1998 Warmwater Fish Survey of Worth Lake, Franklin County, Washington

by

Marc Divens and Larry Phillips
Washington Department of Fish and Wildlife
Warmwater Enhancement Program
8702 N Division Street
Spokane, Washington 99218-1199

August 2000

Acknowledgments

From the Washington Department of Fish and Wildlife (WDFW) we thank J. Pahutski, P. Round, and T. Nelson for data collection; C. Donley for assisting with data analysis; D. Fletcher for aging scales; S. Bonar, B. Bolding, S. Caromile, W. Meyer, K. Mueller, and M. Downen for technical advice; and J. Cummins, K. Divens, J. Easterbrooks, and S. Jackson for providing critiques of the manuscript. This project was funded through the WDFW Warmwater Enhancement Program in an effort to provide greater opportunities to fish for and catch warmwater fish in Washington State.

Abstract

Worth Lake (Franklin County) was surveyed by a three person assessment team September 21 - 22, 1998. Fish were captured using boat electrofishing, gill netting and fyke netting. Largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), common carp (*Cyprinus carpio*), and sculpin (*Cottus* spp.) were captured. Largemouth bass comprised the highest proportion of the catch by number. Common carp were the most abundant by weight. A high density largemouth bass population, as indicated by catch per unit effort, showed above average growth and condition. Few yellow perch were captured limiting the interpretation of population indices for the species. Sculpin, which were collected in high numbers, may be an important prey item for largemouth bass in Worth Lake considering the low abundance of yellow perch and the absence of other panfishes. Common carp do not appear to be negatively affecting the largemouth bass population at the time of this survey, but should be monitored.. Management options include evaluating the feasibility of constructing a barrier to prevent the immigration of unwanted species, removing carp using electrofishing and netting, and imposing a slot-limit on largemouth bass.

Table of Contents

List of Tables

List of Figures

Introduction

Worth Lake (Figure 1) is a small body of water located northwest of Mesa (surface area = 12 acres; mean depth = 2 m [6 ft]; max depth = 3.5 m [12 ft]). Worth Lake is fed intermittently by irrigation and wetland runoff. An irrigation canal is the only outlet to the lake. Development around the lake is low and limited to agriculture.

Historically, Worth Lake has provided rainbow trout (*Oncorhynchus mykiss*) and warmwater angling opportunities. In 1969 the lake was rehabilitated with rotenone to eliminate common carp (*Cyprinus carpio*). However, common carp inhabit the lake today as a result of immigration, limited rehabilitation success, or illegal reintroduction. Following the rehabilitation, the lake was periodically stocked with rainbow trout which provided some angling opportunity. No stocking of Worth Lake has occurred recently. Today, angling opportunities are the result of naturally reproducing warmwater fish populations and statewide general regulations apply.

A Washington Department of Fish and Wildlife (WDFW) parking site provides good shoreline, float tube, and car-top boat access to the lake.

WDFW Warmwater Enhancement Program personnel conducted this survey of Worth Lake in September 1998 to assess the current state of the fish community and to identify possible enhancement opportunities.

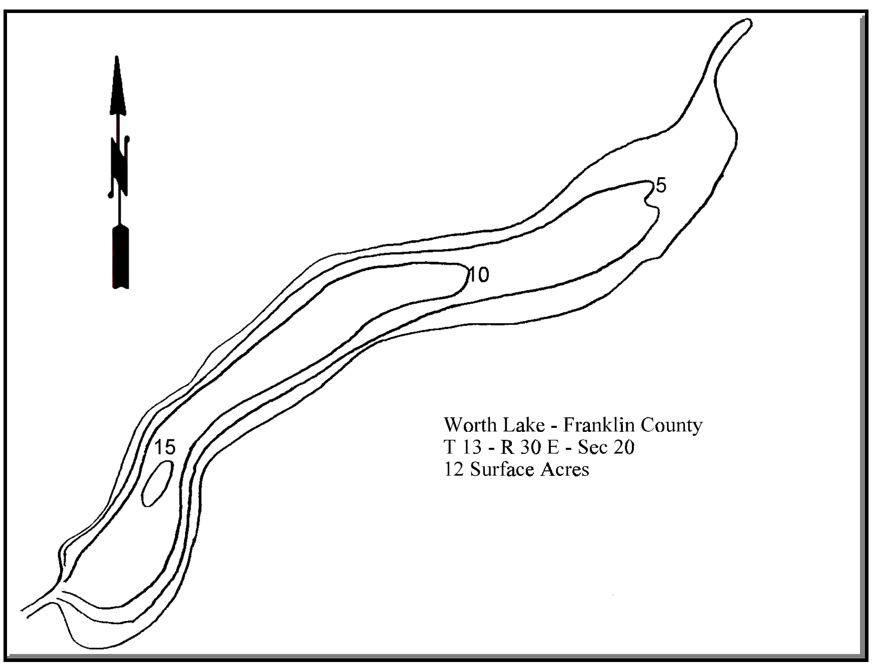

Figure 1. Map of Worth Lake, Franklin County.

