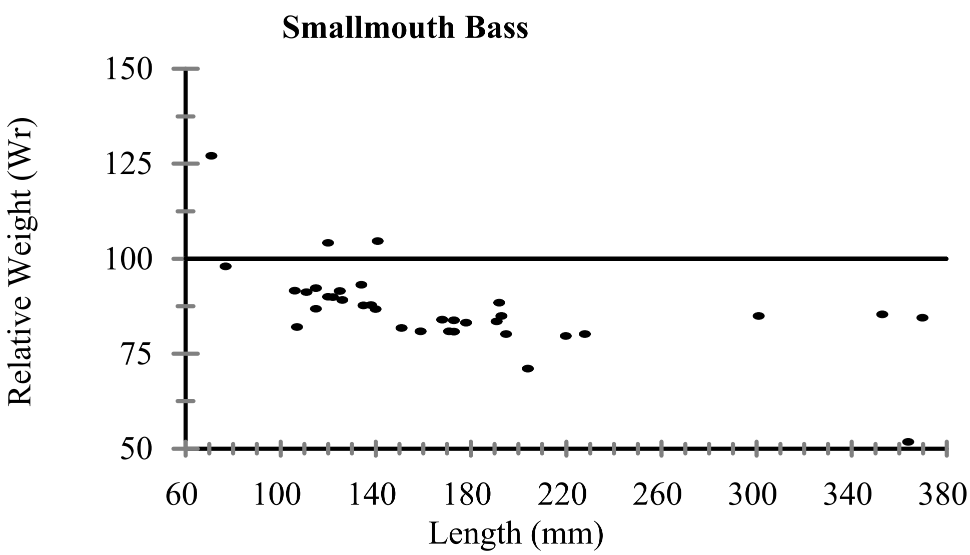

Figure 5. Relative weights of smallmouth bass (n=37), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Yellow Perch

Yellow perch sampled in Newman Lake ranged in length from 68 to 235 mm (Table 5; Figure 6). The age of yellow perch sampled ranged from one to five years (Table 11) and showed variable year-class strength. The 1996 and 1997 year-classes were the strongest of the five year classes observed (Table 11). When compared to other yellow perch populations sampled in Washington lakes, Newman Lake yellow perch growth rates were slower than average for all ages collected (Fletcher et al. 1993; Table 11). Overall, condition of yellow perch was at or below the national average (Figure 7). The lack of quality size (≥ 200 mm) yellow perch, slow growth, and low condition, indicates extensive inter- and/or intra-specific competition for available resources. Fish exhibiting relative weights below 85 are typically underweight and may indicate that the population is overcrowded (Flickinger and Bulow 1993).

Table 11. Baclk-calculated mean length at age (mm) of yellow perch collected at Newman Lake (Spokane County) during September 2000. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). 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**
1999	0	--				
		--				
1998	1	50	86			
		65	91			
1997	21	45	102	129		
		66	111	133		
1996	25	46	95	120	143	
		68	108	128	146	
1995	2	58	109	138	156	177
		79	122	146	161	179
Overall Mean		50	98	129	149	177
Weighted Mean		67	109	131	147	179
Direct Proportion State Average		60	120	152	193	206

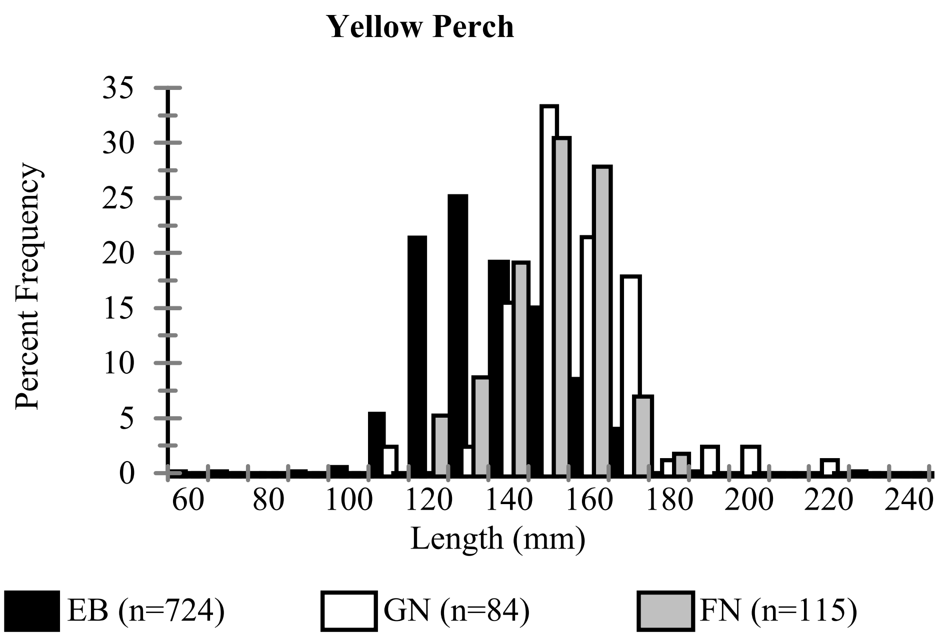

Figure 6. Length frequency distribution of yellow perch, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

