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2008 Warmwater Fisheries Survey of Newman Lake, Spokane County

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Washington Department of FISH AND WILDLIFE
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Abstract

Washington Department of Fish and Wildlife biologists surveyed Newman Lake (Spokane County) on June 8-10, 2008 as a follow-up to a similar survey conducted in September 2000. Fish were sampled using boat electrofishing, gill netting, and fyke netting. A total of 942 fish from twelve species were collected during the survey. Bluegill sunfish Lepomis macrochirus was the most abundant species (43%), followed by yellow perch Perca flavescens (16%) and largemouth bass Micropterus salmoides (13%). The majority of the biomass was comprised of carp Cyprinus carpio (37%), largemouth bass (17%), and tiger muskellunge Esox lucius x E. masquinongy (10%). Pumpkinseed sunfish L. gibbosus, black crappie Pomoxis nigromaculatus, brown bullhead Ameiurus nebulosus, smallmouth bass M. dolomieu, yellow bullhead A. natalis, rainbow trout Oncorhynchus mykiss, and tench Tinca tinca, were also sampled in lower numbers.

The results of this survey suggest that little has changed with the Newman Lake fish communities since 2000. Newman Lake continues to be prey-crowded; however, the structure of the fish community has shifted from one being dominated by yellow perch (in 2000) to one dominated by bluegill sunfish (in 2008). Fewer largemouth bass were sampled in 2008 (n=124) compared to 2000 (n=208). Despite the apparent decrease in relative abundance, condition of largemouth bass remains below the national 75th percentile, particularly for fish <300 mm total length. This suggests that largemouth bass larger than quality size continue to have adequate forage, whereas smaller bass are having to compete with the abundant bluegill and yellow perch, as well as themselves, for available resources. Stock density indices for bluegill sunfish, yellow perch, and pumpkinseed sunfish were similar between 2000 and 2008, suggesting that predation rates by largemouth bass, smallmouth bass, and tiger muskellunge continue to be insufficient to control the overpopulation of those prey species. Although relatively low in density, the black crappie population continues to be above average in terms of its quality and the angling opportunity it provides.

Carp have, thus far, been overlooked as a potential obstruction to water quality restoration goals for Newman Lake, and even though the operation of the hypolimnetic aerator and alum injection system have improved water quality conditions over the last two decades, hypolimnetic hypoxia remains a lake management issue. We recommend monitoring the carp population to determine whether, or to what extent, this species is impeding water quality restoration measures. If carp are found to be an obstruction, the regulation of carp density should be integrated into the comprehensive water quality management scheme for Newman Lake.

Other future management considerations include the continued stocking of tiger muskellunge, the introduction of channel catfish, and determining the factor(s) that are limiting the condition of larger black crappie in the lake. We also recommend that future surveys be conducted during spring to allow for statistical comparability with this survey.

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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 1900's 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-1970's, 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 3 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.

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

Physical Parameter	Measurement
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

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 1985-6, 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 rely on phosphorous to live and grow (Goldman and Horne 1983).

In the late 1800's, Newman Lake supported a commercial lake whitefish *Coregonus clupeaformis* fishery due to the abundance of this species in the lake. In the 1890's, 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 1940's, Newman Lake has been managed primarily as a trout fishery. In 1948, an annual stocking of rainbow trout *Oncorhynchus mykiss* fingerlings began. In the 1960's, up to 100,000 rainbow fingerlings were planted annually. In the 1970's, 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. Between 2000-2009, rainbow trout were stocked into Newman Lake at a rate much lower than in earlier decades. During that period, Newman Lake received annual plants of catchable sized rainbow trout ranging from 5,000-40,000, with an occasional stocking of rainbow trout fry. In addition to catchable sized rainbow trout, the lake was also stocked with triploid rainbow trout in 2000 (n=3,750) and 2001 (n=3,000)(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. Since 2010, Newman Lake has been managed primarily as a warmwater fishery.

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 2009, a total of 6,478 tiger muskellunge have been stocked in Newman Lake.

Under current statewide WDFW angling regulations, the following rules apply on Newman Lake: largemouth bass *Micropterus salmoides* 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); anglers may retain a daily limit of 10 smallmouth bass *M. dolomieu,* of which only one may exceed 14 inches; only tiger muskellunge over 50 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*, or carp.

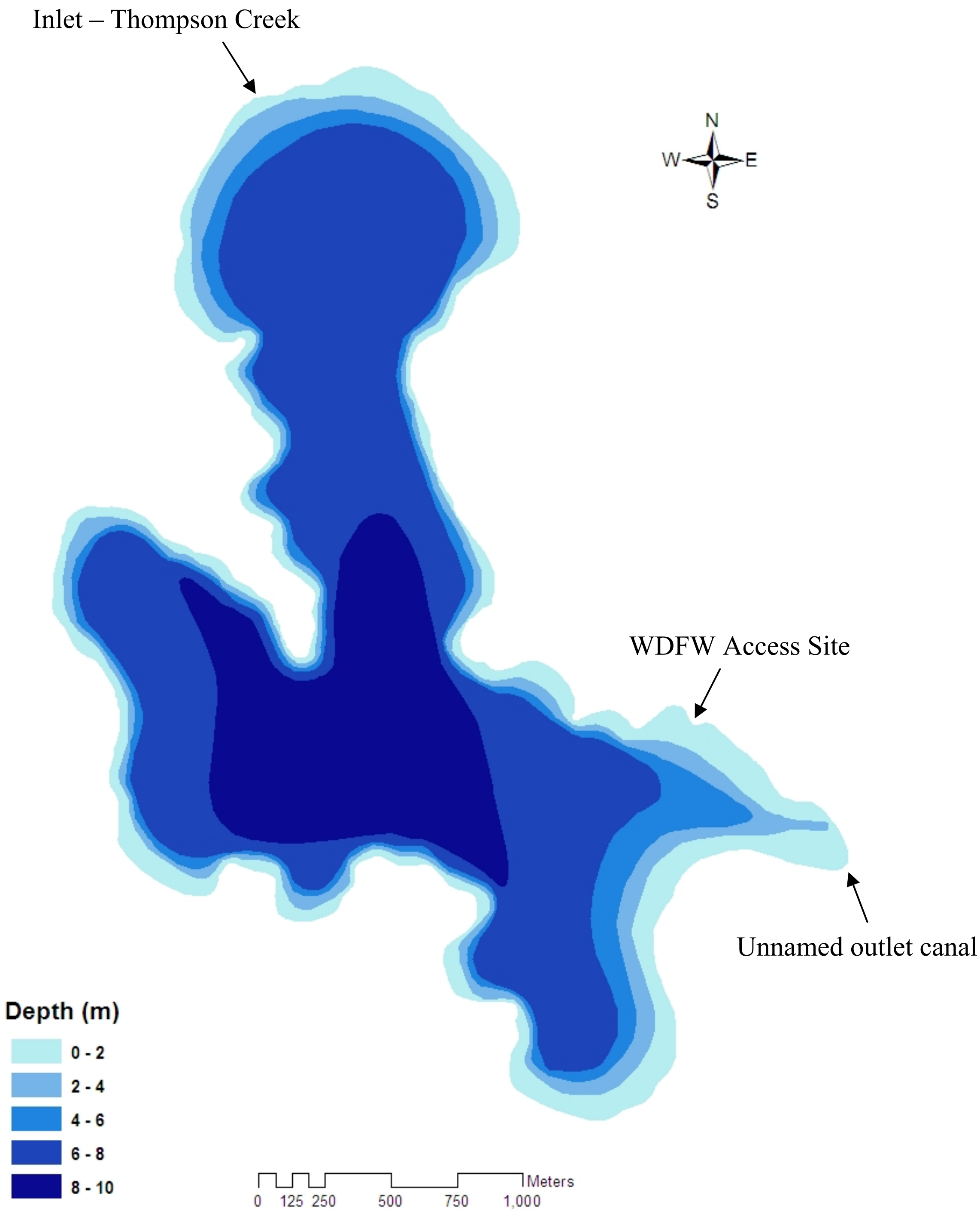

Figure 1. Bathymetric map of Newman Lake, Spokane County, Washington.

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

Year	Number	Size (fish/lb.)
1992	679	14.4
1994	2,366	4.5
1995	955	12.9
1997	999	6.8
1998	500	2.6
1999	400	2.8
2000	400	2.4
2002	500	4.5
2004	350	2.3
2005	700	2.2
2006	700	2.7
2007	400	2.1
2009	700	1.9
2010	700	2.2
2011	700	2.1

In 2000, 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. In 2008, Warmwater Fish Program personnel surveyed Newman Lake again to monitor changes in the dynamics of fish populations in the lake. This report summarizes changes in fish populations between 2000 and 2008 and 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 two three-person teams on June 8 - 10, 2008. All fish were collected using boat electrofishers, gill nets, and fyke nets. The electrofishing units consisted of Smith-Root GPP electrofishing boats, using DC currents 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 a minimum of five fish in each size group (Bonar et al. 2000). Scale samples were mounted on adhesive data cards, pressed onto acetate slides, and aged according to Jearld (1983) and Fletcher et al. (1993).

Data Analysis

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-of-effort (CPUE), by gear type, was determined for each fish species collected (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 the mean $\pm t(N-1)\times SE$, where t=Student's t for confidence level with N-1 degrees of freedom (two tailed) and SE=standard error of the mean. Standardized CPUE allows for comparisons of catch rates between different lakes or sampling dates on the same water.

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 ≥ age 1.

Proportional stock density (PSD) and relative stock density (RSD) 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 and quality lengths, which vary by species (Table 3), are based on percentages of world-record lengths. PSD is calculated using the number of quality size fish, divided by the number of stock size fish, multiplied by 100. Eighty percent confidence intervals were calculated, assuming a normal distribution, as an indication of precision (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 parentheses represent percentages of world record lengths (Gablehouse 1984).

Species	Standard Length Categories				
	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 Sunfish	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

Age and growth of warmwater fishes sampled were evaluated using the direct proportion method (Fletcher et al. 1993) and Lee's modification of the direct proportional method (Carlander 1982). Using the direct proportional method, total length at annulus formation, L_n, was back–calculated as $L_n=(A\times TL)/S$, where A is the radius of the fish scale at age n, TL is the total length of the fish captured, and S is the total radius of the scale at capture. Using Lee's modification, L_n was back–calculated as $L_n=a+A\times(TL-a)/S$, 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, as well as between the lake average, and growth in other areas within the state of Washington (Fletcher et al. 1993) for the same species.