Methods

Sampling

Worth Lake was surveyed by a three person assessment team September 21 - 22, 1998. Fish were captured using boat electrofishing, gill netting and fyke netting. The electrofishing unit consisted of a 5.5 m Smith-Root 5.0 GPP "shock boat" using a DC current of 120 cycles / sec $^{-1}$ at 5 to 6 amps power. Experimental gill nets (45.7 m long x 2.4 m deep) were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable mesh size (1.3, 1.9, 2.5, and 5.1 cm stretched mesh) monofilament. Fyke nets were constructed of a main trap net (4.7 m long and 1.2 m diameter), a lead net (30.5 m long x 1.2 m deep) and two wings (7.6 m long x 1.2 m deep).

Sampling locations were selected by dividing the shoreline into 8 consecutively numbered sections of approximately 400 meters each. Three sections were randomly selected for sampling by boat electrofishing, two were selected for gill netting, and two were selected for fyke netting using a random number generator (Casio fx-991D scientific calculator). The electrofishing boat was maneuvered slowly through shallow water (depth range = 0.2 - 1.5 m) while following the shoreline. Gill nets were set perpendicular to the shoreline with the small mesh end attached onshore and the large mesh end anchored offshore. Fyke nets were set perpendicular to the shore with the lead net anchored onshore and the wing nets set at a 45 degree angle to the trap. Length of the lead from shore and depths at which fyke nets were set varied with the slope of the shoreline. Sampling was conducted during evening hours to maximize the type and number of fish captured. Samples were weighted so as to achieve a standardized 1:1:1 ratio of electrofishing to gill netting to fyke netting (1:1:1 - 1800 seconds boat electrofishing:24 gill net hours:24 fyke net hours). This methodology is employed to reduce bias between gear types (Fletcher et al. 1993). Total electrofishing time was 1800 seconds ("pedal-down" time), or one standard unit. Total gill net and fyke net time equaled one standard unit of two nets of each type fished for one night.

Each fish captured was identified to species, measured (mm) for total length (TL) and weighed (g). Scales were collected from largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) to analyze age and growth. Scale samples (up to five per 10 mm length class) were mounted, pressed, and aged according to Jearld (1983) and Fletcher et al. (1993).

Data Analysis

Percentages of the total biomass and number of fish collected for each species provides useful information regarding the balance and productivity of the community (Swingle 1950; Bennet

1962; Fletcher et al. 1993). Species composition by weight (kg) and number was calculated from data collected using boat electrofishing, gill netting, and fyke netting.

Catch per unit effort (CPUE) by sampling method was determined for each fish species collected (number of fish/hour electrofishing and number of fish/net night). The CPUE for each fish species was calculated using only stock length fish and larger. Stock length, which varies by species, is the size of a particular fish species that offers threshold recreational value to an angler (Anderson 1976). Randomly chosen sample sections can contribute to high variability among samples, therefore 80% confidence intervals (CI) were calculated for each mean CPUE by species and by sampling method. Each CI was calculated as the mean $\pm t(\propto, N\text{-}1) \times SE$, where t=Student's t for $\propto$ confidence level with $N\text{-}1$ degrees of freedom (two tailed) and SE=standard error of the mean. When standardized sampling is used, CPUE is a useful index that can be used to compare lakes within the State of Washington and monitor changes in relative abundance over time.

Length frequency histograms (percent frequency captured by different sampling methods) were used to evaluate the size structure of all warmwater fish species collected.

Proportional stock density (PSD), calculated as the number of fish$\geq$quality length/number of fish$\geq$stock length$\times$100, was determined for each warmwater fish species collected (Anderson and Neuman 1996). PSD can provide information about the proportion of various size fish in a population and can be a useful tool when sample size is adequate (Willis et al. 1993; Divens et al. 1998). Stock and quality lengths used in the calculation of PSD are based on a percentage of world record catch length and vary depending on fish species (Table 1). Stock lengths (20-26% of the world record) refer to the minimum length that fish are of recreational value, and quality lengths (36-41% of the world record) refer to the minimum length of fish anglers prefer catching. In addition to stock and quality length, Gabelhouse (1984b) introduced preferred, memorable, and trophy length categories. Preferred length (45-55% of world record length) refers to the length fish anglers would prefer to catch if given a choice. Memorable length (59-64% of the world-record length) refers to the minimum length fish most anglers remember catching, whereas trophy length (74-80% of world record length) refers to the minimum length a fish is worthy of acknowledgment.