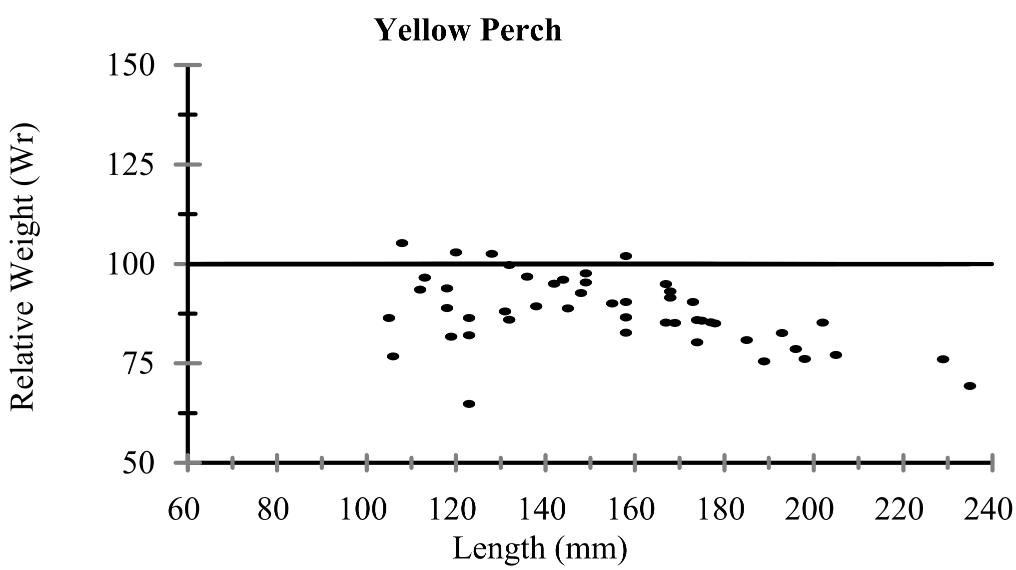

Figure 7. Relative weights of yellow perch (n=50), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Black Crappie

Black crappie sampled from Newman Lake ranged in length from 116 to 319 mm (Table 5; Figure 8). The age of black crappie sampled ranged from one to eight years and showed variable year-class strength (Table 12; Figure 8). Although the 1998 and 1999 year-classes were well represented in the sample, sample sizes of fish representing the 1992-1997 year-classes were low (Table 12). With the exception of age one and age two fish, growth rates of Newman Lake black crappie were higher than other black crappie populations sampled in Washington lakes (Fletcher et al.1993)(Table 12). Black crappie condition was at or above the national average for fish less than 225 mm but appeared to decrease as fish became larger (Figure 9), which may indicate that inter- or intraspecific competition increases with size and age.

Table 12. Baclk-calculated mean length at age (mm) of black crappie collected at Newman Lake (Spokane County) during September 2000. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). 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**	**7**	**8**
1999	8	35							
		60							
1998	23	33	107						
		62	123						
1997	1	32	101	180					
		62	121	189					
1996	2	37	102	198	243				
		67	124	208	247				
1995	2	40	118	182	239	280			
		70	139	196	246	282			
1994	3	40	120	179	211	248	268		
		70	140	193	221	254	271		
1993	1	31	79	153	195	226	276	299	
		63	105	171	209	236	281	301	
1992	1	27	81	162	199	229	242	256	272
		59	106	177	209	236	247	259	274
Overall Mean		34	101	176	217	246	262	277	272
Weighted Mean		63	125	192	230	257	268	280	274
Direct Proportion State Average		46	111	157	183	220	NA	NA	NA

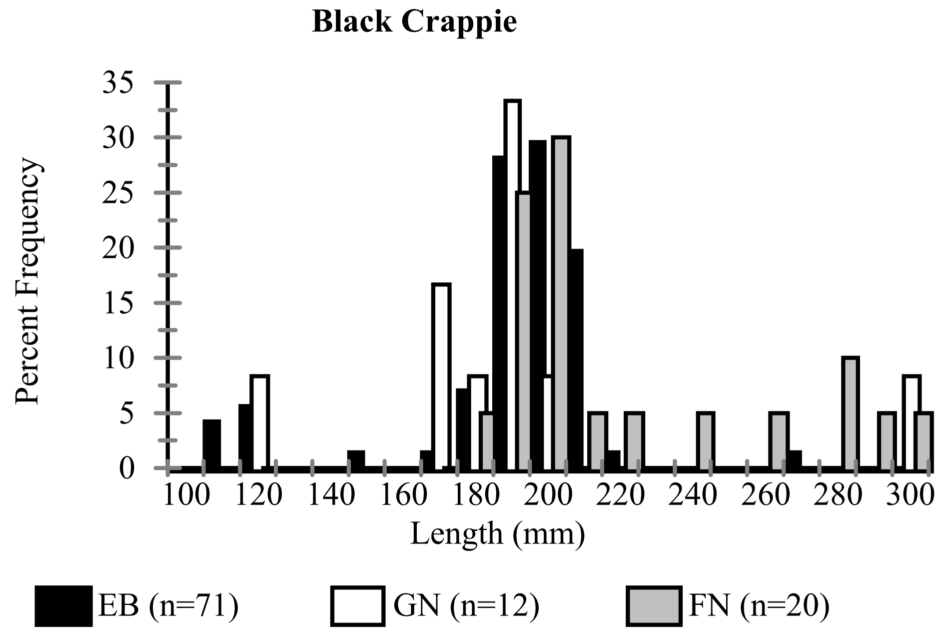

Figure 8. Length frequency distribution of black crappie, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

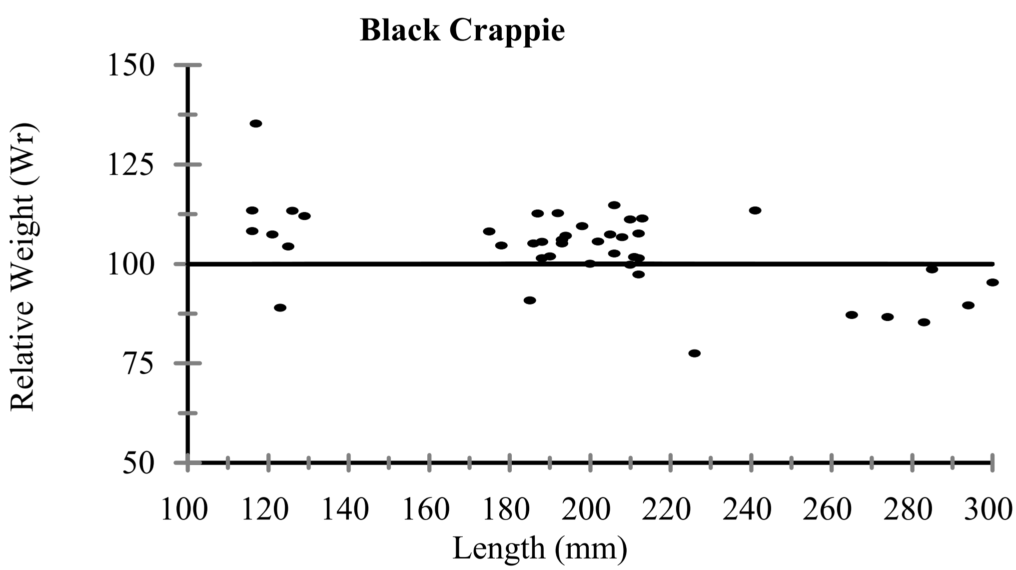

Figure 9. Relative weights of black crappie (n=46), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Bluegill Sunfish