The relative weight (W_r) index was calculated for all species to evaluate condition of fish in Newman Lake (Anderson and Neuman 1996) . The index was calculated as,

$$W_r = \frac{W}{W_s} x100$$

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 . The W_s equations were obtained from Anderson and Neuman (1996), Bister et al. (2000), Hyatt and Hubert (2001a), Hyatt and Hubert (2001b). 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.

Results

Species Composition

A total of twelve fish species were observed in June 2008 (Table 4). Warmwater gamefish comprised approximately 96 percent of the total fish captured. Bluegill were the most abundant species (43.4%) encountered in the samples. Although carp represented only 2 percent of the total number of fish sampled, they contributed over four times the biomass (37.1%) of bluegill. Rainbow trout and tiger muskellunge were observed in low numbers, which may have been a result of sampling methods. The gear used in this survey (electrofishing, gill nets, fyke nets) sample areas of the lake that are no more than 150 ft. out from the shore. Our samples may under represent species, such as rainbow trout, that typically occupy pelagic habitat in the lake, or species, like tiger muskellunge, that have been observed in open water areas of the lake (Osborne et al. 2012).

Table 4. Species composition (excluding young-of-the-year) by weight (kg) and by number of fish collected from Newman Lake (Spokane County), June 2008.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Species	kg	%	No.	%	Min	Max
Bluegill	13.7	9.2	409	43.4	40	188
Yellow Perch	3.8	2.6	152	16.2	69	220
Largemouth Bass	25.3	17.1	124	13.2	82	532
Pumpkinseed	2.7	1.8	73	7.7	71	197
Black Crappie	8.7	5.9	43	4.6	68	376
Brown Bullhead	11.4	7.7	43	4.6	181	351
Smallmouth Bass	5	3.4	35	3.7	103	395
Yellow Bullhead	3.7	2.5	22	2.3	162	285
Carp	54.8	37.1	21	2.2	489	725
Rainbow Trout	2.2	1.5	12	1.3	217	282
Tiger Muskellunge	15.3	10.3	4	0.4	471	950
Tench	1.3	0.9	4	0.4	234	330

Catch Per Unit Effort (CPUE)

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. Boat electrofishing catch rates were highest for bluegill. Boat electrofishing catch rates for pumpkinseed, largemouth bass, and yellow perch were similar, but lower than that of bluegill (Tables 5 and 6). Gill netting catch rates were highest for yellow perch followed by black crappie. Fyke netting catch rates were highest for bluegill followed by brown bullhead, pumpkinseed, and black crappie. Electrofishing catch rates for bluegill, yellow perch, and largemouth bass increased substantially when all fish (excluding young-of-the-year) were analyzed for CPUE (Table 6) compared to the analysis of only stock length fish (Table 5), indicating a relatively high abundance of small fish.

Table 5. Mean catch per unit effort (CPUE) by sampling method, including 80 percent confidence intervals, for all fish, stock length or larger, collected from Newman Lake (Spokane County) in June 2008.

	Gear Type											
	Electrofishing				Gill Netting				Fyke Netting			
Species	No./Hour			No Sites	No./Net Night			Net Nights	No./Net Night			Net Nights
Brown Bullhead	5.5	±	2.9	12	1.4	±	1.6	8	3.8	±	1.8	8
Black Crappie	3.5	±	1.8	12	1.9	±	1.0	8	2.0	±	0.9	8
Bluegill	138.0	±	39.5	12	0.8	±	0.3	8	6.5	±	3.0	8
Carp	9.0	±	3.6	12	0.4	±	0.2	8	0.0			8
Largemouth Bass	21.0	±	6.5	12	0.5	±	0.2	8	0.0			8
Pumpkinseed	24.5	±	14.1	12	0.4	±	0.3	8	2.3	±	1.8	8
Rainbow Trout	3.0	±	2.0	12	0.8	±	0.4	8	0.0			8
Smallmouth Bass	6.5	±	2.9	12	0.0			8	0.1	±	0.2	8
Tiger Muskellunge	1.0	±	0.8	12	0.3	±	0.2	8	0.0			8
Tench	1.5	±	1.0	12	0.0			8	0.1	±	0.2	8
Yellow Bullhead	5.0	±	2.6	12	0.0			8	1.5	±	1.4	8
Yellow Perch	20.0	±	6.0	12	2.0	±	1.2	8	0.1	±	0.2	8

Table 6. 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 June 2008.

	Gear Type											
	Electrofishing				Gill Netting				Fyke Netting			
Species	No./Hour			No Sites	No./Net Night			Net Nights	No./Net Night			Net Nights
Brown Bullhead	5.5	±	2.9	12	1.4	±	1.6	8	3.8	±	1.8	8
Black Crappie	6.0	±	2.7	12	1.9	±	1.0	8	2.0	±	0.9	8
Bluegill	175.0	±	57.3	12	0.8	±	0.3	8	6.6	±	3.0	8
Carp	9.0	±	3.6	12	0.4	±	0.2	8	0.0			8
Largemouth Bass	60.0	±	15.6	12	0.5	±	0.2	8	0.0			8
Pumpkinseed	25.5	±	14.3	12	0.4	±	0.3	8	2.4	±	1.8	8
Rainbow Trout	3.0	±	2.0	12	0.8	±	0.4	8	0.0			8
Smallmouth Bass	17.0	±	7.2	12	0.0			8	0.1	±	0.2	8
Tiger Muskellunge	1.0	±	0.8	12	0.3	±	0.2	8	0.0			8
Tench	1.5	±	1.0	12	0.0			8	0.1	±	0.2	8
Yellow Bullhead	5.0	±	2.6	12	0.0			8	1.5	±	1.4	8
Yellow Perch	66.0	±	14.8	12	2.1	±	1.3	8	0.3	±	0.2	8

Stock Density Indices

Sample sizes of stock length fish were only adequate for evaluating stock density indices for bluegill captured by electrofishing (Table 7). 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 for all other species was lower than desired, stock density analyses may still provide some insight into the size structure of those species in Newman Lake.

The low PSD values of bluegill and pumpkinseed suggest that these populations are dominated by small individuals and that recruitment of these species to quality size or larger is low. Of the 43 black crappie sampled during this survey, 15 captured by gill netting, and 16 captured with fyke nets, were at least quality size. Since black crappie were sampled in relatively low numbers, and were represented in all RSD categories except RSD-T (Trophy) suggests that their population consists of fewer, but larger, individuals. Largemouth bass and smallmouth bass collected by electrofishing had higher PSD values than those for panfish including yellow perch, pumpkinseed sunfish, and bluegill.

Table 7. Traditional stock density indices, including 80 percent confidence intervals, of fish collected from Newman Lake (Spokane County) in June 2008.

Species	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Bluegill	276	14 ± 3	0	0	0
Largemouth Bass	42	36 ± 9	14 ± 7	0	0
Pumpkinseed	49	2 ± 3	0	0	0
Smallmouth Bass	13	38 ± 17	15 ± 13	0	0
Yellow Perch	40	13 ± 7	0	0	0
		Gill Netting			
Black Crappie	15	47 ± 17	33 ± 16	13 ± 11	0
Yellow Perch	16	50 ± 16	0	0	0
		Fyke Netting			
Black Crappie	16	100 ± 0	69 ± 15	25 ± 14	0
Bluegill	52	52 ± 9	0	0	0
Pumpkinseed	19	16 ± 11	0	0	0

Largemouth Bass

Largemouth bass sampled from Newman Lake ranged in total length from 82 to 532 mm (Table 4; Figure 2). The age of largemouth bass sampled ranged from one to twelve years (Table 8). Largemouth bass year-class strength appeared variable (Table 8; Figure 2). Largemouth bass growth rates were similar to the Washington state average (Fletcher et al. 1993) at age 1, but were above the state average at all other ages (Table 8). Condition of largemouth bass < 130 mm was variable with relative weights both above and below the national 75th percentile (Figure 3). For all other largemouth bass, condition was low but tended to improve with increased size.

Table 8. Back-calculated mean length at age (mm) of largemouth bass collected at Newman Lake (Spokane County) during June 2008. 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	12
2007	14	102											
		102											
2006	24	65	178										
		78	178										
2005	13	59	159	260									
		74	167	260									
2004	4	53	163	254	328								
		70	173	259	328								
2003	5	48	155	239	313	371							
		65	166	246	316	371							
2002	2	85	214	293	335	381	407						
		100	224	298	338	383	407						
2001	1	42	161	292	341	374	414	445					
		60	174	299	346	377	416	445					
2000	0	--	--	--	--	--	--	--	--				
		--	--	--	--	--	--	--	--				
1999	0	--	--	--	--	--	--	--	--	--			
		--	--	--	--	--	--	--	--	--			
1998	0	--	--	--	--	--	--	--	--	--	--		
		--	--	--	--	--	--	--	--	--	--		
1997	0	--	--	--	--	--	--	--	--	--	--	--	
		--	--	--	--	--	--	--	--	--	--	--	
1996	1	56	110	180	297	369	413	448	478	494	513	526	532
		74	126	194	306	375	417	451	480	496	513	526	532
Direct Proportion Mean		64	163	253	323	374	411	446	478	494	513	526	532
Lee's Weighted Mean		81	174	259	325	375	412	448	480	496	513	526	532
Direct Proportion State Average		60	146	222	261	289	319	368	396	440	485	472	496

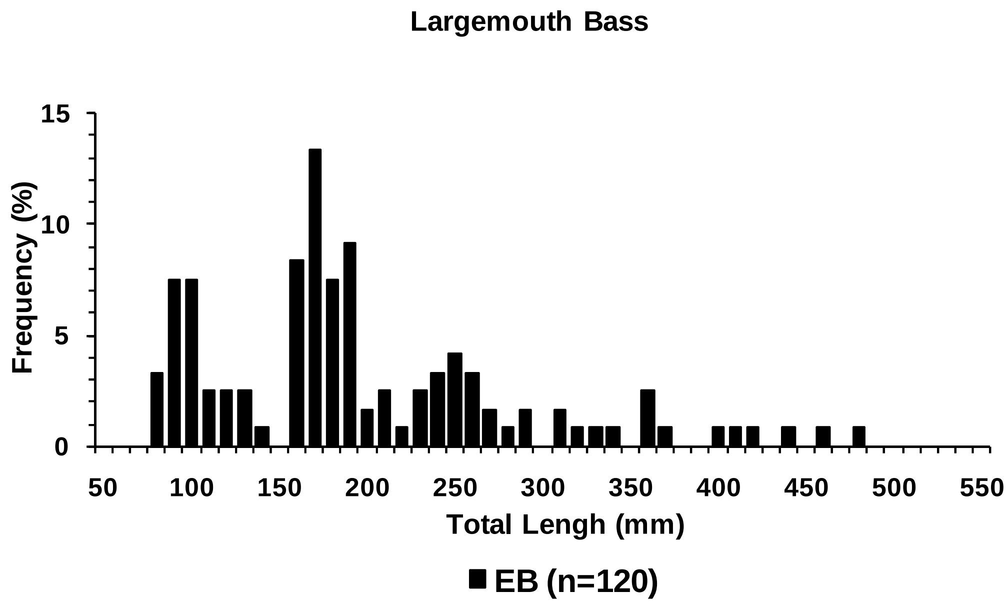

Figure 2. Length frequency distribution of largemouth bass, excluding young-of-the-year, sampled by electrofishing (EB) at Newman Lake (Spokane County) during June 2008.

