2000 Lake Meridian Survey: The Warmwater Fish Community of an Oligotrophic Urban Lake

by

Peter A. Verhey and Karl W. Mueller
Warmwater Fish Enhancement Program
Washington Department of Fish and Wildlife
P.O. Box 1100
La Conner, Washington 98257

July 2001

Acknowledgments

We thank Tom Buroker of the Washington Department of Fish and Wildlife (WDFW) for his invaluable assistance in the field and lab, and Mark Downen for his contribution to the methods. We also thank Lucinda Morrow of the Warmwater Fish Aging unit for timely processing of scale age data and the city of Kent for providing easy access to the lake. Mark Downen and Steve Jackson (WDFW) provided thoughtful criticism of the original draft of the manuscript, whereas Darrell Pruett and Peggy Ushakoff (WDFW) designed the cover. Lauren Munday, Walt Cooper, Everett Latch and Rick Goldsmith (WDFW) proved indispensable when preparing and printing the final report. This project was funded by the Warmwater Fish Enhancement Program, which is providing greater opportunities to fish for and catch warmwater fish in Washington.

Abstract

Lake Meridian was surveyed by a three-person crew on September 11-15, 2000. Multiple gear types (electrofishing, gill nets, and fyke nets) were used to sample the nearshore fish community. In all, 10 species of fish were sampled from Lake Meridian. Yellow perch were the most abundant species and accounted for 62% of our sample by number and 57% by weight. Though stock-size largemouth bass were more abundant than smallmouth bass, no quality-size largemouth bass were captured. Stock density indices for smallmouth bass, yellow perch and pumpkinseed suggest a community managed for "Big Bass" though the disproportionate contribution of yellow perch suggests a fish community out of balance. For species other than yellow perch, sample sizes were small and catch rates were low compared to western Washington state averages, suggesting low species abundance. Low sampling efficiency of our gear may have also contributed the low catch rates. Management options for Lake Meridian include but are not limited to the following: implementing a slot limit (12 - 17") for largemouth and smallmouth bass; consider stocking channel catfish to control abundant yellow perch; or, manage the lake for panfish.

Table of Contents

Abstract i

List of Tables iii

List of Figures v

Introduction and Background 1

Materials and Methods 6
- Data analysis 7
- Species composition 7
- Catch per unit effort 8
- Stock density indices 8
- Age and growth 10
- Length frequency 10
- Relative weight 11

Results and Discussion 12
- Water quality and habitat 12
- Species composition 13
- CPUE 16
- Stock density indices 16
  - Bluegill 18
  - Brown bullhead 18
  - Channel catfish 19
  - Kokanee 19
  - Largemouth bass 21
  - Pumpkinseed 23
  - Rainbow trout 25
  - Sculpin 26
  - Smallmouth bass 26
  - Yellow perch 29

Warmwater Enhancement Options 31
- Change Existing Fishing Rules to Improve Size Structure of Largemouth and Smallmouth Bass 31
- Consider Stocking Channel Catfish to Control Abundant Yellow Perch 32
- Manage Lake Meridian for Panfish 32
- Consider the Potential Impacts of Outlet Modification 32
- Consider Improvements for WDFW Boat Launch 32

Literature Cited 33

List of Tables

Table 1. Hatchery trout and kokanee stocking plans for Lake Meridian (King County), 1998 through 2001(WDFW 1998, 1999, 2000, 2001). 4

Table 2. Fish species reported present in Lake Meridian (King County) since 1934 5

Table 3. Mean catch per unit effort (number of fish/hr electrofishing and number of fish/net night) for stock size fish collected from several western Washington State lakes while electrofishing, gill netting, and fyke netting during 1997 and 1998 8

Table 4. Length categories for cold- and warmwater fish species used to calculate stock density indices (PSD and RSD; Gablehouse 1984) of fish captured at Lake Meridian (King County) during fall 1999. 9

Table 5. Stock density index ranges for largemouth bass and bluegill under three commonly implemented management strategies 9

Table 6. Water quality at Lake Meridian (King County) 12

Table 7. Number of docks and visual estimates of percent bulkheading of shoreline, vegetation coverage and substrate composition within 400 m survey sections at Lake Meridian, September 11, 2000. 13

Table 8. Species composition by weight (kg) and number of fish captured at Lake Meridian (King County) during fall 2000. 14

Table 9. Mean catch per unit effort (number of fish/hour electrofishing and number of fish/net night), including 80% confidence intervals for stock size warmwater fish, salmonids, and non-game fish collected from Lake Meridian (King County) while electrofishing, gill netting, and fyke netting during fall 2000. 16

Table 10. Traditional stock density indices including 80% confidence intervals for cold and warmwater fishes collected from Lake Meridian (King County) while electrofishing, gill netting and fyke netting during fall 1999. 17

Table 11. Age and growth of largemouth bass (*Micropterous salmoides*) captured at Lake Meridian (King County) during fall 2000. 21

Table 12. Age and growth of pumpkinseed (*Lepomis gibosus*) captured at Lake Meridian (King County) during fall 2000. 23

Table 13. Age and growth of smallmouth bass (*Micropterus dolomieu*) captured at Lake Meridian (King County) during fall 2000. 27

Table 14. Age and growth of yellow perch (*Perca flavescens*) captured at Lake Meridian (King County) during fall 2000. 29

List of Figures

Figure 1. Map of Lake Meridian (King County) showing depth contours (10-ft increments), sample locations by gear type, and numbered survey boundary markers 1

Figure 2. Average monthly surface water temperature of Lake Meridian during the 1998-99 water year 2

Figure 3. Map of Lake Meridian showing number of fish captured by species by gear type 15

Figure 4. Length frequency histogram of brown bullhead sampled from Lake Meridian (King County) during fall 2000 18

Figure 5. Relationship between total length and relative weight (*Wr*) of brown bullhead from Lake Meridian (King County) compared with means from up to 25 western Washington lake and the national 75th percentile 19