Table 1. Length categories for warmwater fish captured at Worth Lake (Franklin County), September 1998. Measurements are minimum total lengths (mm) for each PSD and RSD category.

Species	**Size**				
	Stock	**Quality**	**Preferred**	**Memorable**	**Trophy**
Largemouth Bass	200	300	380	510	630
Yellow Perch	130	200	250	300	380

The relative stock density (RSD), calculated as the number of fish$\geq$specific length/number of fish$\geq$stock length$\times$100, was also calculated for each game fish species. Like PSD, it can also provide useful information regarding population dynamics and is more sensitive to changes in year-class strength. For example, RSD-P was the percentage of stock length fish greater than or equal to preferred length, RSD-M, the percentage of stock length fish that are greater than or equal to memorable length, and so on. 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).

Age and growth of largemouth bass and yellow perch was evaluated using the direct proportion method (Fletcher et al. 1993) and Lee's modification of the direct proportional method (Carlander 1982). Although Lee's modification corrects for species-specific threshold length at the time of scale formation, direct proportion allows for comparison of growth with in-state survey averages previously calculated using direct proportion (Fletcher et al. 1993). We have chosen to present the results for calculations from both methods until survey averages can be developed using Lee's modification. Using the direct proportional method, total length at annulus formation, L_n, was back-calculated as $L_n=(A\times TL)/S$, were A is the radius of the fish scale at age n, TL is the total length of the fish captured, and S is the total radius of the scale at capture. Using Lee's modification, L_n was back-calculated as $L_n=a+A\times(TL-a)/S$, where a is the species-specific standard positive y-axis intercept from a scale radius-fish length regression. Mean back-calculated lengths at age n for each species were presented in tabular form for easy comparison of growth between year classes, as well as between the lake average and what has been found in other in Washington for the same species using the direct proportion method (Fletcher et al. 1993).

Relative weight (Wr) index was used to evaluate the condition of fish in the lake. Relative weight is useful for comparing the condition of different size groups within a single population to determine if all sizes are finding adequate forage (ODFW 1997). A Wr value of 100 generally indicates average condition compared to the national average for a species. This index was calculated as $Wr=W/Ws\times 100$, where W is the weight (g) of an individual fish and Ws is the standard weight of a fish of the same length (mm) (Murphy and Willis 1991). *Ws* is calculated from the standard log10 weight-log10 length relationship defined for the species of interest. Anderson and Neumann (1996) list the parameters for the Wr equations of many warmwater fish species, including the minimum length recommendations for their application. Wr values calculated from this survey were compared to the national average (Wr=100) for each species.

Results

Species Composition

Four species were collected at Worth Lake in September 1998 (Table 2). Largemouth bass was the most abundant species by number. The relatively few (32), but large, common carp made up the majority of the catch by weight. Together largemouth bass and common carp totaled (98%) of the catch by weight. Yellow perch and sculpin (*Cottus* spp.) were sampled at lower densities.

Table 2. Species composition by weight (kg) and number of fish captured at Worth Lake (Franklin County) during September 1998.

Species	by Weight (kg)	by Weight (%)	by Number (#)	by Number (%)	Size Range (mm TL) Min	Size Range (mm TL) Max
Common Carp	33.50	57.93	32	7.86	288	618
Largemouth Bass	23.00	39.78	331	81.33	69	454
Yellow Perch	0.87	1.50	17	4.18	105	291
Sculpin	0.46	0.79	27	6.63	69	185

CPUE

Stock length largemouth bass were captured at the highest rate by electrofishing at 118 fish per hour. Sculpin were captured by electrofishing at 52 fish per hour. Stock length common carp and yellow perch catch rates were lower by number. Few fish were captured by gill netting except common carp. No stock length fish of any species were captured by fyke netting (Table 3).

Table 3. Mean catch per unit effort by sampling method including 80% confidence intervals for stock length fish collected from Worth Lake (Franklin County) during September 1998.

Species	Electrofishing (#/hour)	Electrofishing Sites	Gill Netting #/Net Night	Gill Netting Net Nights	Fyke Netting #/Net Night	Fyke Netting Net Nights
Largemouth Bass	118.00 ± 93.58	3	2.50 ± 1.92	2	0	2
Sculpin, Unknown	52.00 ± 59.12	3	0.50 ± 0.64	2	0	2
Common Carp	30.00 ± 24.72	3	8.50 ± 10.89	2	0	2
Yellow Perch	2.00 ± 2.56	3	0.50 ± 0.64	2	0	2

Stock Density Indices

Considering the limited amount of sampling conducted for this survey, the catch of stock length largemouth bass was high compared to other lakes surveyed (Unpublished data, WDFW). Largemouth bass PSD was 8 ± 5 indicating an abundance of stock length fish (Table 4). A RSD-P value of 7 ± 4 indicates that the lake does have a number of largemouth bass of preferred length (380 mm or 15 inches).