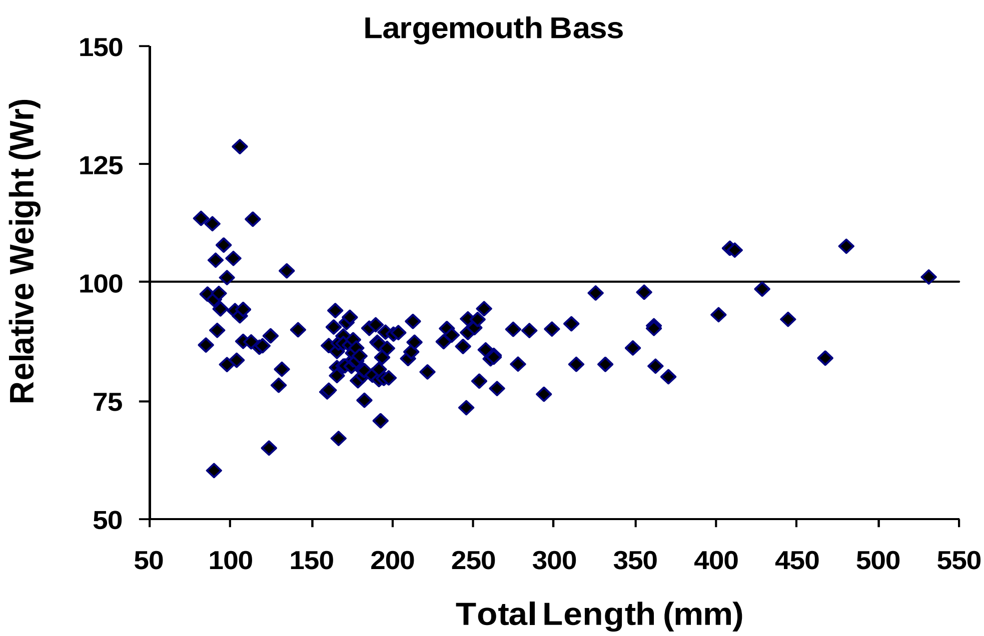

Figure 3. Relative weights of largemouth bass (n=124), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Smallmouth Bass

Smallmouth bass sampled from Newman Lake ranged in total length from 103 to 395 mm (Table 4; Figure 4). The age of smallmouth bass sampled ranged from one to eight years (Table 9). Smallmouth bass year-class strength appeared variable (Table 9; Figure 4). Smallmouth bass growth rates were below the Washington state average (Fletcher et al. 1993) at all ages (Table 9). Condition of smallmouth bass was below the national 75th percentile at all sizes sampled (Figure 5).

Table 9. Back-calculated mean length at age (mm) of smallmouth bass collected at Newman Lake (Spokane County) during June 2008. 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
2007	1	103							
		103							
2006	10	59	157						
		81	157						
2005	1	38	110	187					
		66	124	187					
2004	2	53	118	177	243				
		80	136	187	243				
2003	2	54	146	209	282	346			
		84	167	223	288	346			
2002	0								
2001	1	55	112	172	225	279	341	380	
		85	137	191	239	289	344	380	
2000	1	39	112	178	220	249	276	336	395
		70	137	197	235	262	286	341	395
Direct Proportion Mean		57	126	185	242	292	308	358	395
Lee's Weighted Mean		81	151	204	256	311	315	361	395
Direct Proportion State Average		70	146	212	268	334	356	393	NA

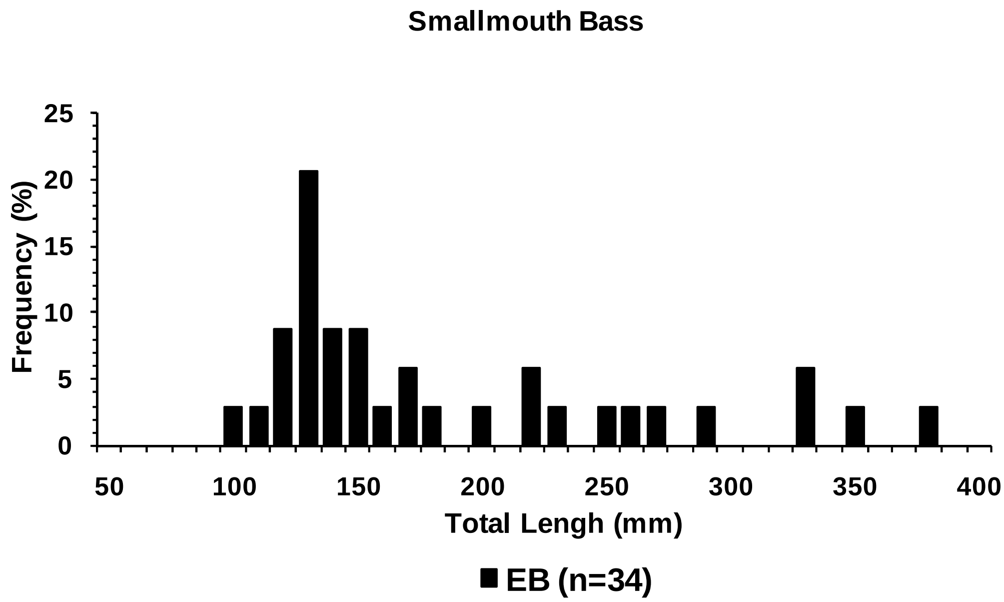

Figure 4. Length frequency distribution of smallmouth bass, excluding young-of-the-year, sampled by electrofishing (EB) at Newman Lake (Spokane County) during June 2008.

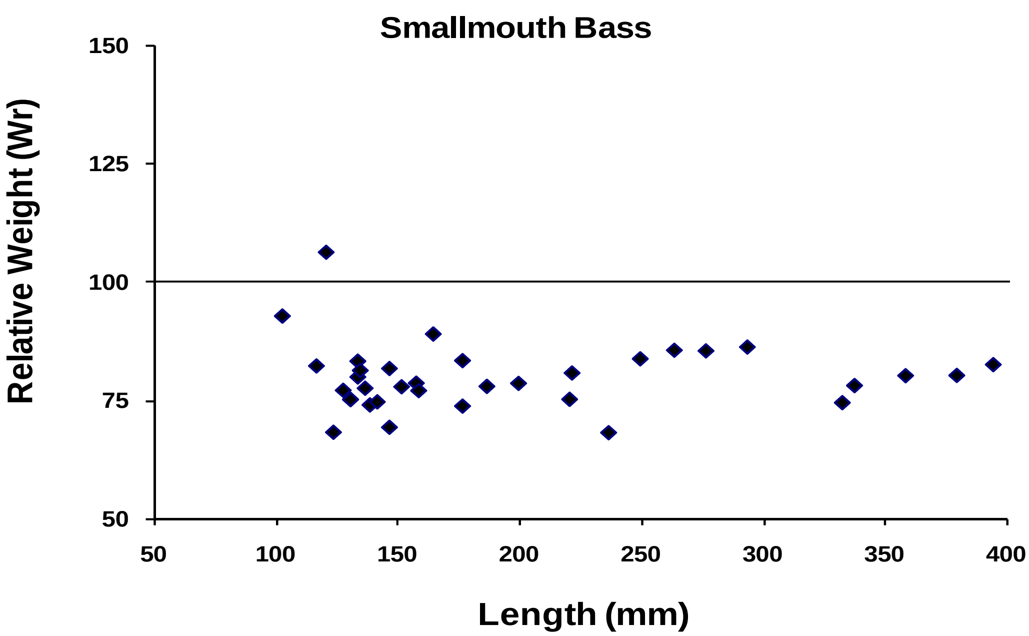

Figure 5. Relative weights of smallmouth bass (n=35), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Yellow Perch

Yellow perch sampled from Newman Lake ranged in total length from 69 to 220 mm (Table 4; Figure 6). The age of yellow perch sampled ranged from one to six years (Table 10). Yellow perch year-class strength appeared variable (Table 10; Figure 6). Yellow perch growth rates were above the Washington state average (Fletcher et al. 1993) at ages 3, 5, and 6, but were below average at all other ages (Table 10). Condition of yellow perch less than 100 mm TL was variable, with relative weights both, above and below the national 75th percentile (Figure 7). Relative weights of yellow perch greater than 100 mm TL were below the national 75th percentile and condition tended to decrease as fish became larger.

Table 10. Back-calculated mean length at age (mm) of yellow perch collected at Newman Lake (Spokane County) during June 2008. 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
2007	2	74					
		78					
2006	6	48	115				
		66	117				
2005	10	50	100	157			
		70	111	158			
2004	6	43	98	146	185		
		66	112	152	185		
2003	3	43	113	169	197	214	
		67	127	176	199	214	
2002	5	43	112	163	184	200	211
		67	126	170	187	201	211
Direct Proportion Mean		50	108	159	189	207	211
Lee's Weighted Mean		68	117	161	189	206	211
Direct Proportion State Average		60	120	152	193	206	197

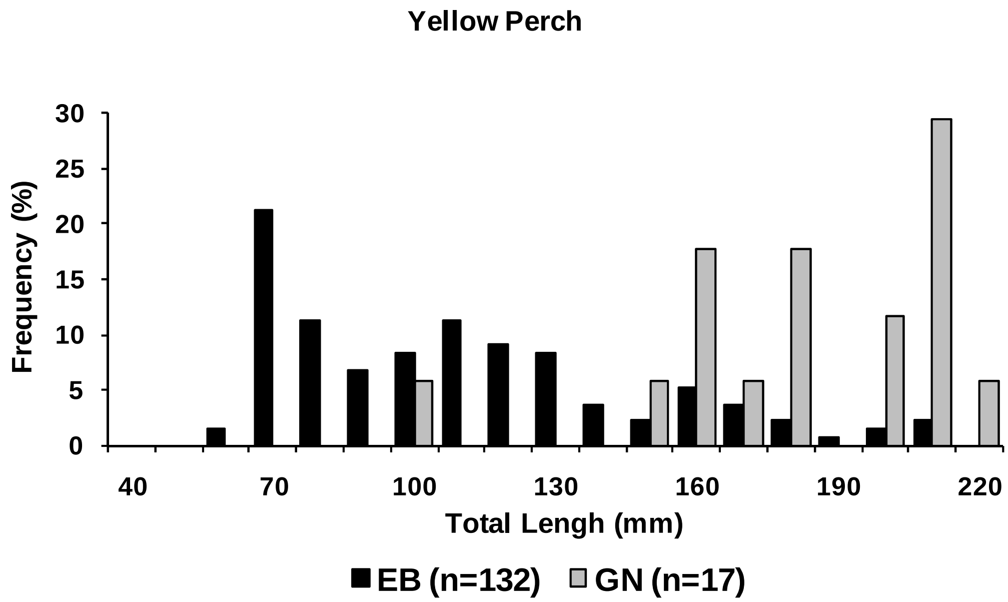

Figure 6. Length frequency distribution of yellow perch, excluding young-of-the-year, sampled by electrofishing (EB) and gill netting (GN) at Newman Lake (Spokane County) during June 2008.