Figure 6. Length frequency histogram of cutthroat trout sampled from Lake Meridian (King County) in fall 2000 20

Figure 7. Relationship between total length and relative weight (*Wr*) of cutthroat trout from Lake Meridian (King County) compared to the national 75th percentile 20

Figure 8. Length frequency histogram of largemouth bass sampled from Lake Meridian (King County) in fall 2000 22

Figure 9. Relationship between total length and relative (*Wr*) of largemouth bass from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile 22

Figure 10. Length frequency histogram of pumpkinseed sampled from Lake Meridian (King County) in fall 2000 24

Figure 11. Relationship between total length and relative weight (*Wr*) of pumpkinseed from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile 24

Figure 12. Length frequency histogram of cutthroat trout sampled from Lake Meridian (King County) in fall 2000 25

Figure 13. Relationship between total length and relative weight (*Wr*) of rainbow trout from Lake Meridian (King County) compared with the national 75th percentile 26

Figure 14. Length frequency histogram of smallmouth bass sampled from Lake Meridian (King County) in fall 2000 28

Figure 15. Relationship between total length and relative weight (*Wr*) of smallmouth bass from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile 28

Figure 16. Length frequency histogram of yellow perch sampled from Lake Meridian (King County) in fall 2000 30

Figure 17. Relationship between total length and relative weight (*Wr*) of yellow perch from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile 30

Introduction and Background

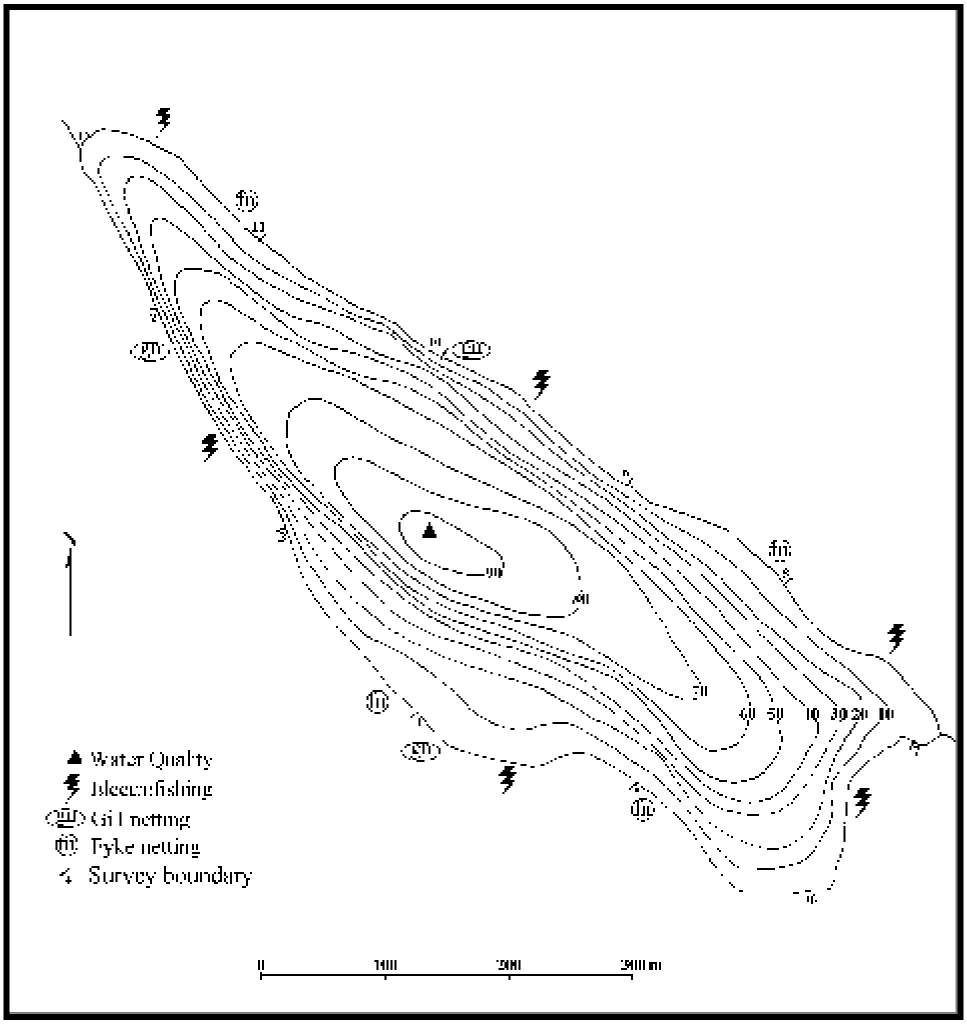

Figure 1. Map of Lake Meridian (King County) showing depth contours (10-ft increments), sample locations by gear type, and numbered survey boundary markers. Electrofishing, indicated by bolts, occurred along the length of the shoreline between adjacent survey boundaries.

Lake Meridian (Figure 1) lies within the city limits of Kent (King County) approximately 6 kilometers (4 miles) east of the city center. Glacial in origin, Lake Meridian formed during the Pleistocene about 25,000 years ago. The lake is 60.7 ha (150 acres) at an elevation of 113 m (370 ft) and a volume of 750,000 m^3 (6,100 acre-ft). The mean and maximum depths are 12.4 m (41 ft) and 27.4 m (90 ft), respectively. Oriented northwest to southeast, the lake has a maximum width of 540 m (1,770 ft) and length of 1,710 m (5,610 ft). The drainage basin has an area of 300 ha (1.16 mi^2) (Bortelson et al. 1976). The inlet located at the northwest end of the lake discharges a peak volume of 3.8 cfs during periods of high precipitation and averages 0.3 cfs during most of the year (Metro 1977). Subsurface springs also discharge into the lake. Surface water leaves the lake at the southeast end, flows into Big Soos Creek, and eventually discharges into the Green River. Outflow is highest during the winter but both the inlet and outlet dry up during summer months. Flooding along the outlet channel during periods of high water has been a persistent problem for the city of Kent (personal communication, Keith Binkley, consultant, Interfluff).