Bluegill sunfish sampled from Newman Lake ranged in length from 57 to 186 mm (Table 5; Figure 10). The age of bluegill sunfish sampled ranged from one to five years and showed variable year-class strength (Table 13). Growth rates of bluegill sunfish sampled in Newman Lake were lower than bluegill sunfish populations sampled in other Washington lakes (Fletcher et al. 1993) at all ages observed (Table 13). Although the condition of bluegill sunfish varied greatly (i.e., W_r 55-130), most had relative weights near the national average and condition appeared to increase with length and age (Figure 11).

Table 13. Baclk-calculated mean length at age (mm) of bluegill sunfish collected at Newman Lake (Spokane County) during September 2000. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). 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**
1999	1	20				
		34				
1998	23	17	56			
		34	66			
1997	3	18	60	115		
		35	71	119		
1996	12	15	53	120	139	
		33	66	124	141	
1995	2	13	53	99	120	138
		31	66	106	124	139
Overall Mean		17	55	111	130	138
Weighted Mean		34	66	121	138	139
Direct Proportion State Average		37	97	132	148	170

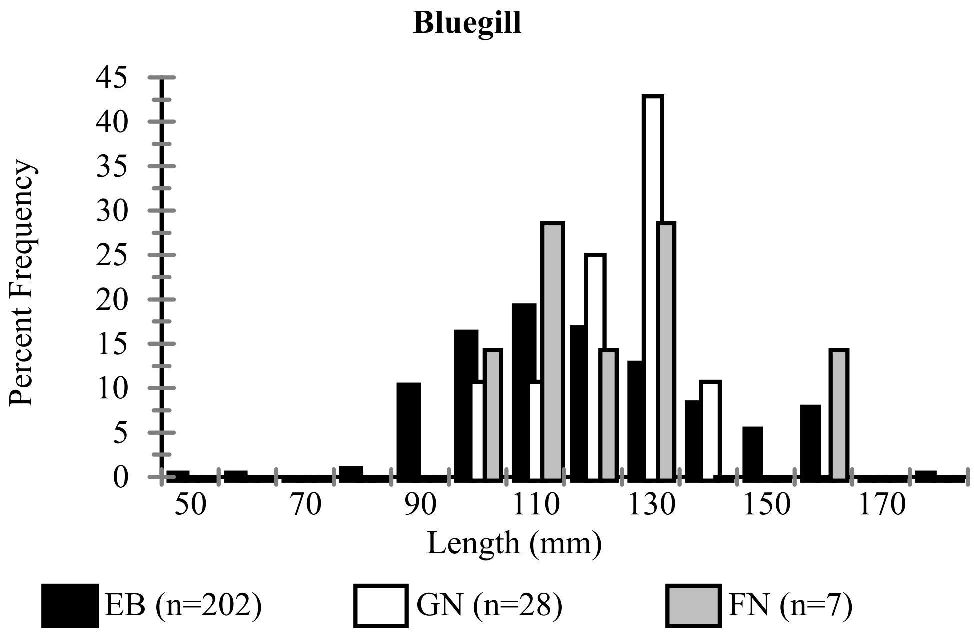

Figure 10. Length frequency distribution of bluegill sunfish, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

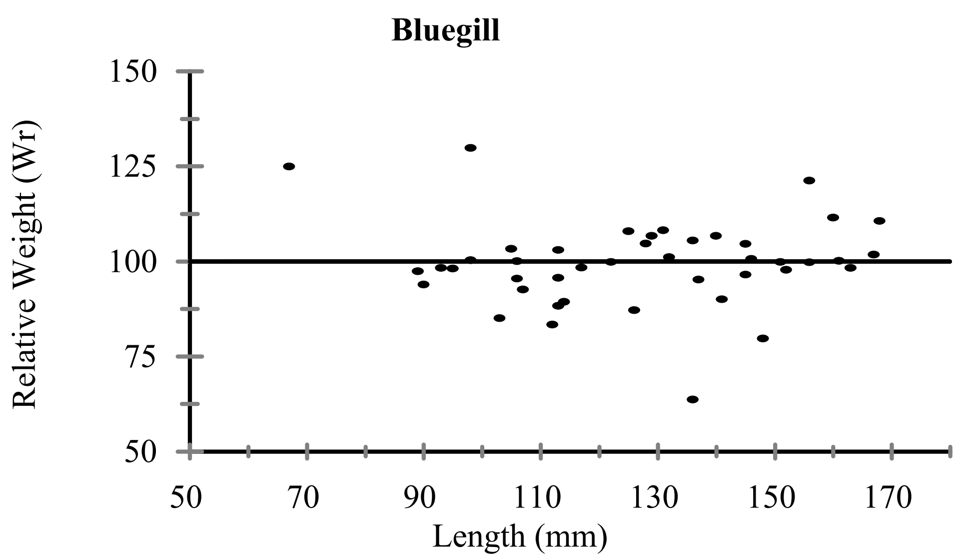

Figure 11. Relative weights of bluegill sunfish (n=44), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Pumpkinseed Sunfish

Pumpkinseed sunfish sampled from Newman Lake ranged in length from 66 to 140 mm (Table 5; Figure 12). Pumpkinseed sunfish sampled ranged in age from one to five years and exhibited variable year-class strength (Table 14; Figure 12). Growth rates of pumpkinseed sunfish sampled from Newman Lake were slightly lower than the Washington state average at all ages (Table 14). Condition of Newman Lake pumpkinseed sunfish was near the national average at all sizes (Figure 13).