Yellow perch catch was so limited no calculation or interpretation of stock density indicies was possible for the population from data collected in this survey.

Table 4. Traditional stock density indices, including 80% confidence intervals, of fish collected from Worth Lake (Franklin County) September 1998 by sampling method.

Species	Electrofishing				
	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
Largemouth Bass	59	8 ± 5	7 ± 4	0	0

Largemouth Bass

Worth Lake largemouth bass sampled ranged in size from 69 to 454 mm TL (Table 2; Figure 2). The age of largemouth bass from which scales were collected for analysis ranged from one to five years (Table 5). Largemouth bass growth rates were higher than the known Washington average at all age classes sampled. Largemouth bass condition was high compared to the national 75th percentile and appeared to increase as length increased indicating adequate forage (Figure 3).

Table 5. Age and growth of largemouth bass sampled from Worth Lake (Franklin County) September 1998. Unshaded values are mean back-calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification (Carlander 1982).

Year Class	# Fish	Mean length (mm) at age				
		1	2	3	4	5
1997	34	83				
		92				
1996	37	85	179			
		97	183			
1995	37	85	179	220		
		101	181	224		
1994	2	92	214	283	324	
		107	222	288	326	
1993	3	124	188	276	344	385
		139	199	283	348	387
Direct proportion Overall Mean		94	189	260	334	385
Lee's Weighted Mean		97	186	262	339	387
Direct Proportion State Average		68	135	190	248	300

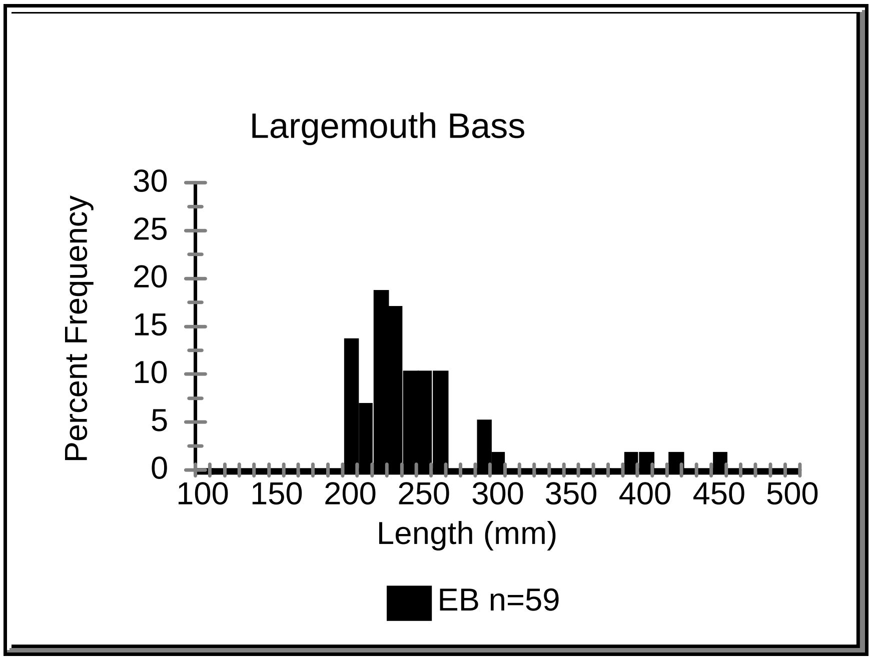

Figure 2. Length frequency distribution of stock length largemouth bass sampled at Worth Lake (Franklin County) September 1998 by boat electrofishing (EB).