In 2000, the city began investigating ways to modify the outlet of Lake Meridian and the channel which forms a ditch along 152nd Avenue to Soos Park and Big Soos Creek. As modification options have not yet been presented, it is unclear how changes of the outlet would effect fish populations in the lake, if at all. The shore slopes off abruptly to deep water except for the few shallow places located at or near the northwest and southeast ends of the lake. The steeply sloping areas of the lake are characterized by a gravelly substrate, while the shallow areas and the lake bottom are muddy.

Water quality of Lake Meridian has been monitored since 1995 by volunteers working with the King County Water and Land Resources Division (KCWLRD) as part of the their lake quality and lake level fluctuations monitoring efforts of 44 King County lakes (KCWLRD 1999). Volunteers measure typical water quality parameters including temperature (Figure 2), secchi depth (water transparency), total phosphorus, total nitrogen, and Chlorophyll *a* concentrations. Trophic state index (TSI) values are calculated using methods established by Carlson (1977) which use these common water quality parameters to rate lakes in terms of the amount of plant and animal biological activity on a scale of 1 to 100. Under this scheme, lakes may be classified as having low biological activity (TSI <40, oligotrophic), moderate biological activity (TSI 40 - 50, mesotrophic), or high biological activity (TSI 50> eutrophic). For the last five years, Lake Meridian has had relatively high (deep) secchi disk readings and low concentrations of total phosphorus and Chlorophyl *a*; thus, it has been classified as an oligotrophic body of water. In 1999, mean summer values of secchi depth, total phosphorus, and chlorophyll *a* translated into TSI ratings of 38.2, 36.7 and 41.6, respectively (KCWLRD 2001).

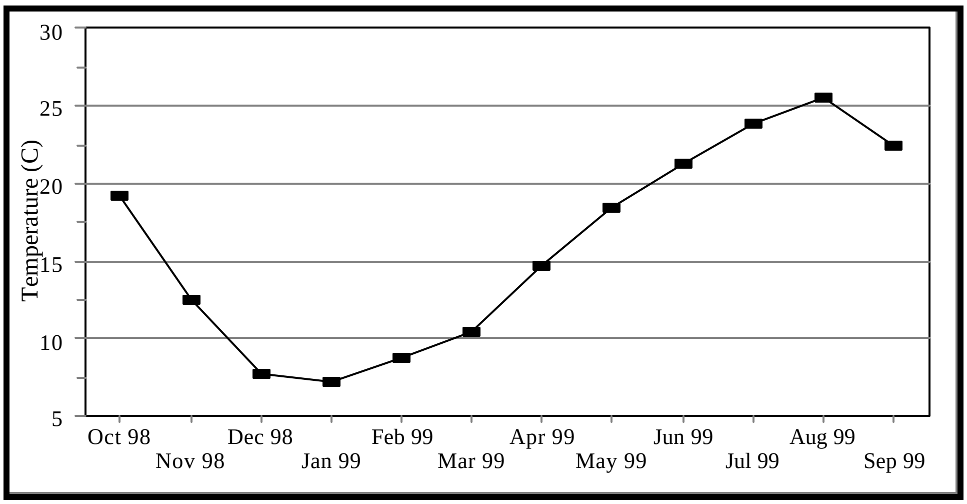

Figure 2. Average monthly surface water temperature of Lake Meridian during the 1998-99 water year (KCWLRD 1999).

Nineteen plant species have been identified in the lake including seven emergent types, two floating types, and ten submergent types (KCSWM 1996). In 1994, surface coverage by floating plants totaled 5.3 acres while the submergent community comprised 25.4 acres. Emergent vegetation coverage was very limited due to extensive shoreline development. The aquatic nuisance species *Myriophyllum spicatum* (water milfoil) was the most abundant species in the lake, forming a continuous band around the lake at a depth between 1 and 3 meters. This band of weeds has effectively inundated the gravelly substrate in the photic zone throughout the lake. *M. spicatum* was also the dominant species noted in surveys conducted between 1976 and 1980 (KCSWM 1996).

Lake Meridian is used by the public for swimming, boating, and fishing. Park attendance in the mid-1970s was estimated at about 42,000 people during the summer months (Metro 1977). Public access is via a city park and Department of Fish and Wildlife (WDFW) boat launch. The city park, located on the southeast end of the lake, has a concrete boat ramp, parking for vehicles with trailers, modern restrooms, a large fishing pier, and a sandy beach with swimming area. The city boat ramp and trailer parking area has gates that are open from 8:00 a.m. to dusk year-round. Water skiing and the use of personal water craft has become a popular activity on the lake. Signs that list usage rules for these activities, including speed restrictions and use schedules, have been placed at the boat launch and on buoys in the lake. The small WDFW public access area, donated by resort owner A. C. Larson in 1948, is not gated and has a primitive ramp. The access area is approximately 38 feet wide at the water's edge and 150 feet long with parking space for about six vehicles with trailers. The launch area is shallow, and during periods of low water such as September, may be only 11 inches deep at a distance of 20 feet from the shore (WDFW, unpublished). The primary land use in the drainage basin is urban residential. More than 370 homes lie in the drainage basin with at least 157 homes within 100 meters of the shore. Residential dwellings and public and private parks fill the shoreline. All homes around the lake were connected to sewers in 1974 (Metro 1977).