Table 14. Baclk-calculated mean length at age (mm) of pumpkinseed sunfish collected at Newman Lake (Spokane County) during September 2000. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). 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**
1999	5	21				
		39				
1998	4	25	61			
		44	72			
1997	12	22	59	96		
		42	72	102		
1996	2	18	58	91	113	
		40	72	98	116	
1995	2	16	53	94	113	123
		38	68	102	117	125
Overall Mean		20	58	94	113	123
Weighted Mean		41	72	101	116	125
Direct Proportion State Average		24	72	102	123	139

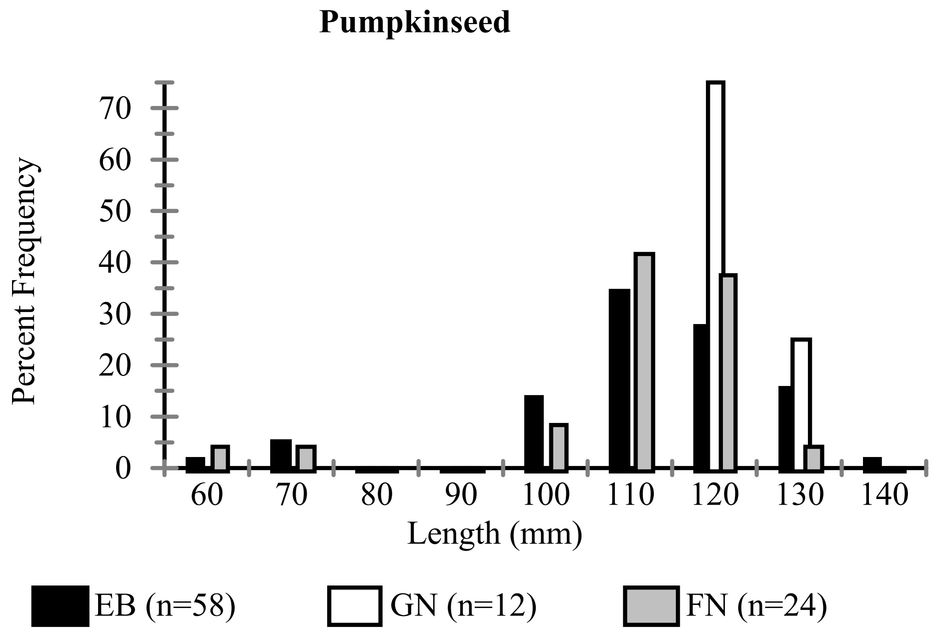

Figure 12. Length frequency distribution of pumpkinseed sunfish, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

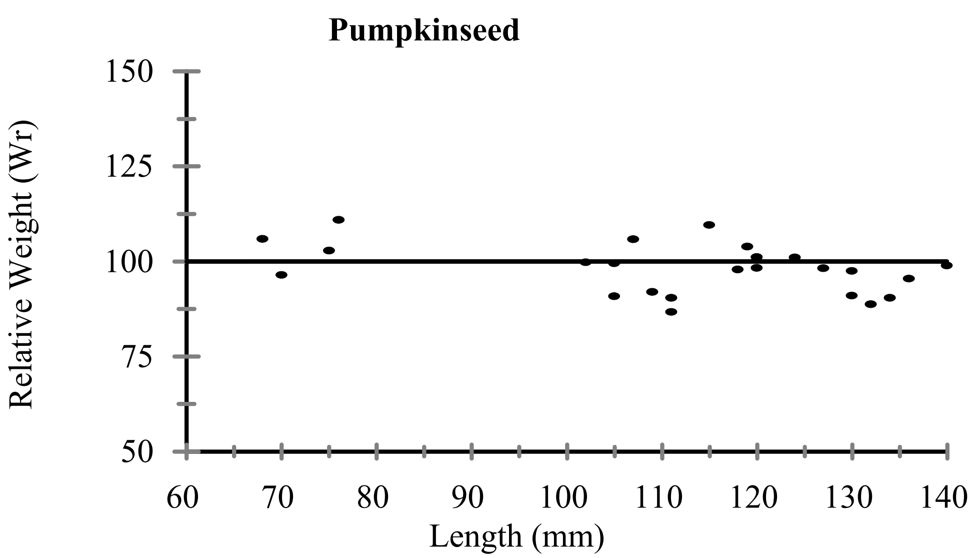

Figure 13. Relative weights of pumpkinseed sunfish (n=25), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Tiger Muskellunge

Tiger muskellunge sampled from Newman Lake ranged in size from 485 to 889 mm (Table 5; Figure 14). The age of tiger muskellunge sampled ranged from one to three years (Table 15). Tiger muskellunge are typically planted into Washington waters as Age-1 fish. Therefore, the 1-, 2-, and 3-year old tiger muskellunge observed in our samples were most likely stocked in Newman Lake in 2000, 1999, and 1998, respectively (Table 2). Because tiger muskellunge have only been stocked in a few Washington lakes, there is little data available on growth rates to compare with Newman Lake tiger muskellunge. Condition of tiger muskellunge was at or below the national average for smaller fish (485 mm-673 mm) and increased above the national average for larger fish (850 mm +) (Figure 15). In some cases, below-average condition is indicative of inter- or intra-specific competition. However, tiger muskellunge have grown rapidly in other Washington lakes (Hillson and Tipping 1999) and typically do well regardless of their forage base (Tomcko et al. 1984; Newman and Storck 1986; Wahl and Stein 1988). Although most carp that were observed during the survey were likely too large for tiger muskellunge to consume (497-700 mm TL), we expected the condition of smaller tiger muskellunge to be higher given the relatively high abundance of other species such as yellow perch, bluegill sunfish, and pumpkinseed sunfish in the lake. Competition with other predators may affect the growth rate of smaller tiger muskellunge until they reach a length at which interspecific competition is limited.