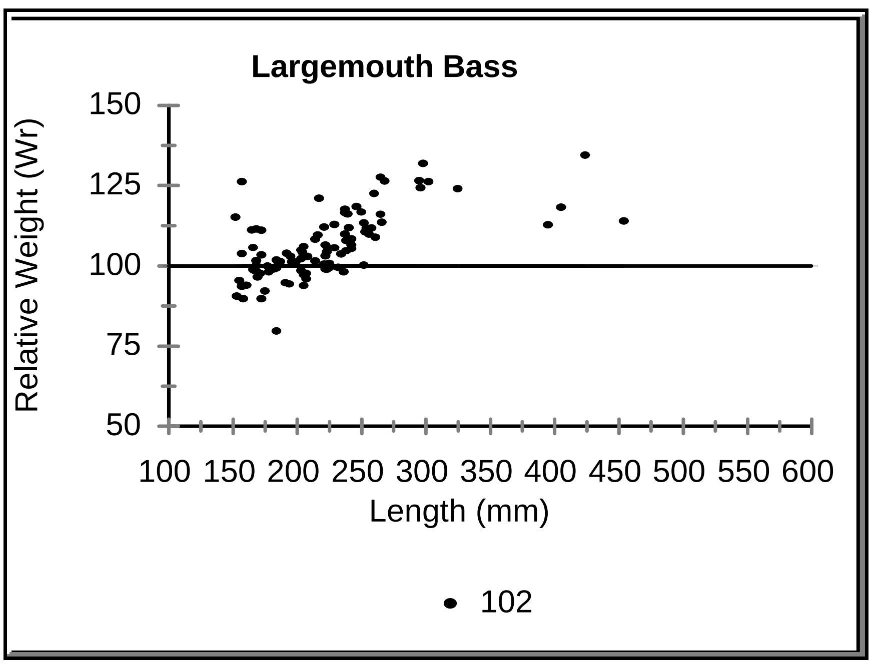

Figure 3. Relative weight of largemouth bass sampled at Worth Lake (Franklin County) September 1998.

Yellow Perch

Worth Lake yellow perch sampled ranged in size from 105 to 291 mm (Table 2; Figure 4). Yellow perch were aged as one and three years (Table 6). Growth rates from the few fish aged were higher than the known Washington average at one and three years. Relative weight showed below average condition compared to the national average (Figure 5).

Table 6. Age and growth of yellow perch sampled from Worth Lake (Franklin County) September 1998. Unshaded values are mean back-calculated length at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification (Carlander 1982).

Year Class	# Fish	Mean length (mm) at age		
		1	2	3
1997	6	85		
		94		
1996	0	0	0	
1995	2	85	207	250
		106	215	253
Direct Proportion Overall Mean		85	207	250
Lee's Weighted Mean		97	215	253
Direct Proportion Average		60	120	152

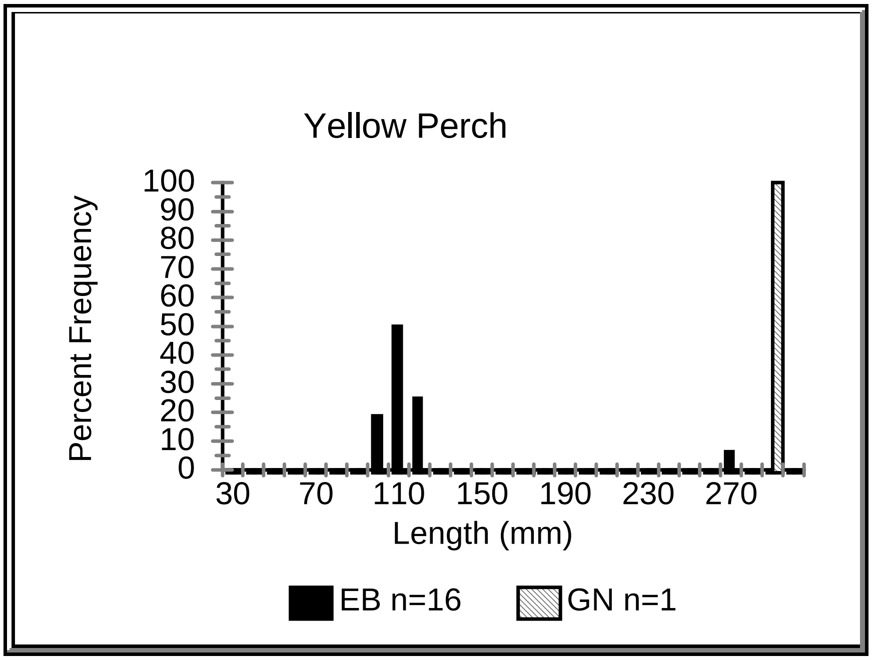

Figure 4. Length frequency distribution of yellow perch sampled at Worth Lake (Franklin County) September 1998 by boat electrofishing (EB) and gill net (GN).