Sport fishing has been an important activity at Lake Meridian which has been stocked with rainbow trout (*Oncorhyncus mykiss*) for decades. In 1934, the lake supported three small resorts where boats could be rented and fishing tackle was for sale. Anglers fished mainly for rainbow trout though yellow perch (*Perca flavescens*), largemouth bass (*Micropterus salmoides*), bullhead catfish (*Ameiurus sp.*) and crappie (*Pomoxis sp.*) were also present as well (WDFW, unpublished data). Given its easy access and location near cities, the lake sustained increasing fishing pressure over the years which ultimately reduced fishing success and angler satisfaction. The Washington Department of Game (WDG) began augmenting the lake's fish production in the mid-1930s by stocking kokanee fry (*Oncorhynchus nerka*) and rainbow trout. As early as 1942, it was suggested that during wet periods, when the inlet and outlet streams had flowing water, fry tended to migrate out the outlet and escape, or up the inlet where they were at risk of becoming stranded (WDG unpublished data). From 1943 through 1946, an average of 30,000 rainbow trout fry per year were stocked, but returns to the angler creel were poor (WDG, unpublished data). In the mid-1940s, WDG began stocking catchable-size rainbow trout, which though more expensive than fry demonstrated better survival. Still, from 1945 to 1947, the Lake Meridian Shore Club reported 80 percent of all fish taken were yellow perch. In 1948, the local lake association installed a screen in the outlet to help keep stocked fish in the lake. The lake stocking and screening helped improve angler satisfaction. However, because of the additional expense in raising rainbow trout to a catchable size, WDG allotments to Lake Meridian were relatively small, averaging 5,000 per year, and some years no fish were allotted. With the donation of the public access in 1948, the WDG became obligated to continue bolstering fishing opportunities at the lake and stocked 10,000 catchable-size rainbow trout that year.

In 1951, Lake Meridian was rid of all fish with rotenone, a plant derived piscicide, and restocked with rainbow trout. On opening day in 1953, an estimated 8,000 rainbow trout were taken by anglers. The lake was again treated with rotenone, or “rehabilitated”, in 1954; however, public support for rehabilitation on Lake Meridian was mixed. Some constituents complained that within a few weeks of opening day no fish could be caught, whereas before rehabilitation, experienced anglers could generally bag sizable crappie (305 to 381 mm) and bass (356 to 457 mm), and children were generally successful angling for yellow perch (WDFW unpublished). In a 1963 public meeting to determine public support for rehabilitation of Lake Meridian, residents voted 21-12 to support the WDG plan - despite an undercurrent of opposition (KNJ 1963). Lake Meridian was rehabilitated for the last time in fall 1963. Since then, it has been managed as a mixed-species fishery. WDFW currently stocks catchable-size rainbow trout and kokanee fry annually or semi-annually (Table 1).

Table 1. Hatchery trout and kokanee stocking plans for Lake Meridian (King County), 1998 through 2001(WDFW 1998, 1999, 2000, 2001).

Year	Species	Number fry, 2-4"	Number 8-12 inches	Number 14" or larger	Total Stocked	Approx. time of Stocking
2001	RB		15,000		15,000	Apr
	TRB			1,000	1,000	Apr, May
	K	23,000			23,000	
2000	RB		13,000		13,000	Early May
	K	30,000			30,000	
1999	RB		15,000		15,000	April, mid-May
	K	30,065			30,065	
1998	RB		18,200		18,200	April, mid-May

Species key: RB= rainbow trout, TRB= triploid rainbow trout, K= kokanee.

Lake Meridian continues to support an active sports fishery composed of seasonally stocked rainbow trout, kokanee, and persistent populations of largemouth bass and yellow perch (Table 2). Lake Meridian is a well known and popular trout fishing lake located close to home for many urban anglers. It is a kid-friendly lake with a county park and playground, public fishing dock, shore access and modern restrooms (Rudnick 1978). Also, the lake has been noted as one of the top 10 largemouth and smallmouth bass (*Micropterus dolomieu*) waters in King County (Johansen 1999). To help manage these fisheries more effectively, the WDFW Warmwater Fish Enhancement Program conducted a stock assessment in fall 2000. We assessed species composition, abundance, size structure, growth, and condition of fish in the lake. We also evaluated habitat and access, then outlined options for enhancing the fishery and fishing opportunities on the lake.

Table 2. Fish species reported present in Lake Meridian (King County) since 1934 (Washington Department of Fish and Wildlife, unpublished data).

Date	Sample method	Sample size (# fish)	Species composition by number
1934 [a]	unknown	unknown	Yellow perch, smallmouth bass, largemouth bass, bullhead catfish, crappie, rainbow trout
1939	angling	9	100% yellow perch
1946 [a]	angling	unknown	Rainbow trout, yellow perch, smallmouth bass, bluegill (*Lepomis macrochirus*)
1947	angling	37	45% smallmouth bass, 27% crappie, 13.5% catfish, 13.5% rainbow trout
1948 [a]	angling	unknown	Rainbow trout, largemouth bass, smallmouth bass, crappie, catfish, bluegill
1949	angling	424	86.6% rainbow trout, 9.2% yellow perch, 3.5% crappie, 0.7% smallmouth bass
1950	angling	2,409	61.1% rainbow trout, 37.3% kokanee, 1.6% yellow perch
Fall 1963	whole-lake rotenone	91,500	32.7% yellow perch and bluegill (25-51 mm), 21.9% largemouth bass (51-254 mm), 21.9% bullhead catfish (51-203 mm), 11% yellow perch and bluegill (76-127 mm), 11% bullhead catfish (229-279 mm), 1% largemouth bass (279-356 mm), 0.5% rainbow trout

[a] data indicates species presence only, not relative percentages.

Materials and Methods

Lake Meridian was surveyed from September 11 -15, 2000 by a three-person team consisting of two biologists and one scientific technician. Fish were captured using three sampling techniques: electrofishing, gill netting, and fyke netting. The electrofishing unit consisted of a 4.9 m Smith-Root 5.0 GPP ‘shock boat’ set to 250 volts of 6 amp pulsed DC (120 cycles/sec). Experimental gill nets (45.7 m long × 2.4 m deep) were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable-size (13, 19, 25, and 51 mm stretched) monofilament mesh. Fyke nets were constructed of 1.2 m diameter hoops with funnels attached to a 2.5 m cod end (6.4 mm nylon mesh). Attached to the mouth of the net were two 15.2 m wings and a 31 m lead.