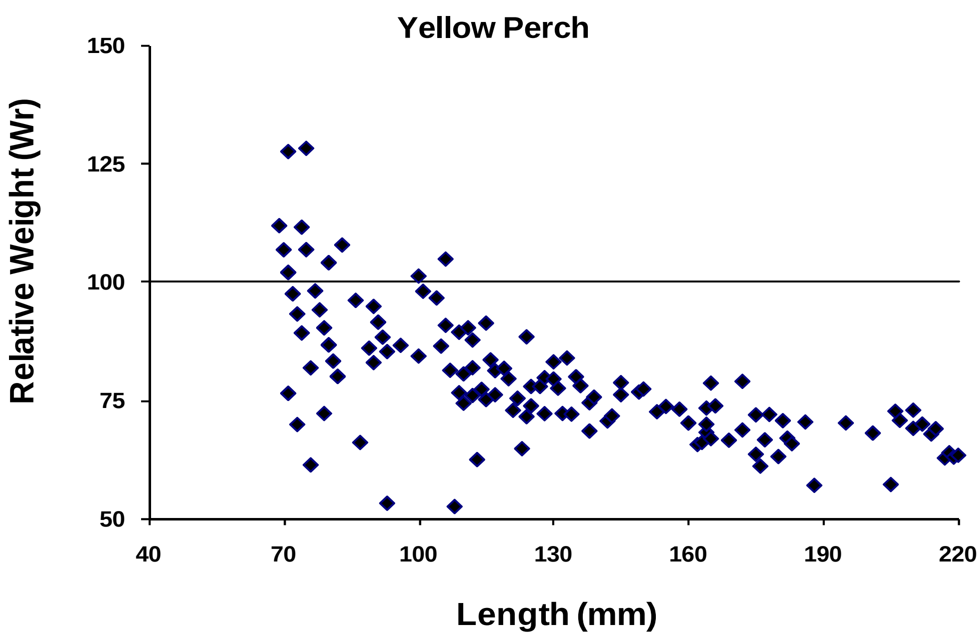

Figure 7. Relative weights of yellow perch (n=151), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Black Crappie

Black crappie sampled from Newman Lake ranged in total length from 68 to 376 mm (Table 4; Figure 8). The age of black crappie sampled ranged from two to eleven years (Table 11). Black crappie year-class strength appeared variable (Table 11; Figure 8). With the exception of age one fish, growth rates of Newman Lake black crappie were higher than other black crappie populations sampled in Washington lakes (Fletcher et al. 1993)(Table 11). Black crappie condition was at or above the national 75th percentile for fish less than 170 mm TL but appeared to decrease as fish became larger (Figure 9).

Table 11. Back-calculated mean length at age (mm) of black crappie collected at Newman Lake (Spokane County) during June 2008. 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
2007	0	--										
		--										
2006	7	39	148									
		65	150									
2005	7	33	109	207								
		63	125	207								
2004	3	34	116	203	253							
		64	135	210	253							
2003	2	39	141	209	256	287						
		69	158	219	259	287						
2002	8	38	121	202	237	265	289					
		68	141	213	243	268	289					
2001	2	34	98	187	238	266	288	304				
		65	121	200	246	271	290	304				
2000	1	33	129	205	236	273	299	314	327			
		65	150	218	245	279	302	315	327			
1999	1	34	116	212	279	320	338	351	365	376		
		66	140	227	288	326	342	353	366	376		
1998	0	--	--	--	--	--	--	--	--	--	--	
		--	--	--	--	--	--	--	--	--	--	
1997	1	26	106	162	186	259	276	295	307	324	330	336
		58	130	180	201	267	282	300	310	325	331	336
Direct Proportion Mean		34	120	198	241	278	298	316	333	350	330	336
Lee's Weighted Mean		65	126	210	247	275	294	315	335	351	331	336
Direct Proportion State Average		46	111	157	183	220	NA	NA	NA	NA	NA	NA

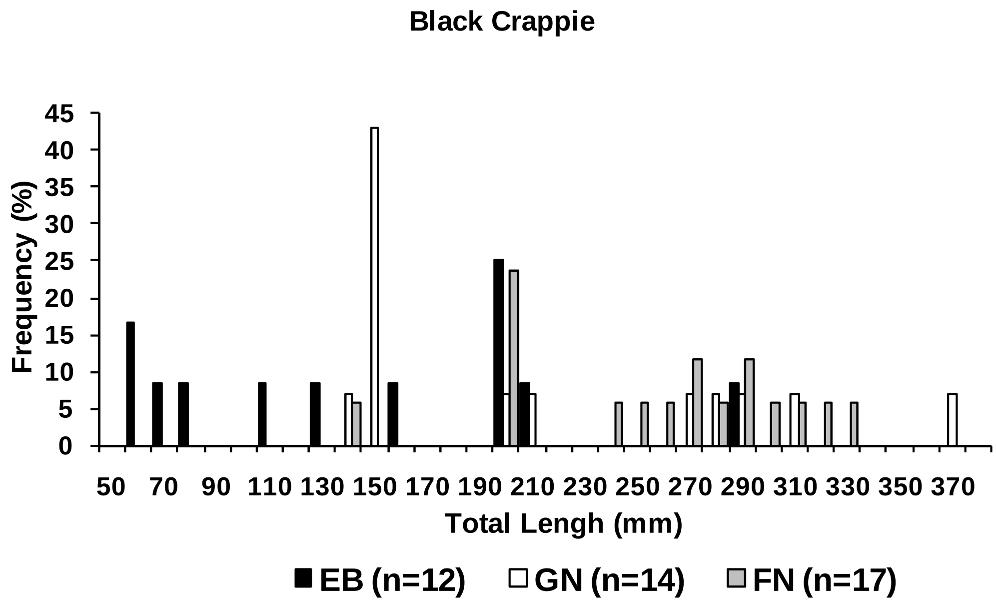

Figure 8. Length frequency distribution of black crappie, excluding young-of-the-year, sampled by electrofishing (EB), gill netting (GN), and fyke netting (FN) at Newman Lake (Spokane County) during June 2008.

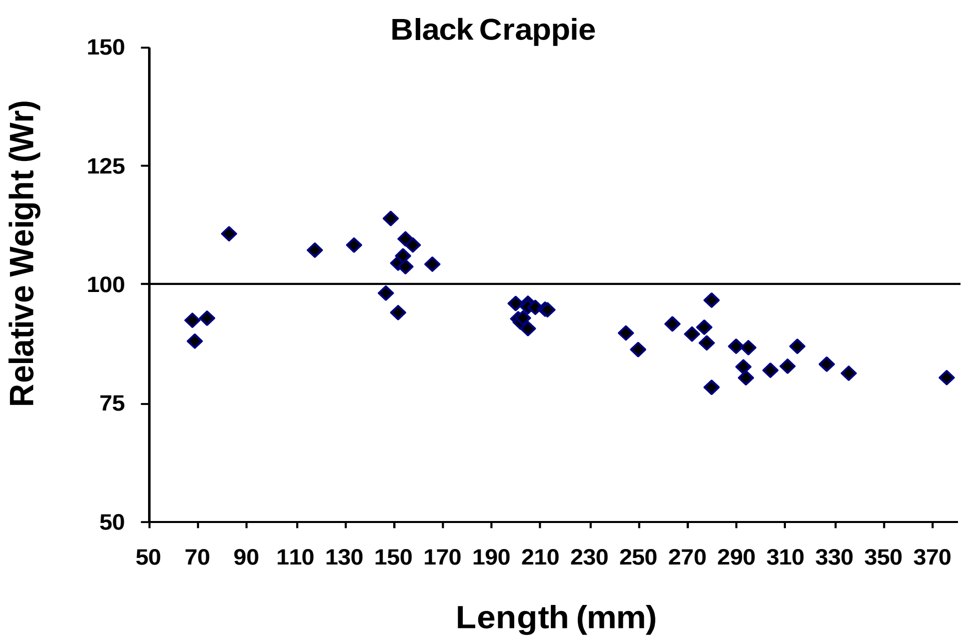

Figure 9. Relative weights of black crappie (n=43), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Bluegill Sunfish

Bluegill sunfish sampled from Newman Lake ranged in total length from 40 to 188 mm (Table 4; Figure 10). The age of bluegill sampled ranged from two to five years (Table 12). Bluegill year-class strength appeared variable (Table 12; Figure 10). Growth rates of age three and younger bluegill were far below those of other bluegill populations sampled in Washington lakes (Fletcher et al. 1993)(Table 12). Growth rates of four and five year old bluegill were above the Washington state average. Condition of most bluegill was at or below the national 75th percentile (Figure 11).