Table 15. Baclk-calculated mean length at age (mm) of tiger muskellunge collected at Newman Lake (Spokane County) during September 2000. Values represent length at age calculated using the direct proportion method (Fletcher et al. 1993).

		Mean Total Length (mm) at Age		
Year Class	**# Fish**	**1**	**2**	**3**
1999	1	207		
1998	7	185	439	
1997	3	134	402	691
Overall Mean		175	421	691
Weighted Mean		N/A	N/A	N/A
WA State Average		N/A	N/A	N/A

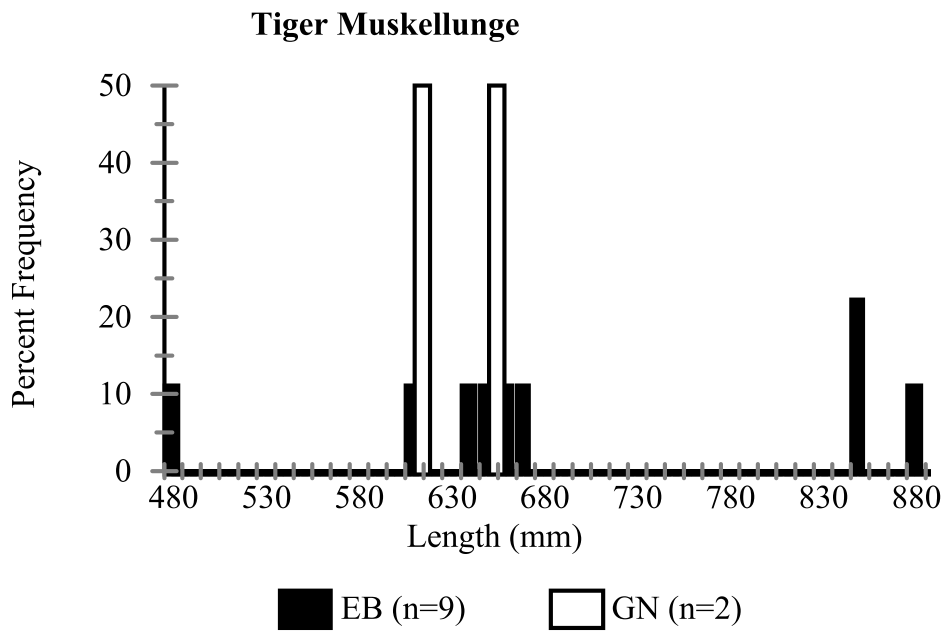

Figure 14. Length frequency distribution of tiger muskellunge sampled by electrofishing (EB) and gill netting (GN) at Newman Lake (Spokane County) during September 2000.

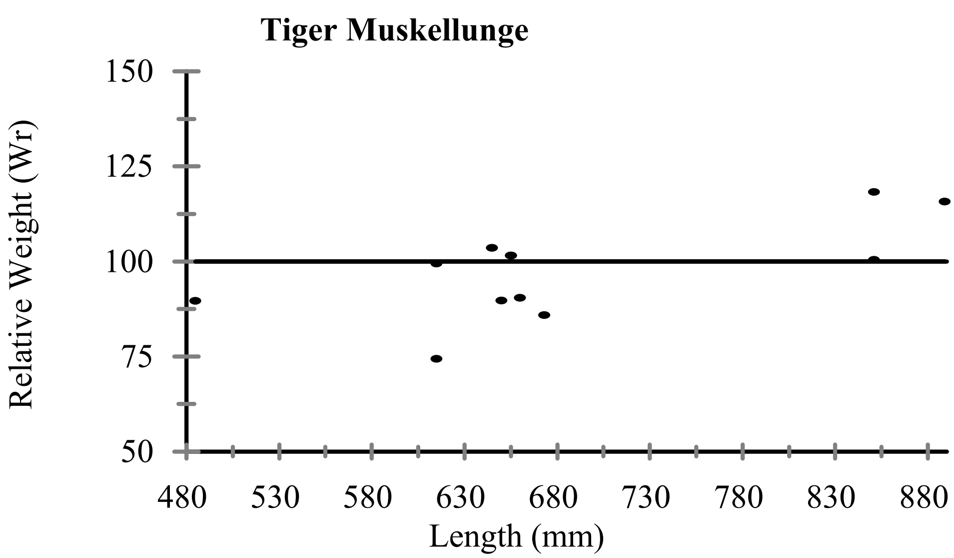

Figure 15. Relative weights of tiger muskellunge (n=11) sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Yellow Bullhead

Yellow bullhead sampled in Newman Lake ranged in length from 135 to 380 mm (Table 5; Figure 16). Condition of yellow bullhead less than 200 mm in length was near the national average whereas condition of all fish greater than 200 mm was above the national average (Figure 17). Age and growth were not analyzed for yellow bullhead.