Sampling locations were selected by dividing the shoreline into 11 consecutively numbered sections of about 400 m each (determined visually from a map). Nine of these sections were then systematically sampled to maximize dispersion of gear types. Nighttime electrofishing was done along 6 sections, or 56% of the shoreline (Figure 1). The shock boat was maneuvered through the shallows (depth range: 0.2 - 1.5 m), adjacent to the shoreline, at a rate of 18.3 m/minute. Gill nets and fyke nets were set overnight at four locations each (=4 net nights for each gear type). Gill nets were set perpendicular to the shoreline. The small-mesh end was attached onshore while the large-mesh end was anchored offshore. The fyke nets were set in water less than 3 m deep with wings extended at 70E angles from the lead. Sampling occurred during evening hours to maximize the type and number of fish captured.

With the exception of sculpin (Family Cottidae), all fish captured were identified to the species level. Each fish was measured to the nearest 1 mm and assigned to a 10-mm size class based on total length (TL). For example, a fish measuring 156 mm TL was assigned to the 150-mm size class for that species, a fish measuring 113 mm TL was assigned to the 110-mm size class, and so on. When possible, up to 10 fish from each size class were weighed to the nearest 1 g. However, if a sample included several hundred individuals of a given species, then a sub-sample (n ' 100 fish) was measured and weighed while the remainder was only counted. The length frequency distribution of the sub-sample was then applied to the total number collected. Weights were estimated for fish not individually weighed using a linear regression of $\log_{10}$-length on $\log_{10}$-weight of fish from the sub-sample. Scales were removed from up to 10 fish from each size class for aging. Scale samples were mounted, pressed, and the fish aged according to Jearld (1983) and Fletcher et al. (1993). However, brown bullhead (*Ameiurus nebulosus*) and channel catfish (*Ictalurus punctatus*) were not aged.

Water quality data was collected during midday September 11, 2000 near the deepest part of the lake at 1-m intervals. Using a Hydrolab® probe and digital recorder, information was gathered on dissolved oxygen, temperature, pH, specific conductance and total dissolved solids.

Visual estimates of several shoreline and nearshore habitat characteristics were made relative to each 400 m survey section (Figure 1). Characteristics included manmade shoreline development, including dock counts and bulkheading - retaining walls along the lake shore - and percent coverage of shoreline emergent vegetation and nearshore floating and submersed vegetation, as well as nearshore substrate composition.

Data analysis

Balancing predator and prey fish populations is the hallmark of warmwater fisheries management. According to Bennett (1962), the term ‘balance’ is used loosely to describe a system in which omnivorous forage fish maximize food resources to grow to harvestable-size stocks and for the forage fish to be abundant enough to feed predators. Predators must reproduce and grow to control overproduction of prey and predator species, as well as provide adequate fishing. To maintain balance, predator and prey fish must be able to forage effectively. Evaluations of species composition, catch rates, size structure, growth, and condition (plumpness or robustness) of fish provide useful information on the adequacy of the food supply (Kohler and Kelly 1991), as well as the balance and productivity of the community (Swingle 1950; Bennett 1962).

Species composition

We determined species composition by weight (kg) of fish captured using procedures adapted from Swingle (1950). The species composition by number of fish captured was determined using procedures outlined in Fletcher et al. (1993) with one exception. While young-of-year or small juveniles are often not considered because large fluctuations in their numbers may lead to misinterpretation of results (Fletcher et al. 1993), we chose to include them since their relative contribution to total species biomass was small. Moreover, the overall length frequency distribution of fish species may suggest successful spawning and initial survival during a given year, as indicated by a preponderance of fish in the smallest size classes. Many of these fish would be subject to natural attrition during their first winter (Chew 1974), resulting in a different length frequency distribution by the following year. However, the presence of these fish in the system relates directly to fecundity, forage base for larger fish, and interspecific and intraspecific competition at lower trophic levels (Olson et al. 1995). We therefore rely on species composition as an ecological indicator and catch per unit effort (CPUE) and proportional stock density (PSD) as stock indicators.

The percent species composition by weight was calculated as the weight of fish captured of a given species divided by the total weight of all fish captured × 100. The species composition by number was calculated as the number of fish captured of a given species divided by the total number of all fish captured × 100.

Catch per unit effort

Catch per unit effort (CPUE) by gear type was determined for all species (number of fish/hour electrofishing and number of fish/net night). Only stock-size fish and larger were used to determine CPUE for the warmwater species and salmonids, whereas CPUE for non-game fish were calculated for all sizes. Stock length, which varies by species (Table 4), refers to the minimum size of fish having recreational value. Since sample locations were randomly selected, which might introduce high variability due to habitat differences within the lake, 80% confidence intervals (CI) were determined for each mean CPUE by species and gear type. CI was calculated as the mean ± $t_{(á,\ N\text{-}1)} \times SE$, where t = Student's t for á confidence level with N-1 degrees of freedom (two-tailed) and SE = standard error of the mean. Because it is standardized, CPUE is a useful way to compare relative abundance of stocks between lakes. The confidence intervals express the relative uniformity of species distributions throughout a given lake. CPUE values for Lake Meridian were then compared to western Washington State averages compiled by the WDFW Inland Fisheries Research Unit (Table 3).

Table 3. Mean catch per unit effort (number of fish/hr electrofishing and number of fish/net night) for stock size fish collected from several western Washington State lakes while electrofishing, gill netting, and fyke netting during 1997 and 1998 (WDFW Inland Fisheries Research Unit, unpublished data).