Table 12. Back-calculated mean length at age (mm) of bluegill sunfish collected at Newman Lake (Spokane County) during June 2008. 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
2007	0	--				
		--				
2006	12	25	84			
		39	84			
2005	28	19	51	123		
		36	63	123		
2004	16	18	54	117	161	
		36	67	122	161	
2003	2	21	70	136	164	182
		38	82	141	166	182
Direct Proportion Mean		20	59	121	162	182
Lee's Weighted Mean		36	69	123	162	182
Direct Proportion State Average		37	97	132	148	170

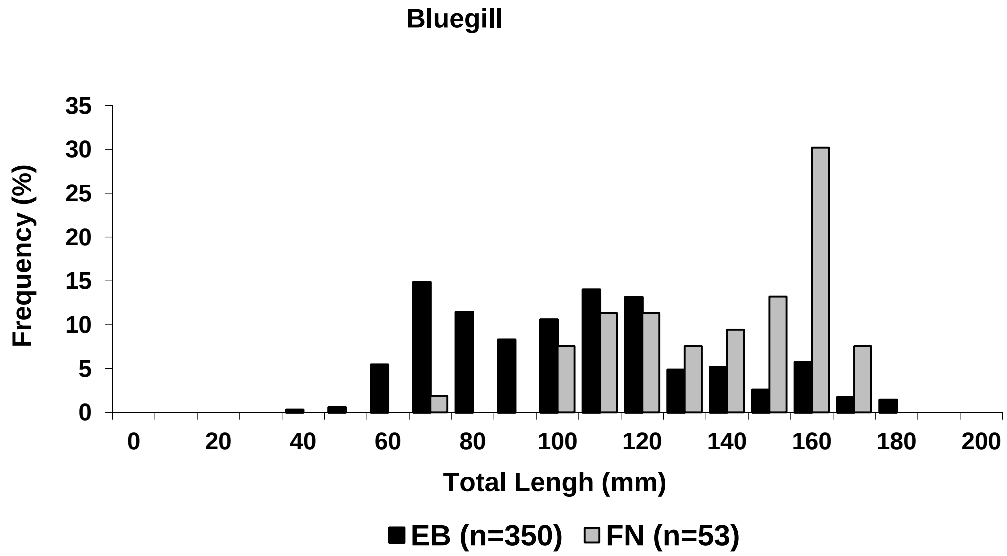

Figure 10. Length frequency distribution of bluegill sunfish, excluding young-of-the-year, sampled by electrofishing (EB) and fyke netting (FN) at Newman Lake (Spokane County) during June 2008.

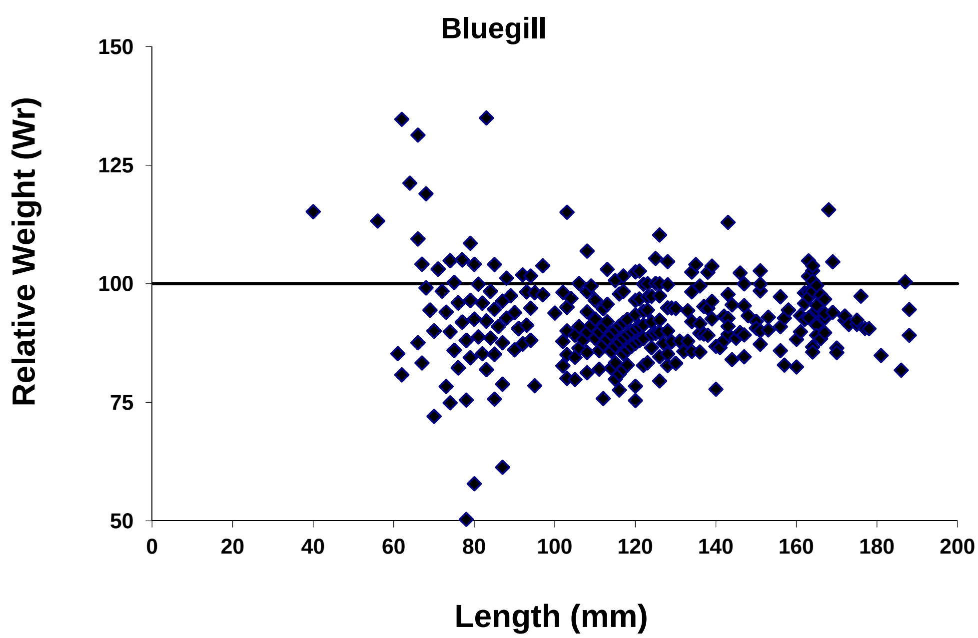

Figure 11. Relative weights of bluegill sunfish (n=409), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Pumpkinseed Sunfish

Pumpkinseed sunfish sampled from Newman Lake ranged in total length from 71 to 197 mm (Table 4; Figure 12). The age of bluegill sampled ranged from two to six years (Table 13). Pumpkinseed year-class strength appeared variable (Table 13; Figure 12). With the exception of age two fish, growth rates of pumpkinseed were above the Washington state average at all ages (Fletcher et al. 1993)(Table 13). Condition of Newman Lake pumpkinseed was variable with relative weights of sampled fish being both above and below the national 75th percentile (Figure 13).

Table 13. Back-calculated mean length at age (mm) of pumpkinseed sunfish collected at Newman Lake (Spokane County) during June 2008. 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
2007	0	--					
		--					
2006	2	26	78				
		43	79				
2005	7	26	58	106			
		45	70	106			
2004	14	23	61	101	136		
		44	75	108	136		
2003	1	29	67	115	136	150	
		49	81	121	139	150	
2002	2	23	76	152	172	186	196
		45	91	157	175	188	196
Direct Proportion Mean		25	63	107	140	174	196
Lee's Weighted Mean		45	75	112	141	175	196
Direct Proportion State Average		24	72	102	123	139	NA

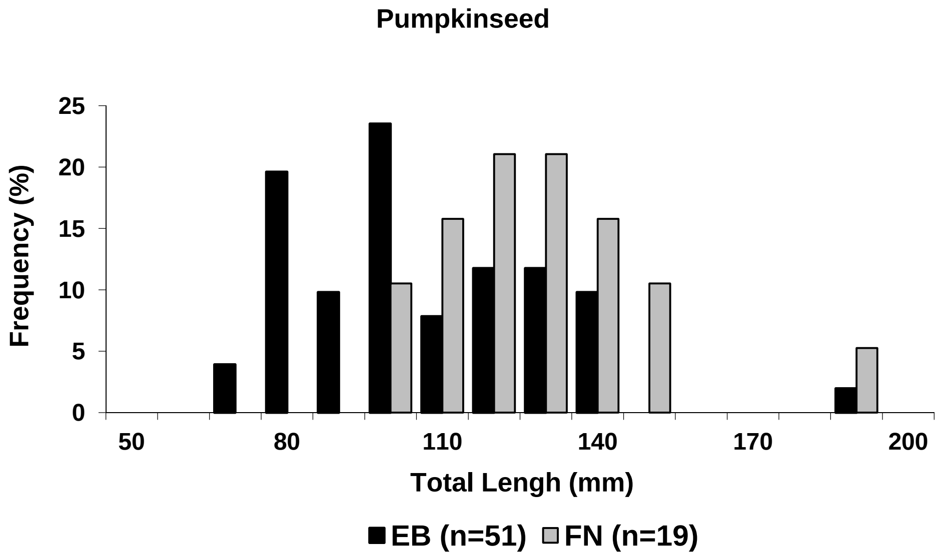

Figure 12. Length frequency distribution of pumpkinseed sunfish, excluding young-of-the-year, sampled by electrofishing (EB) and fyke netting (FN) at Newman Lake (Spokane County) during June 2008.

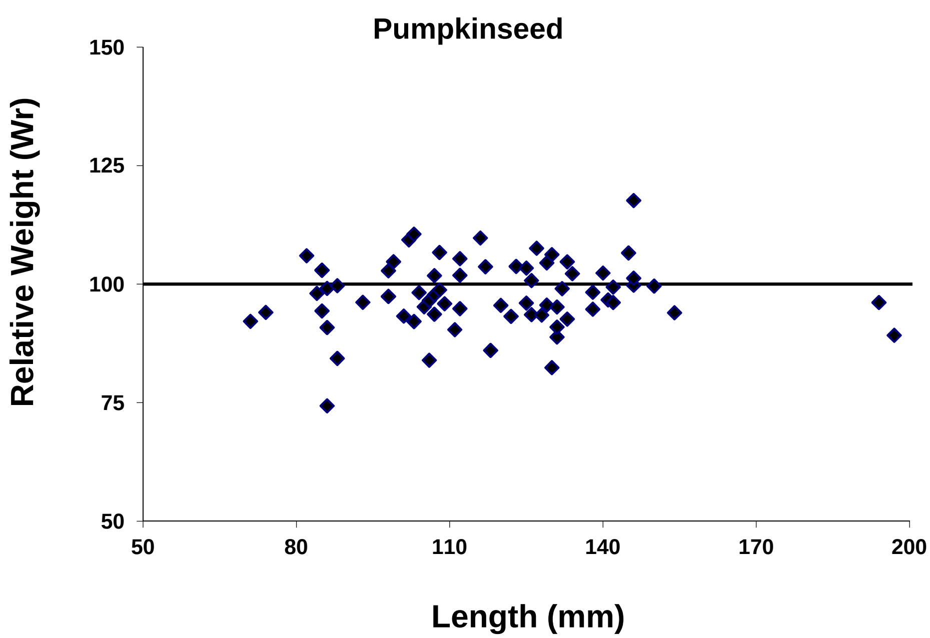

Figure 13. Relative weights of pumpkinseed sunfish (n=73), excluding young-of-the-year, sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Tiger Muskellunge

Tiger muskellunge sampled from Newman Lake (n=4) ranged in total length from 471 to 950 mm (Table 4; Figure 14). Age was determined for only one of the four tiger muskellunge that were sampled. This fish (471 mm TL) was two years old. Tiger muskellunge are stocked into Washington waters as age-1 fish, therefore, this fish was stocked into Newman Lake in 2007. The condition of tiger muskellunge was far below the national 75th percentile for the smaller fish sampled, but tended to improve as fish became larger (Figure 15).

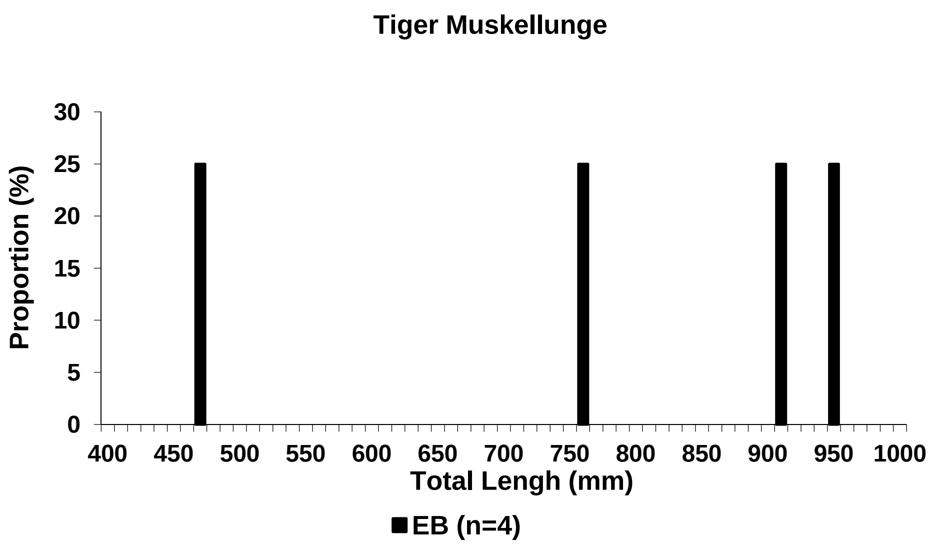

Figure 14. Length frequency distribution of tiger muskellunge sampled by electrofishing (EB) at Newman Lake (Spokane County) during June 2008.