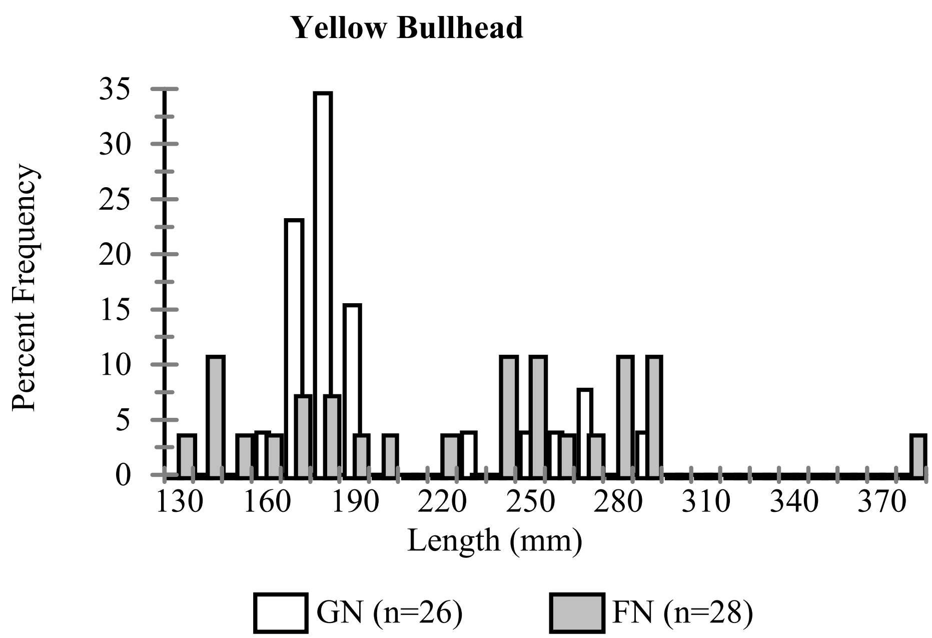

Figure 16. Length frequency distribution of yellow bullhead sampled by gill netting (GN) and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

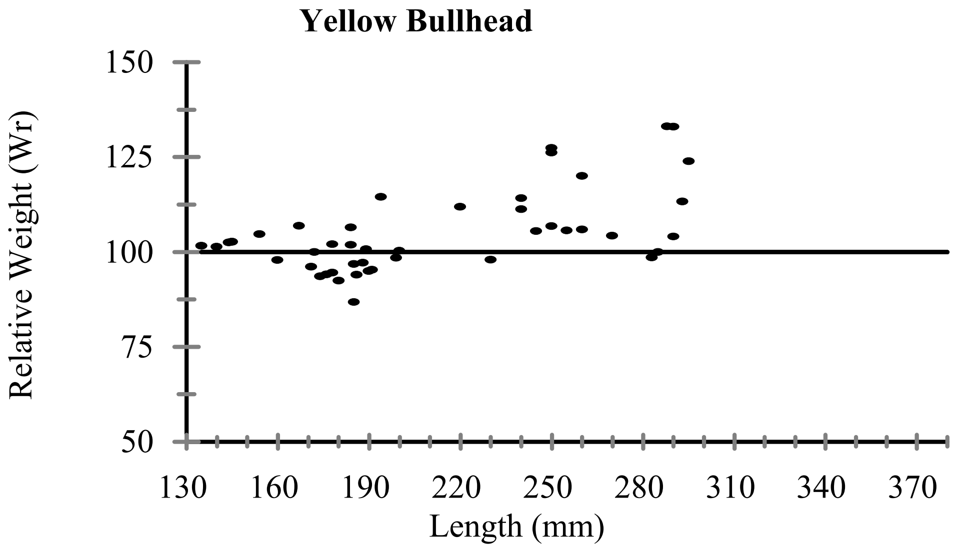

Figure 17. Relative weights of yellow bullhead (n=45) sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Brown Bullhead

Brown bullhead sampled in Newman Lake ranged in length from 204 to 343 mm (Table 5; Figure 18). Condition of brown bullhead less than 250 mm in length was below the national average whereas condition of fish greater than 250 mm was equally above and below the national average (Figure 19). Age and growth were not analyzed for brown bullhead.

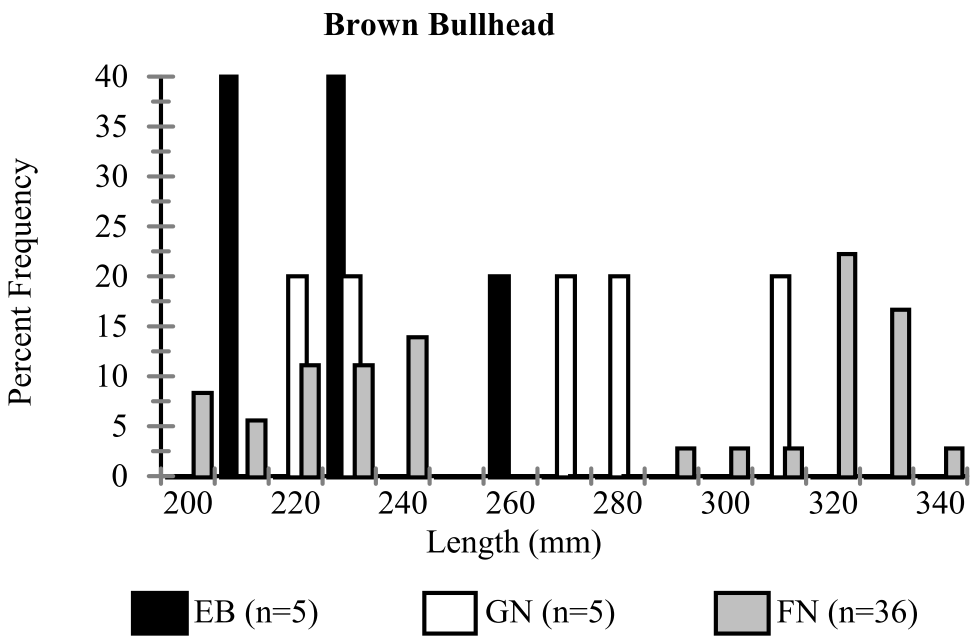

Figure 18. Length frequency distribution of brown bullhead sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during September 2000.