Species	Gear Type					
	Electrofishing (fish/hr)	**# lakes**	**Gillnetting (fish/hr)**	**# lakes**	**Fykenetting (fish/hr)**	**# lakes**
Bluegill	169.1	7	1.4	4	20.7	5
Brown bullhead	7.8	10	14.4	7	12.7	6
Largemouth bass	41.6	12	1.9	8	0.3	1
Pumpkinseed	70.8	11	3.8	9	7.9	4
Yellow perch	97.5	8	13.7	6	0.2	2

Stock density indices

The proportional stock density (PSD) of each fish species was determined following procedures outlined in Anderson and Neumann (1996). PSD was calculated as the number of fish $ quality length/number of fish $ stock length × 100, is an index of length frequency data that gives the percentage of fish in a population that are of recreational value to anglers. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Again, stock length (20-26% of world-record length) refers to the minimum size fish with recreational value, whereas quality length (36-41% of world-record length) refers to the minimum size fish most anglers like to catch.

The relative stock density (RSD) of each fish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality length, Gabelhouse (1984) introduced preferred, memorable, and trophy length categories (Table 4). Preferred length (45-55% of world-record length) refers to the minimum size fish anglers would prefer to catch when given a choice. Memorable length (59-64 % of world-record length) refers to the minimum size fish most anglers remember catching, whereas trophy length (74-80 % of world-record length) refers to the minimum size fish considered worthy of acknowledgment. Like PSD, RSD provides useful information regarding population dynamics, but is more sensitive to changes in year-class strength. RSD was calculated as the number of fish $ specified length/number of fish $ stock length × 100. For example, RSD P was the percentage of stock length fish that also were longer than preferred length, RSD M, the percentage of stock length fish that also were longer than memorable length, and so on. Eighty-percent confidence intervals for PSD and RSD were selected from tables in Gustafson (1988).

Table 4. Length categories for cold- and warmwater fish species used to calculate stock density indices (PSD and RSD; Gablehouse 1984) of fish captured at Lake Meridian (King County) during fall 1999. Measurements are minimum total lengths (mm) for each category (Anderson and Neumann 1996; Bister et al. 2000; Hyatt and Hubert, Wyoming Cooperative Fish and Wildlife Unit, University of Wyoming, unpublished data).

	Minimum size (mm)				
Species	**Stock**	**Quality**	**Preferred**	**Memorable**	**Trophy**
Bluegill	80	150	200	250	300
Brown bullhead	130	200	280	360	430
Channel catfish	280	410	610	710	910
Kokanee	200	250	300	400	500
Largemouth bass	200	300	380	510	630
Pumpkinseed	80	150	200	250	300
Rainbow trout	250	400	500	650	800
Smallmouth bass	180	280	350	430	510
Yellow perch	130	200	250	300	380

PSD and RSD have become important tools for assessing size structures of warmwater fish populations and determining management options for warmwater fish communities (Willis et al. 1993). Three major management options commonly implemented for these communities include the panfish option, balanced predator-prey option, and big bass option and each of these has associated ranges of PSD and RSD values (Table 5).

Table 5. Stock density index ranges for largemouth bass and bluegill under three commonly implemented management strategies (from Willis et al. 1993). PSD = proportional stock density, whereas RSD = relative stock density of preferred length fish (RSD-P), and memorable length fish (RSD-M).

	Largemouth bass			Bluegill	
Option	**PSD**	**RSD-P**	**RSD-M**	**PSD**	**RSD-P**
Panfish	20 - 40	0 - 10		50 - 80	10 - 30
Balanced	40 - 70	10 - 40	0 - 10	20 - 60	5 - 20
Big bass	50 - 80	30 - 60	10 - 25	10 - 50	0 - 10

Age and growth

Scale samples from fish collected at Lake Meridian were evaluated to determine age and growth characteristics using the direct proportion method (Jearld 1983, Fletcher et al. 1993) and Lee's modification of the direct proportion method (Carlander 1982). Using the direct proportion 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 in tabular form for easy comparison of growth between year classes, as well as between Lake Meridian fish and the state average for the same species (listed in Fletcher et al. 1993).

While total length at the end of a given age provides valuable information on relationships of length frequency to age of a population and gives some indication of overall growth, instantaneous growth is a better measure of actual growth (Ricker 1975). Because it is an incremental measure, instantaneous growth also allows for analysis of life stage- specific patterns in growth. For example, it is not uncommon for a population to display below average total length across all age classes even though growth rates were only below average during the first or second year of life (Downen and Mueller 2000a). Annual average instantaneous growth rates, G, are defined as the difference between the natural logarithms of successive sizes over a unit of time, and were calculated according to Ricker (1975). Mean annual G was compared to the state average, G_{avg}, derived similarly from the data listed in Fletcher et al. (1993).

Length frequency

The size structure of each species captured was evaluated by constructing a stacked length frequency histogram (percent frequency of fish in a given size class captured by each gear type). Although length frequencies are generally reported by gear type, we report the length frequency of our catch with combined gear types which is then broken down by the relative contribution each gear type makes to each size class. Selectivity of gear types not only biases species catch based on body form, and behavior, but also based on size classes and subsequent habitat use within species (Willis et al. 1993). Therefore, an unbiased assessment of length frequency is unlikely under any circumstance. Our standardized 1:1:1 gear type ratio adjusts for differences in sampling effort between sampling times and locations. Furthermore, differences in size selectivity of gear types may in some circumstances result in offsetting biases (Anderson and Neumann 1996). Length frequency proportions for each gear type are divided by the total numbers of fish caught by all gear types for each size class. This changes the scale but not the shape of the length frequency percentages by gear type. If concern arises that pooled gear does not represent the least biased assessment of length frequency for a given species, then the shape of the gear type-specific distributions is still represented on the graphs, and these may be interpreted independently.