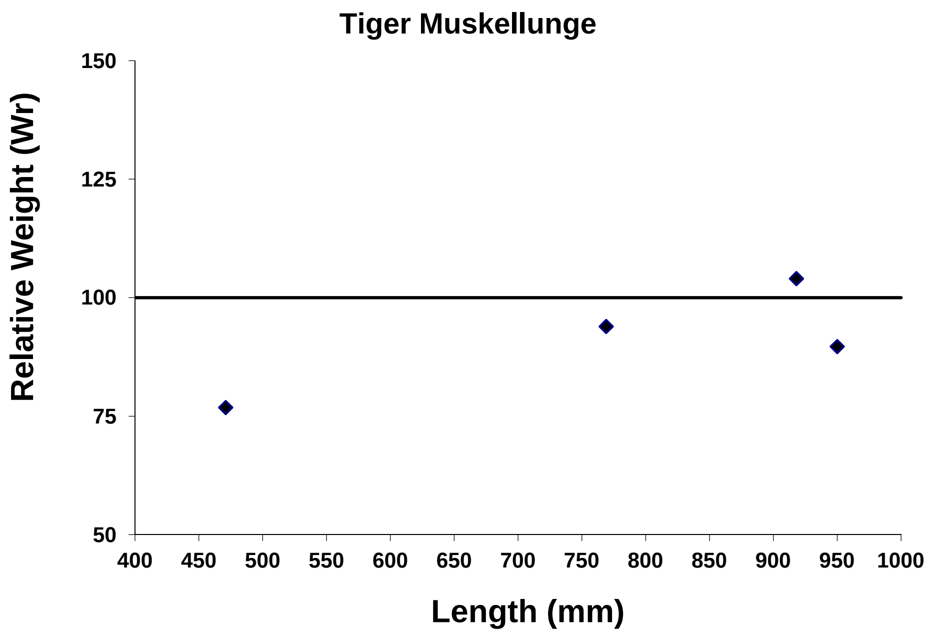

Figure 15. Relative weights of tiger muskellunge (n=4) sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Brown Bullhead

Brown bullhead sampled from Newman Lake ranged in total length from 181 to 351 mm (Table 4; Figure 16). Condition of Newman Lake brown bullhead was variable, but relative weights of most sampled fish fell below the national 75th percentile (Figure 17). Age and growth were not analyzed for brown bullhead.

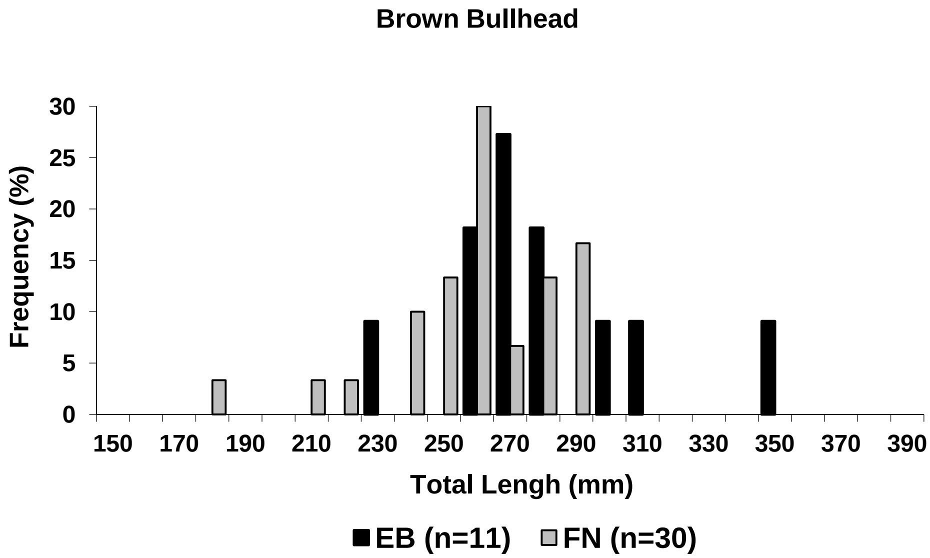

Figure 16. Length frequency distribution of brown bullhead sampled by electrofishing (EB) and fyke netting (FN) at Newman Lake (Spokane County) during June 2008.

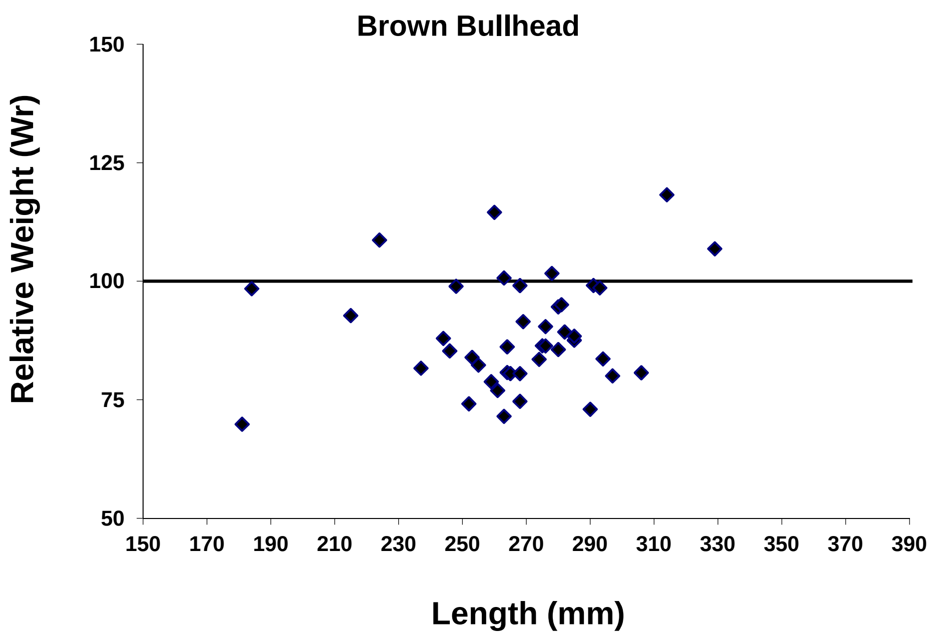

Figure 17. Relative weights of brown bullhead (n=43) sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Yellow Bullhead

Yellow bullhead sampled from Newman Lake ranged in total length from 162 to 285 mm (Table 4; Figure 18). Condition of Newman Lake yellow bullhead was variable with relative weights of sampled fish being both above and below the national 75th percentile (Figure 19). Age and growth were not analyzed for yellow bullhead.

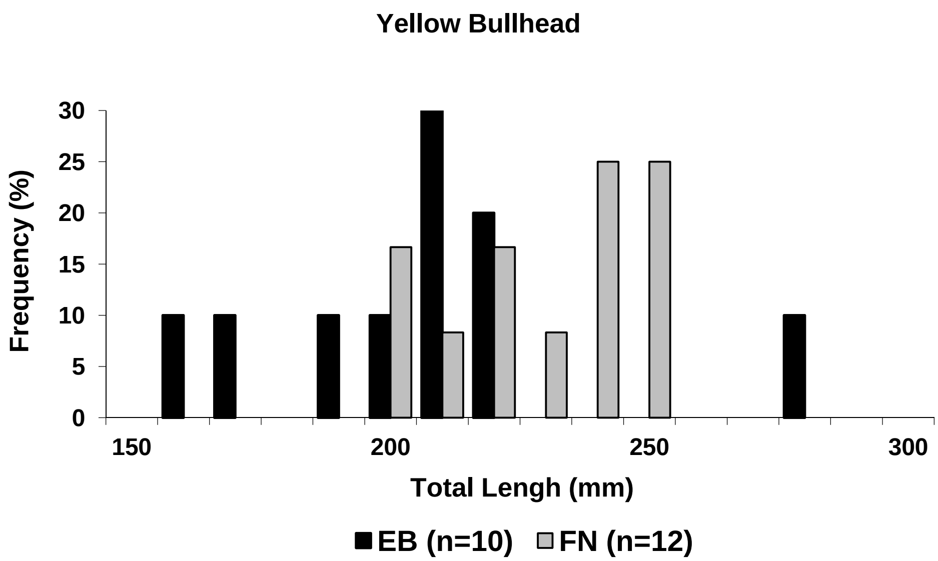

Figure 18. Length frequency distribution of yellow bullhead sampled by electrofishing (EB) and fyke netting (FN) at Newman Lake (Spokane County) during June 2008.

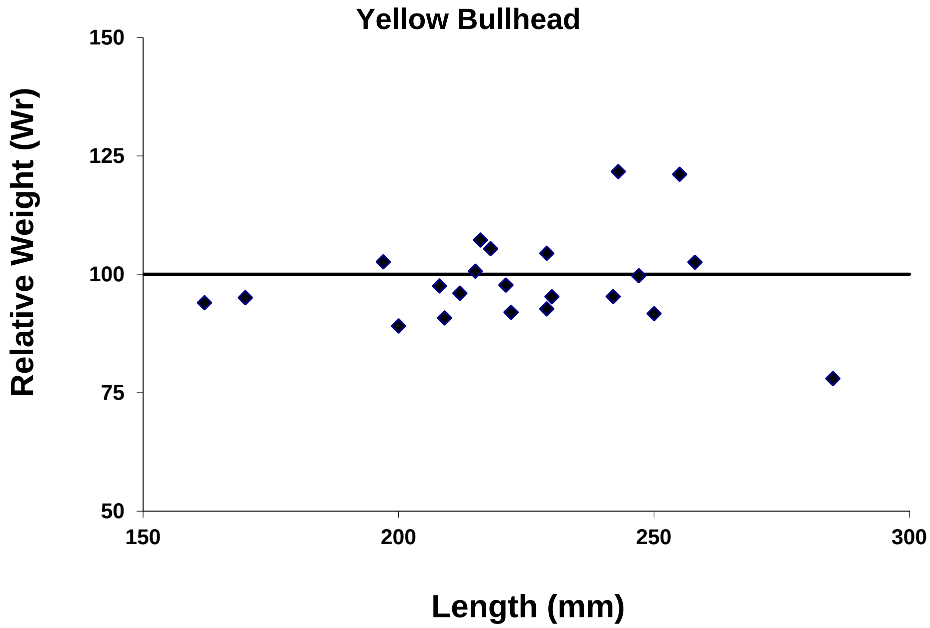

Figure 19. Relative weights of yellow bullhead (n=22) sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Rainbow Trout

Rainbow trout sampled from Newman Lake ranged in total length from 217 to 282 mm (Table 4; Figure 20). Condition of Newman Lake rainbow trout was variable, but relative weights of most sampled fish fell below the national 75th percentile (Figure 21). Age and growth were not analyzed for rainbow trout.