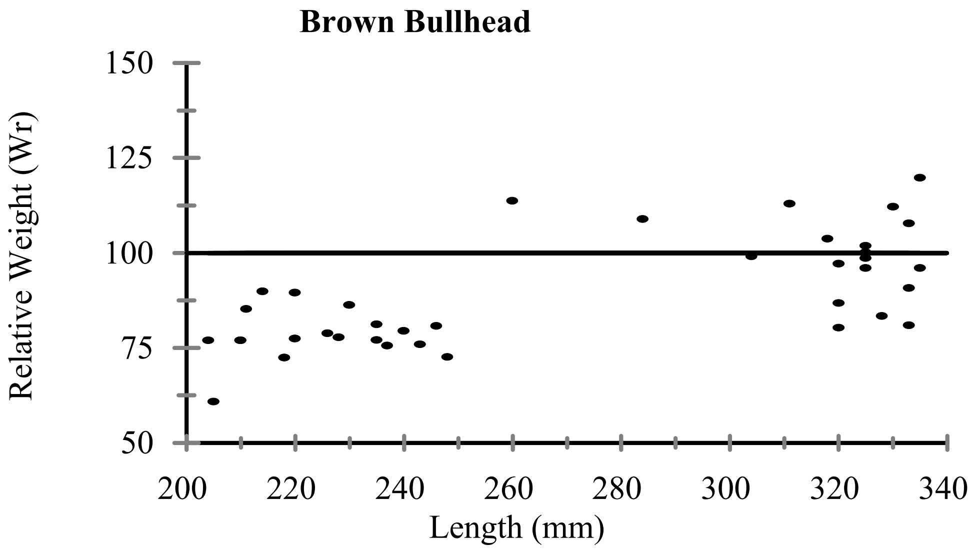

Figure 19. Relative weights of brown bullhead (n=38) sampled at Newman Lake (Spokane County) during September 2000, as compared to the national average, W_r=100 (Anderson and Neumann 1996).

Discussion

Since 1992, over 6,400 tiger muskellunge have been stocked into Newman Lake in an attempt to prevent the overpopulation of panfish and carp and to provide a unique recreational fishing opportunity for trophy size fish ($36 inches). Despite those efforts, Newman Lake shows indications of having a prey-crowded fish community dominated by yellow perch and bluegill sunfish less than quality size. Largemouth bass are also fairly abundant in the lake, but most are small (<200 mm). Although the condition of bluegill and pumpkinseed sunfish was not alarmingly low, condition of yellow perch and smaller size largemouth bass were far below the national average, which may indicate that largemouth bass are having to compete with their forage rather than prey upon them. In addition, the low stock density values for yellow perch, bluegill sunfish, and pumpkinseed sunfish suggest that predation rates on those species by largemouth bass, smallmouth bass, and tiger muskellunge appear to be insufficient to control stunting.

The Newman Lake black crappie population is above average in terms of its quality and the angling opportunity it provides. Newman Lake black crappie exhibit faster than average growth and relatively high stock density values. However, condition of larger black crappie was lower than the national average. The factor(s) limiting the condition and overall quality potential of Newman Lake black crappie is unknown. The abundance of fish prey can largely affect the growth and condition of larger black crappie. Seaburg and Moyle (1964) reported that fast-growing black crappie had a larger proportion of fish prey in their diet than those that were unable to make a diet switch from mostly zooplankton to fish. Olson (1996) also suggested that most piscivores tend to exhibit higher condition values when they are able to shift their diet from invertebrates to fish. The low condition of larger and older black crappie observed in Newman Lake may be an indication of limited prey-fish availability and/or intensive interspecific competition with other deeper water piscivores such as yellow perch or smallmouth bass.

Ongoing water quality monitoring by the Washington State Department of Ecology suggests that water quality in Newman Lake has increasingly improved since the 1992 installation of the hypolimnetic aerator and the alum injection system in 1997 (Moore et al. 2001). The aerator and alum injection systems were installed in response to findings of Phase 1 of the Clean Lake Restoration Project, which suggested that Newman Lake was extremely efficient at phosphorus recycling and that water quality would continue to deteriorate, even if all external sources of phosphorus loading were eliminated. Since 1997, the effectiveness of the alum injection system has been demonstrated by a reduction of blue-green algal blooms, an increase in water transparency, and other indicators of improved water quality, such as the presence of bryophytes. A "clear water phase," a typical pattern for less-productive lakes, was observed in 2001 as well as Secchi depth readings of 3.75 m, a condition not observed since 1990 (Moore et al. 2001).

As a result of continual aerator operation, hypolimnetic water typically remains above 3 mg/l during summer and the volume of oxygenated epilimnetic and metalimnetic water has increased

(Moore et al. 2001). Warmwater fish can survive at dissolved oxygen concentrations of 3 mg/l; however, their desired range is >5 mg/l (Swingle 1969). Although low dissolved oxygen concentrations may be limiting open water fish habitat during certain times of the year, the results of this survey suggest that those effects on warmwater fish populations in Newman Lake have been minimal. In general, a reduction of habitat caused by water quality is similar to a reduction of habitat caused by water level manipulations in drawdown reservoirs in that both can concentrate predators (Bennett and Hatch 1991; Ploskey et al. 1993) and ultimately result in high predator stock density values (Baker et al. 1993). Stock density values for largemouth bass and smallmouth bass in Newman Lake were low compared to those in Lake Spokane (Osborne et al. 2003), a drawdown reservoir on the Spokane River, which may suggest that periodic habitat limitations have had minimal effects on the fish community.

Management Considerations

Tiger Muskellunge Stocking

Considering the high abundance of yellow perch and bluegill sunfish, and the continued presence of nuisance species such as tench and common carp, fishery managers should continue to stock tiger muskellunge into Newman Lake. At the time of this survey, Newman Lake exhibited characteristics of a prey-crowded fish community as evidenced by slow growth rates and low condition of yellow perch and bluegill sunfish. Increasing the number of tiger muskellunge would likely reduce the density of panfish and nuisance species populations, and would increase the growth potential for warmwater gamefish in the lake.

In addition to being a biological control, tiger muskellunge may also provide a trophy fishing opportunity in Newman Lake. The largest tiger muskellunge observed during this survey was 889 mm (35 inches) in length and weighed 6,000 g (13.2 lbs.). Although angler catch rates on tiger muskellunge in Newman Lake are unknown, fishery managers should define targets for angler and/or sampling catch rates and consider additional monitoring to evaluate the tiger muskellunge fishery.

It seems apparent that under the current stocking regime, the number of tiger muskellunge stocked annually into Newman Lake has been insufficient to achieve measurable effects on panfish and nuisance species densities. Additionally, although anglers have some opportunity to catch tiger muskellunge in Newman Lake, past stocking levels have not produced a quality or trophy tiger muskellunge fishery. Increasing annual stocking numbers would bolster efforts to realize a measurable effect in prey-fish abundance and to produce a trophy fishery.