Relative weight

A relative weight (W_r) index was used to evaluate the condition of all species except sculpin. A W_r value of 100 generally indicates that a fish is in good condition when compared to the national standard (75th percentile) for that species. Furthermore, W_r is useful for comparing the condition of different size groups within a single population to determine if all sizes are finding adequate forage or food (ODFW 1997). Following Murphy and Willis (1991), the index was calculated as $W_r = W/W_s \times 100$, where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same total length (mm). W_s is calculated from a standard $\log_{10}$weight-$\log_{10}$length relationship defined for the species of interest. The parameters of the W_s equations for many cold- and warmwater fish species, including the minimum length recommendations for their application, have been compiled by Anderson and Neumann (1996), Bister et al. (2000), as well as Mathew W. Hyatt and Wayne A. Hubert (Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, unpublished data). With the exception of sculpin, the W_r values from this study were compared to the national standard (W_r = 100) and, where available, the mean W_r values from up to 25 western Washington lakes sampled during 1997 and 1998 (Steve Caromile, WDFW, unpublished data).

Results and Discussion

Water quality and habitat

At the time of our survey during fall 2000, Lake Meridian was thermally stratified with water temperatures of 18.5EC at the surface and 6EC at the bottom. The metalimnion, the region of most rapid vertical temperature change was between 9 and 11 m (Table 6). Dissolved oxygen in the top 8 m of the lake was within optimal limits for most fishes (Moore 1942). Below 8 m, dissolved oxygen was less than 5 mg/L, and was as low as 0.49 mg/L at the bottom of the lake. Water transparency was high with a secchi disk reading of 4.8 m. These parameters were consistent with previous data compiled by King County Water and Land Management (KCWLRD 1999). Conductivity was low (<100 μS/cm) through out most of the water column and was below the optimum range (100-400 μS/cm) for electrofishing efficiency outlined by Willis (1998). Low water conductivity can reduce sampling efficiency if electricity is not effectively transferred from the water into the fish.

Table 6. Water quality at Lake Meridian (King County). Samples were collected mid-afternoon September 11, 2000. DO = dissolved oxygen, TDS = total dissolved solids.

Secchi depth	Depth (m)	DO (mg/L)	Temperature (EC)	pH	Conductance (μS/cm)	TDS (g/L)
	1	7.3	18.5	7.9	98.1	0.0614
	3	7.3	18.2	7.8	95.6	0.0611
4.8 m	5	7.2	18.1	7.8	95.5	0.0613
	7	6.9	17.8	7.8	95.7	0.0612
	9	4.5	12.3	7.6	92.6	0.0602
	11	3.0	8.5	7.6	94.0	0.0604
	13	2.2	7.1	7.5	93.5	0.0600
	15	1.6	6.5	7.4	95.4	0.0610
	17	1.1	6.2	7.4	97.8	0.0626
	19	0.8	6.1	7.3	104.9	0.0669
	21	0.6	6.1	7.3	107.6	0.0691
	23	0.5	6.1	7.2	110.5	0.0708

Estimates of number and quantity of nearshore structures (docks and bulkheads), vegetation coverage, and substrate type are presented in Table 7. We counted a total of 154 docks and estimated that nearly 50% of the shoreline was armored with bulkhead of either concrete stone or wood. Both number of docks and percentage of shoreline bulkheading were highest along the southwest shore of the lake within survey sections 2 and 3 where the surrounding terrain banks steeply into the lake. Here shoreline bulkheading covers nearly 100% of the shore. Percent cover of aquatic vegetation was less than 25% for the floating community and between 5 and 75% for the submergent community. Emergent vegetation coverage was limited due to extensive shoreline development and covered 5% or less of shoreline in most survey sections examined. The aquatic nuisance plant, Eurasian milfoil (*M. spicatum*) was the most abundant species in the lake, forming a near continuous band at depths between 1 and 3 meters. Substrates of the littoral zone were comprised mainly of gravel in the steep areas and sand and mud in the gently sloping sections.

Table 7. Number of docks and visual estimates of percent bulkheading of shoreline, vegetation coverage and substrate composition within 400 m survey sections at Lake Meridian, September 11, 2000.

			Vegetation			Substrate		
Section	# Docks	%Bulkhead	%Floating	%Emergent	%Submersed	%Mud/sand	%Gravel	%Bedrock
1	12	85	35	50	10	60	30	10
2	19	100	5	5	5	50	40	10
3	23	95	20	5	50	50	50	0
4	8	10	60	70	20	60	40	0
5	15	50	20	5	70	50	50	0
6	8	10	20	20	30	50	40	10
7	15	60	15	5	60	50	50	0
8	18	15	1	5	75	50	40	10
9	15	50	5	5	75	50	30	20
10	13	40	10	5	60	80	20	0
11	8	5	30	60	60	80	10	10
Ave.	14	47.3	20.1	21.4	46.8	57.3	36.4	6.4

Species composition

During fall 2000, we captured a total of ten fish species (Table 8 and Figure 3). Of these, yellow perch were dominant both numerically and by weight. Yellow perch contributed 61.6% by number and 57.4% by weight to the species composition. Combined, largemouth and smallmouth bass were about half as abundant as yellow perch contributing 33% by number and 28% by weight. Largemouth bass were about half as abundant as smallmouth bass. Young-of-year (YOY) fish were included in our species composition counts. Of the largemouth bass captured, 86% were YOY. Smallmouth bass and yellow perch totals were composed of 89% YOY and 59% YOY, respectively. One channel catfish was captured which contributed 0.1% by number but 2.1% by weight. Bluegill added less than 0.5% by number and weight while pumpkinseed made up 3.5% of the species composition by number and 2.3% by weight. Sculpin were scarce in our samples. Kokanee contributed 0.5% by number and 8.6% by weight while rainbow trout made up less than one percent by number and weight.

Table 8. Species composition by weight (kg) and number of fish captured at Lake Meridian (King County) during fall 2000.