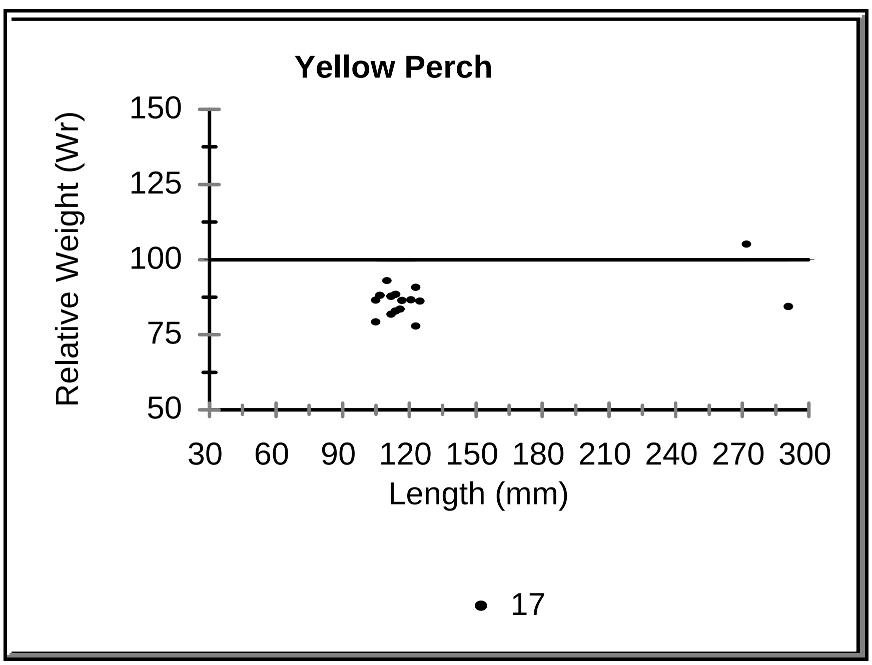

Figure 5. Relative Weight of yellow perch sampled at Worth Lake (Franklin County) September 1998.

Sculpin

Worth Lake sculpin ranged in size from 69 to 185 mm (Table 2; Figure 6).

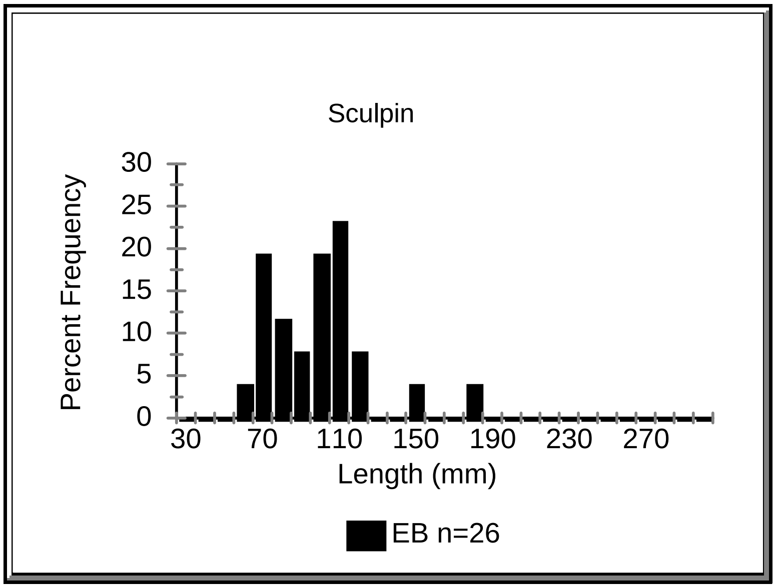

Figure 6. Length frequency distribution of sculpin sampled at Worth Lake (Franklin County) September 1998 by boat electrofishing (EB).

Common Carp

Worth Lake common carp ranged in size from 288 to 618 mm (Table 2; Figure 7). Common carp made up the greatest proportion of the catch by weight in the sample (Table 2). Common carp of several size classes were captured indicating natural reproduction or immigration.

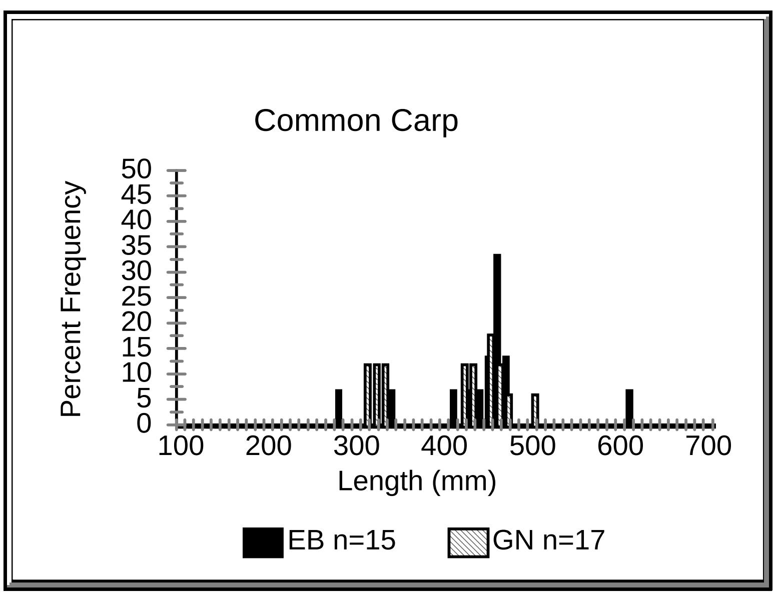

Figure 7. Length frequency distribution of common carp sampled at Worth Lake (Franklin County) September 1998 by boat electrofishing (EB) and gill net (GN).