Tiger muskellunge have been stocked almost annually in Newman Lake since 1992. However, the eleven tiger muskellunge observed during this survey ranged in age from one to three years. Although we know tiger muskellunge exhibit fast growth rates in this lake, relatively little is known about their survival or behavior. It is unknown whether the absence of fish older than three years of age in our samples is due to poor survival or our inability to capture them with gears (shoreline electrofishing, gill netting, and fyke netting) used in the warmwater sampling protocols. Tiger muskellunge may be able to avoid those gears or may inhabit open water areas of Newman Lake not typically sampled using those protocols. Marking individual tiger muskellunge could provide information that would bolster efforts to evaluate survival and behavior of stocked fish. An understanding of tiger muskellunge survivability and behavior will help fisheries managers best manage this species in the lakes in which they are stocked.

Slot-limit Regulation Monitoring

The 12- to17-inch slot-limit on largemouth bass was implemented in May 1999, and the indices of population structure from this fall 2000 survey are likely representative of the population under the previous regulation. Therefore, this survey may serve as a baseline for documenting changes in the Newman Lake fish community under the new, more restrictive regulation. Length-frequency data (Figures 2 and 4) suggest that numbers of bass in the protected size range are low. If the slot-limit regulation performs as intended, numbers of bass within the protected size range should increase in time. Considering this, management biologists should consider developing a long-term monitoring plan to document any changes in the fish community over time. Objectives of such a program should focus on documenting changes in population density, size structure, and condition of largemouth bass and smallmouth bass and changes in panfish population structure possibly due to increased predation by largemouth bass and smallmouth bass. Additionally, creel survey data should be collected regularly to evaluate angler compliance.

Black Crappie Condition

Although growth of Newman Lake black crappie is above the statewide average, the condition of black crappie greater than 220 mm is below the national average. Future research is required to determine the factors that are limiting the condition of the larger black crappie in Newman Lake. Above average growth and below average condition has been observed in black crappie from other eastern Washington lakes (Osborne et al. 2003) raising the same questions. In systems with suitable forage, condition of black crappie usually increases after they shift to piscivory. Forage fish abundance should be assessed to determine whether or not suitable forage is lacking. In addition, analyzing the diet of other Newman Lake piscivores could help determine whether interspecific competition is contributing to the poor condition of adult black crappie. Analyzing abundance of forage fish and the diet of piscivores in Newman Lake may provide information pertinent not only to the black crappie in that lake, but to populations statewide.

Creel Survey

Warmwater fisheries surveys can provide management biologists useful information on the state of a fish community; however, they provide only circumstantial evidence as to the effects of angler harvest. Detailed and well planned creel surveys can provide information on fishing effort, angler catch per unit effort (e.g., number fish/hour fishing), and numbers of fish caught or harvested. Creel surveys can also be used to determine angler preferences with regard to management actions, regulations, as well as species and sizes of fish desired (Hahn et al. 1993).

Biological information collected from the anglers creel can provide information not typically colleted during standard surveys. For example, otoliths collected from dead fish are very accurate when determining fish age.

Recommended creel survey objectives for Newman Lake include documenting fishery utilization throughout the year, angler catch per unit effort, and angler preferences. Otoliths should be collected from fish retained by anglers for more definitive aging. Over time, creel information should aid management biologists in evaluating current regulations and their effect on fisheries management objectives.

Water Quality Monitoring

Measures taken to improve the water quality of Newman Lake have included the installation of a hypolimnetic aerator and an alum injection system, and watershed-wide nutrient reduction education and outreach activities. The Washington State Department of Ecology currently monitors the water quality of Newman Lake through the Newman Lake Watershed Committee, a volunteer citizens group, and the Newman Lake Flood Control Zone District (Moore et al. 2001).

Since these efforts began in the early 1990s, nutrient loading and blue-green algal productivity have been reduced (Washington Department of Ecology 2002), and hypolimnetic dissolved oxygen concentrations and water clarity has increased. Fish habitat that was once reduced by near-anoxic conditions in the deeper water of Newman Lake has been somewhat restored. Additionally, water transparency, the most important water quality factor for both residents and visitors to Newman Lake due to aesthetics (Moore et al. 2001), has increased to levels not seen since the early 1990s. Considering this, we encourage the DOE to continue monitoring efforts, the operation of the aerator and alum injection system such that current water quality conditions can be maintained or improved and habitat conditions remain favorable for resident fisheries.

Lake User Conveniences

The WDFW access site on Newman Lake is relatively new and in good condition. Construction of the access site occurred in 1986-87, which included two concrete plank boat ramps and a combination of paved and gravel parking spaces that accommodates close to 30 vehicles with boat trailers. In 1999, a vault-type restroom was installed at the access site and improvements were made to the boat ramps to reduce erosion problems. Although the access site provides the public with many recent improvements, latitude for additional improvements exists.

Boater access at the WDFW site would be significantly enhanced with the installation of a boat loading dock. Since the boat ramp is located on a point of shoreline which is vulnerable to wave action, most of the shoreline within the access boundary has been lined with rock to prevent erosion. Because of the rocky shoreline and concrete ramp, it is difficult for boaters to load or unload passengers and gear without damaging their vessels, even under calm lake conditions.

Because of private development, Newman Lake currently has limited access for shoreline anglers. A fishing pier built at the WDFW access site would increase the opportunity for anglers without boats. A fishing pier would not only provide anglers better access to deeper waters, but would also serve as seasonal fish cover. In addition, artificial structure or fish attractors could be placed near the pier to promote harvest of the overabundant yellow perch, pumpkinseed sunfish, and bluegill sunfish in the lake. Although artificial structure near the pier would not likely alter the structure of the fish community if done on a small scale, it may increase shoreline angler satisfaction and maximize the benefit of the fishing pier.

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