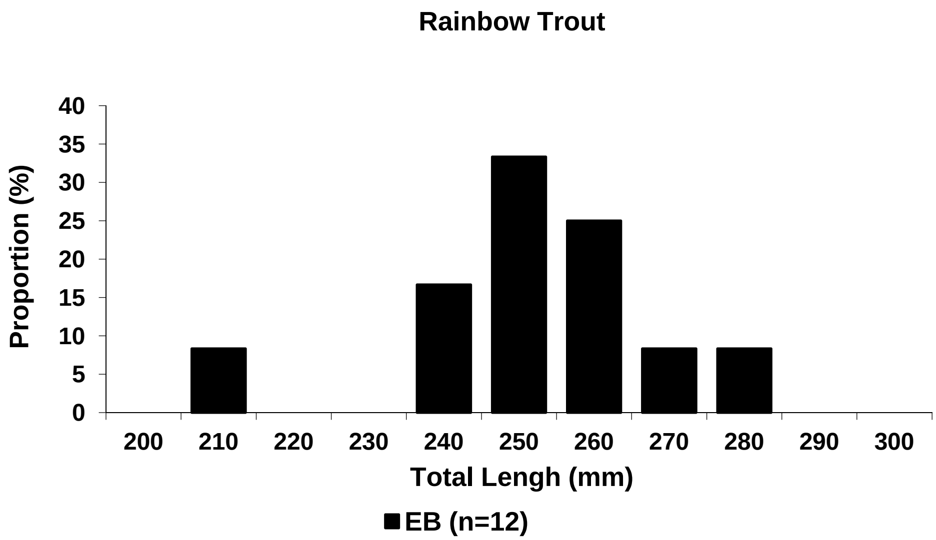

Figure 20. Length frequency distribution of rainbow trout sampled by electrofishing (EB) at Newman Lake (Spokane County) during June 2008.

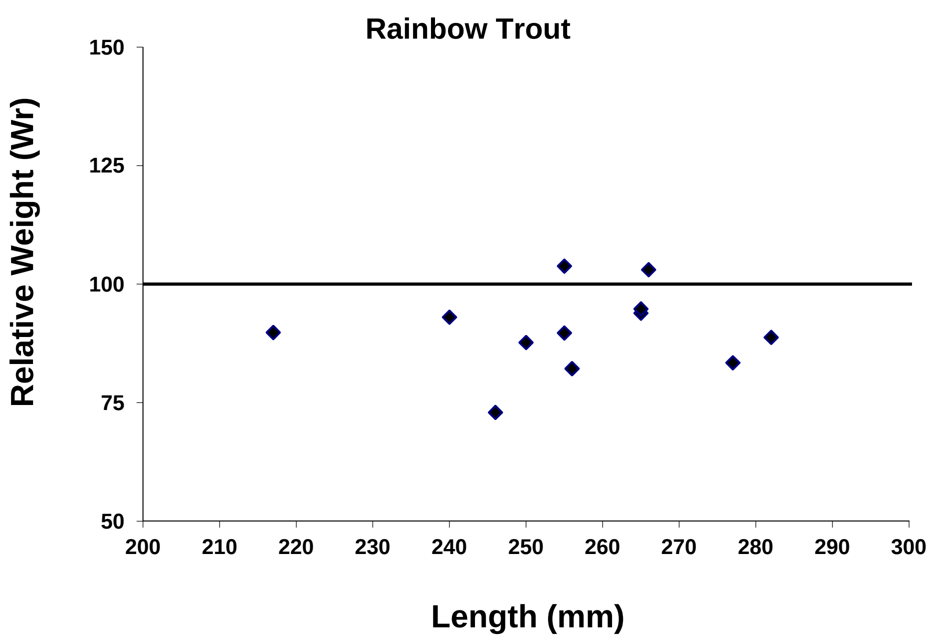

Figure 21. Relative weights of rainbow trout (n=12) sampled at Newman Lake (Spokane County) during June 2008, as compared to the national 75th percentile, W_r=100 (Anderson and Neumann 1996).

Discussion

Since 1992, over 10,300 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 (≥50 inches). Despite those efforts, Newman Lake shows indications of having a prey-crowded fish community dominated by bluegill sunfish and yellow perch less than quality size. Largemouth bass are also fairly abundant in the lake, and although many are small (<250 mm), stock density indices suggest anglers have opportunities to catch bass in the quality (300-380 mm) and preferred (380-510 mm) size range. Although the condition of pumpkinseed sunfish was not alarmingly low, relative weights of most bluegill sunfish, yellow perch, smallmouth bass, and smaller size largemouth bass (<300 mm) were far below the national 75th percentile which suggest that the smallmouth bass and largemouth bass are having to compete for available resources with their forage, as well as between themselves. In addition, the low stock density values for yellow perch and bluegill sunfish suggested that predation rates by largemouth bass, smallmouth bass, and tiger muskellunge appear to be insufficient to control stunting of those species.

In 2000, WDFW conducted a similar survey on Newman Lake to evaluate the warmwater fish populations in the lake (Osborne et al. 2004). Because the 2000 and 2008 surveys were conducted during different seasons, statistical comparisons of the data were not performed. However, descriptive results of both surveys suggest that, with few exceptions, little has changed with the fish communities between 2000 and 2008. In 2000, Newman Lake was characterized as having a prey-crowded fish community dominated by yellow perch and bluegill sunfish (Osborne et al. 2004). Although the fish community was prey-crowded in 2008 as well, the structure of that community has shifted from one being dominated by yellow perch, to one dominated by bluegill sunfish. As in 2000, most fish species sampled continue to be in relatively poor condition. Fewer largemouth bass were sampled in 2008 than in 2000. Despite this apparent decrease in relative abundance, condition of largemouth bass sampled remained below the national 75th percentile; particularly for fish <300 mm. This suggests that largemouth bass larger than quality size continue to have adequate forage, whereas smaller bass are forced to compete with the abundant bluegill and yellow perch for available resources. In addition, the stock density values for yellow perch, bluegill sunfish, and pumpkinseed sunfish in 2000 and 2008 were similar, suggesting that predation rates by the three primary predators (e.g., largemouth bass, smallmouth bass, and tiger muskellunge) continue to be insufficient to control the overpopulation of those prey species.

Although fewer black crappie were sampled in 2008 compared to 2000 (Osborne et al. 2004), the Newman Lake black crappie population continues to be above average in terms of its quality and the angling opportunity it provides. Newman Lake black crappie continue to exhibit faster than average growth and relatively high stock density values. However, condition of larger black crappie remains lower than the national average, which is common for populations in Washington. 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 in, both, 2000 and 2008 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. On the other hand, the low relative abundance and high growth rates suggest that supplemental stocking of crappie may provide additional angling opportunity for quality sized fish.

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 (Moore et al. 2006), 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, Moore et al. (2001) reported that hypolimnetic water typically remains above 3 mg/l during summer and the volume of oxygenated epilimnetic and metalimnetic water has increased. Warmwater fish can survive at dissolved oxygen concentrations of 3 mg/l; however, their desired range is >5 mg/l (Swingle 1969). Low dissolved oxygen concentrations may be limiting open water fish habitat during certain times of the year, and the effects of the low dissolved oxygen on warmwater fish populations in Newman Lake are unknown. 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 warmwater fish community.

Considering the current water quality limitations, and the potential resulting fish community responses, options for including trout in the management of the lake are somewhat limited. To provide anglers with trout fishing opportunities at Newman Lake, trout would have to be stocked at a relatively large size as to reduce the effects of predation. Stocking fish in the spring may provide anglers put-and-take trout fishing opportunity until early summer when water quality conditions and potential predator concentration could severely limit trout survival.

Management Considerations

Tiger Muskellunge Stocking

The two objectives for stocking tiger muskellunge in Newman Lake were to reduce the abundance of panfish and nuisance species in the lake, and to provide anglers with an opportunity to catch trophy size fish. As of 2008, the first objective has not been met and the second objective has only been marginally successful. 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. 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. Increasing the number of tiger muskellunge may reduce the density of panfish and nuisance species populations, and thus increasing the growth potential for other warmwater gamefish in the lake.

Although tiger muskellunge have yet to control the overpopulation of panfish and nuisance species in the lake, they have provided anglers with a unique angling opportunity found in only a select few waters in the state. Although growth rates of tiger muskellunge in Newman Lake are less compared to those seen in Silver (Spokane County) and Curlew (Ferry County) lakes, tiger muskellunge fishing in Newman Lake remains a popular activity for a variety of angler types. Newman Lake has become a regular tournament destination for both private (Cascade Musky Association) and national (Muskies Inc. Chapters 57 and 60) fishing clubs and has hosted six tiger muskellunge tournaments since 2009 (Bruce Baker, WDFW, Personal communication). 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.

Tiger muskellunge have been stocked almost annually in Newman Lake since 1992. However, the oldest tiger muskellunge observed during both surveys (2000 and 2008) was three years of age. Although we know tiger muskellunge can grow to large sizes and up to 7 years of age in this lake (Osborne et al. 2012), relatively little is known about their survival. It is unknown whether the absence of fish older than three years of age in our warmwater surveys is due to poor survival or our inability to capture a representative sample with gears (shoreline electrofishing, gill netting, and fyke netting) used in the warmwater sampling protocols. Results from a biotelemetry study (Osborne et al. 2012) conducted at Newman Lake between 2004-2006 suggests that WDFW standard warmwater sampling protocols may not be overly effective at sampling tiger muskellunge populations since up to 75% of recorded tiger muskellunge locations were in areas of the lake not sampled using the standard sampling protocols. Considering this, the formulation of specific protocols for monitoring tiger muskellunge populations should be considered. Additionally, marking individual tiger muskellunge could provide information that would bolster efforts to evaluate survival of stocked fish. An understanding of tiger muskellunge survivability will help fisheries managers best manage this species in the lakes in which they are stocked.