Discussion

Warmwater fisheries managers typically consider the “balance” between predator and prey fish populations when assessing warmwater fish communities. The term balance is used loosely to describe a system in which omnivorous prey fish maximize food resources to produce harvestable-size fish stocks for anglers and an adequate forage base for piscivorous fish (Bennett 1962). Fish communities may otherwise typically be described as being prey-crowded or predator-crowded. To provide quality warmwater fishing opportunities, predatory gamefish species such as largemouth bass must be able to reproduce and grow to control overpopulation of both prey and predator species.

Due to the small number of sections sampled, and number of fish sampled, interpretation of the results is difficult and less than conclusive. However, some inferences can be made from analysis of the data collected. In September 1998, Worth Lake showed indications of having a prey crowded, fish community dominated by small largemouth bass, yellow perch, and sculpin. The high abundance and condition of largemouth bass indicates abundant forage and limited interspecific competition. The relatively low number of yellow perch sampled in this survey may be attributed to the limited sampling conducted or representative of their limited abundance. Additional sampling of the yellow perch may reveal additional information about the population.

The common carp collected comprised a high proportion of the catch by weight, however were few in number. The low number and lack of small common carp suggests that natural reproduction is not occurring in Worth Lake. Common carp are likely immigrating into the lake via the irrigation canal system. Considering the high abundance, growth, and condition of largemouth bass sampled, carp did not appear to be negatively impacting the population at the time of this survey. The impact common carp may have on yellow perch is uncertain. A high density of common carp can affect water quality, reduce total zooplankton biomass, reduce the production of more desirable gamefish species, and reduce angler success. Lougheed et al. (1998) saw an increase in turbidity, total phosphorus, and total ammonia and a reduction in total zooplankton biomass in experimental enclosures with common carp. Drenner et al. (1997) did not see a significant difference in the density of catchable-sized largemouth bass (> 200 mm total length) in ponds with and without common carp. However, higher turbidity in ponds with common carp significantly reduced angler catch rates. The relatively high proportion of common carp at Worth Lake may be limiting the abundance of yellow perch and largemouth bass. However, it is difficult to assess the full impact of common carp on the fish community from the data collected during this limited survey. If future surveys indicate that control measures are required there are several techniques which may be employed including biological, chemical and mechanical means. Rotenone and antimycin impregnated baits have been used to control common carp without eliminating the entire fish community (Fajt and Grizzle 1993; Rach et al. 1994). Schwartz (1986) successfully used a leadless stackable trap to capture common carp mechanically. However, mechanical means have been employed on a large scale with only minimal success. Verrill and Berry (1995) used an electrical barrier and lake drawdown to reduce the abundance of common carp in two Minnesota Lakes. Although introducing predators has been suggested as a means to control undesirable fish population, we could find no reference in which common carp were controlled successfully by this means.

Sculpin collected during this survey were not identified to species. However, prickly sculpin (*Cottus asper*) is the species most common to the Columbia Basin (Paul Mongillo, WDFW, personal communication). Although sculpin make little or no contribution to angling recreation, the high number of sculpin collected during this short survey is noteworthy. Sculpin are negatively buoyant bottom-dwelling fishes which are typically difficult to sample in lakes by boat electrofishing and are likely under-represented in this sample. Considering the low relative abundance of yellow perch and the lack of other panfishes in this survey, sculpin may be a primary food source for largemouth bass in Worth Lake. Prickly sculpin were found to be the most important food source of Lake Washington (King County) largemouth bass (Wydoski and Whitney 1979). This Worth Lake observation may warrant further investigation, especially considering the size and condition of largemouth bass sampled.

Management Options to Consider

Carp Barrier

Common carp do not appear to be negatively impacting the Worth Lake fish community at this time. However, they have, and will likely continue to, affect fisheries management of the lake. Considering the fact that carp are likely immigrating to Worth Lake via the outlet irrigation canal, it may be possible to exclude them by constructing a height barrier. The feasibility of constructing such a barrier to fish passage deserves further investigation.

Mechanical Removal of Adult Carp

If a barrier to fish passage is constructed, undesirable fish species could likely be controlled or eliminated by electrofishing and netting. The overall success of using mechanical removal as a fisheries management tool has been limited. However, it may be feasible at Worth Lake considering it's relatively small size and shallow depth.

Largemouth Bass Slot-Limit Regulation

Worth Lake would be a likely candidate for inclusion under the states 12 - 17 inch slot-limit for largemouth bass. This regulation consists of a five fish limit, fish 12"-17" are to be released, and only one fish over 17" may be retained. The intent of this regulation would be to increase the number of quality size (≥300mm, 12") largemouth bass in the lake, which would then be available for catch and release angling opportunities. Slot-limits have been used successfully in other states and some lakes in Washington to provide both quality bass and panfish angling (Rasmussen and Michaelson 1972; Eder 1984; Wilde 1997).

Literature Cited

Anderson, R. O. 1976. Management of small impoundments. Fisheries (Bethesda) 1(6):5-7.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in Murphy, B.R. and Willis(eds.), Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

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

Carlander, K. D. 1982. Standard intercepts for calculation lengths from scale measurements for some centrarcid and percid fishes. Transaction of the American Fisheries Society 111:332-336.

Conover, W. J. 1980. Practical nonparametric statistics, 2nd Edition. John Wiley and Sons, Inc., New York.

Divens, M. J., S. A. Bonar, B. D. Bolding, E. Anderson, and P. W. James. 1998. Monitoring warm-water fish populations in north temperate regions: sampling considerations when using proportional stock density. Fisheries Management and Ecology 5:383-391.

Drenner, R. W., K. L. Gallo, C. Michael Edwards, K. E. Rieger, and E. D. Dibble. 1997. Common carp affect turbidity and angler catch rates of largemouth bass in ponds. North American Journal of Fisheries Management 17:1010-1013.

Elder, S. 1984. Effectiveness of an imposed slot length limit 0f 12.0-14.9 inches on largemouth bass. North American Fisheries Management 4:469-478.

Fajt, J. R. and J. M. Grizzle. 1993. Oral toxicity of rotenone for common carp. Transactions of the American Fisheries Society 122:302-304.

Fletcher, D., S. Bonar, B. Bolding, A. Bradbury, and S. Zeylmaker. 1993. Analyzing warmwater fish populations in Washington state. Washington Department of Fish and Wildlife, Warmwater Fish Survey Manual.

Gabelhouse, D. W., Jr. 1984b. A length categorization system to assess fish stocks. North American Journal of fisheries Management 4:273-285.

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

Jearld, A. 1983. Age determination. Pages 301-324 *in* Nielsen, L. A., and D.L. Johnson (eds.), Fisheries Techniques. American Fisheries Society, Bethesda, MD.

Laugheed, V. L., B. Crosbie, and P. Chow-Fraser. 1998. Predictions on the effect of common carp (*Cyprinus carpio*) exclusion on water quality, zooplankton, and submergent macrophytes in a Great Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences 55:1189-1197.

Murphy, B. R., and D. W. Willis. 1991. Application of relative weight (Wr) to western warmwater fisheries. Pages 243-248 in Proceedings of the Warmwater Fisheries Symposium I, June 4-8, 1991, Scottsdale, Arizona. USDA Forest Service, General Technical Report RM-207.

ODFW (Oregon Department of Fish and Wildlife). 1997. Fishery biology 104-Body condition. Oregon Department of Fish and Wildlife, Warmwater Fish News 4(4):3-4.

Rach, J. J., J. A. Luoma, and L. L. Marking. 1994. Development of an antimycin-impregnated bait for controlling common carp. North American Journal of Fisheries Management 14:442-446.

Rasmussen, J. L. and S. M. Michaelson. 1972. Attempts to prevent largemouth bass overharvest in three northwest Missouri lakes. Symposium on overharvest and management of largemouth bass in small impoundments. American Fisheries Society, Special Publication Number 3.

Schwartz, F. J. 1986. A leadless stackable trap for harvesting common carp. North American Journal of Fisheries Management 6:596-598.

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

Verrill, D. D. and C. R. Berry, Jr. 1995. Effectiveness of an electrical barrier and lake drawdown for reducing common carp and bigmouth buffalo abundances. North American Journal of Fisheries Management 15:137-141.

Wilde, G. R. 1997. Largemouth bass fishery responses to length limits. Fisheries 22(6):14-23.

Willis, D. W., B. R. Murphy, and C. S. Guy. 1993. Stock density indicies: development, use, and limitations. Reviews in Fisheries Science 1(3):203-222.

Wydoski, R. S. and R. R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press, Seattle and London.