Channel Catfish Stocking

We recommend stocking Newman Lake with channel catfish to reduce numbers of panfish and other nuisance fish species and to provide an additional sportfishing opportunity for anglers. Tiger muskellunge have been stocked almost annually in Newman Lake, but have yet to successfully prevent the overpopulation of panfish and other nuisance species in the lake. Because of this, the introduction of an additional predatory species, such as channel catfish *Ictalurus punctatus* (Swingle 1954; Perry 1969; Wydoski and Whitney 2003), may be warranted. In addition to largemouth bass and tiger muskellunge, stocking channel catfish would help restore the predator-prey balance in Newman Lake by reducing numbers of panfish and other nuisance species. Also, channel catfish are a sport fish desirable to anglers, especially during seasons when other species may be difficult to locate and catch (O’Shea and Hubert 1991).

Channel catfish are considered an important sport fish by most fish and game agencies throughout the United States (Eder and McDannold 1987). Bonar et al. (1997) reported that growth and survival rates of channel catfish studied in six Washington lakes were similar to those observed in the eastern and southern regions of the United States, and also suggested that stocking channel catfish in this region should provide viable put-grow-and-take fisheries. At least 35 lakes in Washington have been stocked with channel catfish since 2005 (Bruce Bolding, WDFW, personal communication). In 2011 alone, more than 49,700 fish were stocked into 30 lakes across Washington State. In addition to their recreational value, fisheries managers can also use channel catfish as an additional predator in systems overpopulated with undesirable species. Channel catfish have proven to be a suitable species to stock in waters with preestablished predator populations (Krummrich and Heidinger 1975; Powell 1976; Hanson 1989; Cole et al. 1991; O'Shea and Hubert 1991; Michaletz et al. 2008).

Moore et al. (2001) reported that dissolved oxygen in Newman Lake's hypolimnion typically remains above 3 mg/l during the summer due to the continued operation of the aerator. Although the desired range of dissolved oxygen for most warmwater fish is at least 5 mg/l (Swingle 1969), channel catfish can tolerate slightly lower oxygen levels. Torrans (2008) suggested that a dissolved oxygen concentration of 2.3-2.5 mg/l is a practical target for fish farms raising channel catfish. In addition to slightly lower dissolve oxygen, channel catfish can also tolerate pH values up to 9.0 and temperatures ranging from 0.5-35°C (Piper et al. 1982). Considering these tolerances, channel catfish should be able to provide anglers a year-round fishery at Newman Lake.

We recommend stocking Newman Lake with 10,000 channel catfish (8.3 fish/acre) the first year, and restocking the lake with 3,000 fish (2.5 fish/acre) every other year thereafter. Stocking rates used by fish and game agencies across the United States greatly varied, but were typically adjusted once post-stocking performance (growth) was determined (Hanson 1989; Michaletz 2009). Channel catfish should be a minimum of 200 mm TL at time of stocking to minimize losses due to predation (Krummrich and Heidinger 1975). Studies have found that stocking channel catfish ≥ 200 mm TL resulted in relatively high survival rates and the greatest return to the creel (Spinelli et al. 1985; Storck and Newman 1988; Hanson 1989; O'Shea and Hubert 1991; Santucci et al. 1994; Michaletz et al. 2008). Currently, WDFW purchases 8-11 inch (200-279 mm) channel catfish (certified disease-free) from Hopper-Stephens Hatcheries, Incorporated (Lonoke, AR) at a cost of $0.84/fish, which includes delivery. Based on the proposed stocking rates, the cost for the initial stocking into Newman Lake would be $8,400 (10,000 fish x $0.84/fish), whereas the cost of subsequent plants would cost $2,520 (3,000 fish x $0.84/fish) each. Once channel catfish have been stocked into Newman Lake, periodic surveys should be conducted to determine the performance of stocked fish and to determine whether future stocking rates and/or fish size should be adjusted.

Slot-limit Regulation Monitoring

The 12-17 inch slot-limit on largemouth bass was implemented in May 1999, and the indices of population structure from the fall 2000 survey were likely representative of the population under the previous regulation. If the slot-limit regulation performs as intended, numbers of bass within the protected size range should increase in time. However, as of spring 2008, numbers of largemouth within the protective slot had only slightly increased. A total of 14 largemouth bass between 12-17 inches were sampled in 2008 compared to 11 sampled in 2000. Although numbers of largemouth bass within the protected slot have remained essentially unchanged between 2000 and 2008, numbers of fish directly below the slot (~220-300 mm TL) have become more abundant. The reason for the shift in largemouth bass size structure is unknown, but could have been caused by the advancement of a stronger year class or the catch-and-release techniques practiced by many bass anglers. Although length-frequency data (Figure 2) suggest that numbers of bass in the protected size range continue to be low, management biologists should consider developing a long-term monitoring plan to document any changes in the Newman Lake fish community under the more restrictive regulation. Objectives of such a program should focus on documenting changes in population density, size structure, and condition of largemouth bass, and changes in panfish population structure possibly due to increased predation by largemouth bass. Additionally, creel survey data should be collected regularly to evaluate angler compliance.

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 collected 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 angler preferences, 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 1990's, nutrient loading and blue-green algal productivity have been reduced (Washington Department of Ecology 2002; Moore et al. 2006), 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 slightly improved but has yet to be fully 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 also increased over the past two decades.

Problems associated with carp populations have plagued fisheries managers all around the world, and although much money and effort has been spent to improve the water quality at Newman Lake, this species has been previously overlooked as a potential limiting factor in achieving the water quality objectives in this system. Carp are a prolific, invasive species that have established populations on every continent except Antarctica (Penne and Pierce 2008). Carp are responsible for the deterioration of environmental health in most systems they inhabit and are also a potential obstruction to improvement of those systems (Schrage and Downing 2001; Wahl 2001). Numerous researchers have reported that carp physically uproot aquatic vegetation, resuspend large amounts of sediment into the water column, and can change a system from one that has clear water and abundant vegetation (clear-water state) into one considered a turbid-water state with little vegetation and light penetration (Crivelli 1983; Sidorkewicj et al. 1998; Zambrano et al. 2001; Beklioglu et al. 2003; Chumchal et al. 2005; Miller and Crowl 2006; Colvin et al. 2009; Wanner et al. 2009; Weber and Brown 2011). Besides increased turbidity, the elimination of aquatic vegetation can result in an invertebrate community dominated by bottom dwelling insects and, ultimately, a fish community dominated by bottom feeding species like carp (United States Fish and Wildlife Service 2010). Also, as water quality continues to deteriorate, the deleterious effects of carp increases, while the predatory control of piscivorous fish simultaneously decreases (Bonneau et al. 1995; Colvin et al. 2009; United States Fish and Wildlife Service 2010).

Carp have hindered water quality improvement efforts in numerous systems around the world and the carp population in Newman Lake may be no exception. However, the level of impediment carp are contributing to water quality recovery efforts in Newman Lake is unknown. Because of this, studies to determine the biomass of carp in the lake, and ultimately whether they pose problems, are warranted. Bajer et al. (2009) suggest that carp densities >100 kg/ha pose a serious threat to habitat and water quality in shallow lakes. In that study, Bajer et al. (2009) observed a 50% decrease in both vegetation and waterfowl use when carp densities exceeded 100 kg/ha. Other studies (Bouffard and Hanson 1997; Crivelli 1983; Chumchal et al. 2005; Haas et al. 2007; Jackson et al. 2010) reported similar findings in that carp densities between 100-200 kg/ha can be detrimental to fish and wildlife habitat, water quality, and ecosystem integrity.

If the carp population in Newman Lake is identified as a limiting factor in meeting water quality restoration objectives, measures should be taken to reduce their densities or eliminate the species from the lake entirely. To accomplish this, fisheries managers have several options. If the goal is to eradicate carp from the lake, the lake should be treated with Rotenone. Rotenone is a naturally-occurring substance derived from roots of tropical plants found in Australia, southern Asia, and South America. This substance has been used for centuries in areas where it naturally occurs for capturing fish. Since the 1930's, it has been commonly used in North America as a natural herbicide for plants and livestock, as well a valuable fisheries management tool. In fisheries management, Rotenone can be applied to a lake to kill off all of the existing fish, and then the lake can be restocked with more desirable fish species.

If the goal is to reduce the number of carp in the lake, fisheries managers can use several mechanical removal techniques, either singly, or in combination, in an attempt to achieve the desired density. Possible mechanical removal techniques include intensive netting or trapping projects, commercial carp fisheries, and the promotion of the carp fishery to anglers and/or archers. Projects to mechanically remove carp, such as netting and commercial harvest, can be time consuming and costly, and may not be overly effective (Koehn et al. 2000) due to this species' reproductive capabilities. Although likely ineffective by themselves, harvest from angling and archery could be used to augment the removal of carp through other large-scale removal activities.

Overall, we encourage the DOE to continue monitoring efforts, the operation of the aerator and alum injection system such that water quality and habitat conditions can continue to improve and become favorable for resident fisheries. We also recommend monitoring the carp population in the lake to determine whether, or to what extent, this species is obstructing water quality restoration goals. If carp are an obstruction, the regulation of carp density should be integrated into the comprehensive water quality management scheme of Newman Lake.

Lake User Conveniences

Construction of the current access site occurred in 1986-7, 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. 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 was lined with rock to prevent erosion. Because of the rocky shoreline and concrete ramp, it was difficult for boaters to load or unload passengers and gear without damaging their vessels, even under calm lake conditions. In addition, recent ice events and heavy use damaged and degraded the ramp area, making conditions hazardous for ramp users. These conditions prompted WDFW personnel to seek funding through RCO to make the necessary improvements to the Newman Lake access site.

Personnel from WDFW's Fish Program, Access Program, and Engineering Office applied for, and received a grant through the Washington State Recreation and Conservation Office (RCO) Washington Water Resource Program. Money from this grant was used to install an ADA approved fishing pier, gangway, paved pathways, and parking pads which was completed in September 2010. A separate grant was applied for through the RCO Boating Facilities Program, and was received in 2011. This grant was used to reconstruct the boat ramp and armoring surrounding the ramp, install a new boat loading float, and repair the parking and maneuvering area. Reconstruction of the boat ramp was completed in fall 2011 and the new boat loading float will be installed in spring 2012.

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