	Species composition				
	by weight		**by number**		**Size range**
Species	**(kg)**	**(%) weight**	**(#)**	**(%) n**	**(mm TL)**
Bluegill (*Lepomis macrochirus*)	0.02	0.04	1	0.09	99 - 99
Brown bullhead (*Ameiurus nebulosus*)	0.14	0.30	2	0.18	169 - 184
Channel catfish (*Ictalurus punctatus*)	1.03	2.13	1	0.09	460 - 460
Kokanee (*Oncorhynchus nerka*)	4.15	8.57	6	0.54	392 - 429
Largemouth bass (*Micropterus salmoides*)	6.73	13.92	247	22.37	56 - 284
Pumpkinseed (*Lepomis gibbosus*)	1.09	2.25	39	3.53	41 - 153
Rainbow trout (*Oncorhynchus mykiss*)	0.61	1.27	2	0.18	296 - 325
Sculpin (*Cottus* sp.)	0.01	0.01	1	0.09	80 - 80
Smallmouth bass (*Micropterous salmoides*)	6.82	14.09	125	11.32	65 - 504
Yellow perch (*Perca flavescens*)	27.78	57.43	680	61.59	45 - 253
Total	48.34		1104		

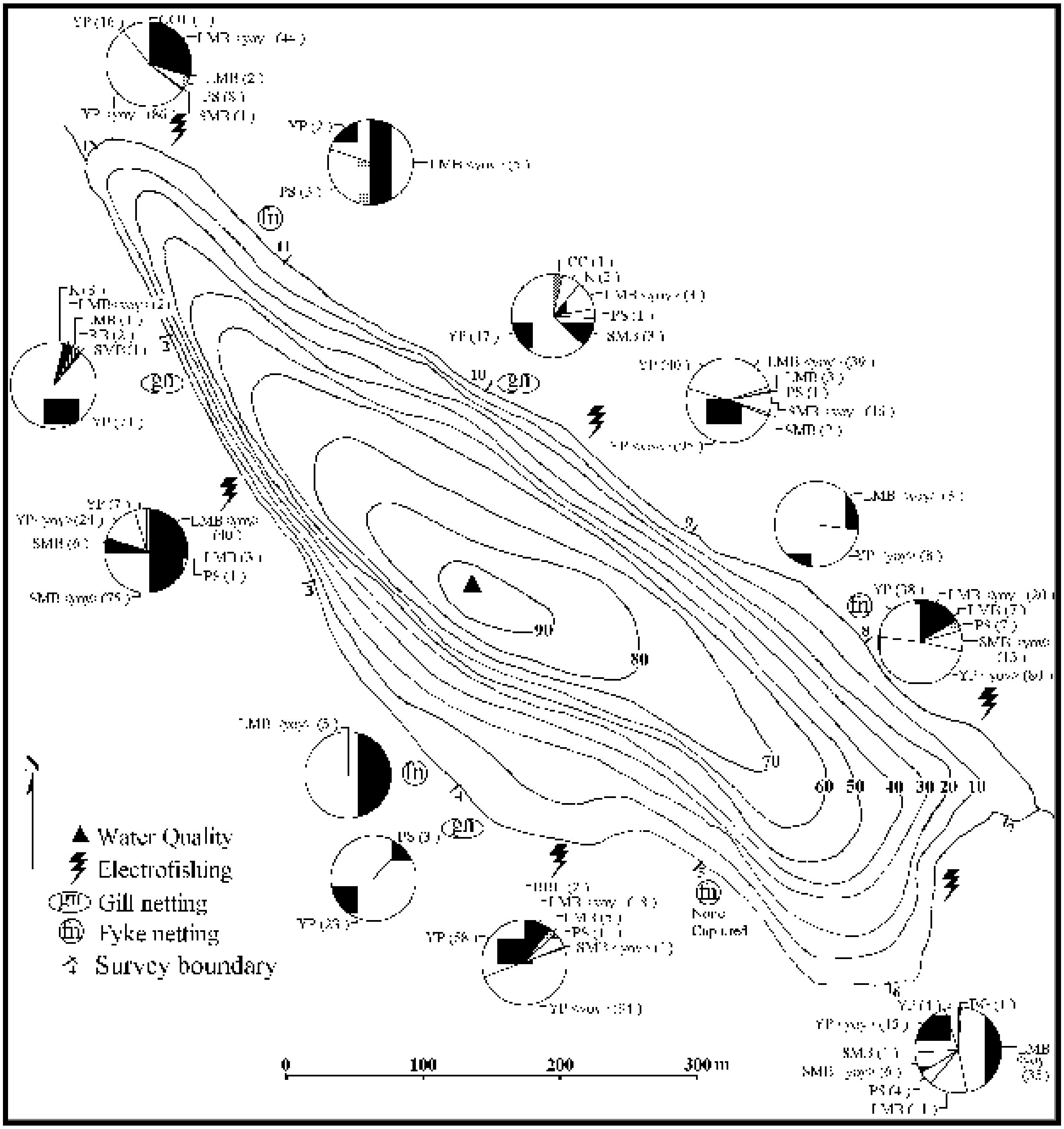

Figure 3. Map of Lake Meridian showing number of fish captured by species by gear type. Pie chart data is for the gear types represented by adjacent gear type symbols. Gill netting and fyke netting occurred at or near the location marked with symbols for those gear types. Electrofishing occurred along the length of survey sections marked with the bolt symbol. Species key: BG = bluegill, BBH = brown bullhead, CC = channel catfish, K = kokanee, LMB = largemouth bass, PS = pumpkinseed, RBT = rainbow trout, COT = sculpin, SMB = smallmouth bass, YP = yellow perch, yoy = young-of-year.

CPUE

Catch per unit effort while electrofishing and gill netting was highest for stock size yellow perch (Table 9). No stock size fish were captured while fyke netting. Catch rates for stock size yellow perch while electrofishing and gill netting exceeded averages for several western Washington State lakes (Table 3). However, CPUE for bluegill, brown bullhead, largemouth bass and pumpkinseed were considerably lower than state averages. CPUE for channel catfish in Lake Meridian (0.25 fish/hr) though low was consistent with rates found in two other western Washington lakes where they were stocked including, Fazon Lake in Whatcom County (0.25 fish/hr) (Mueller 1998) and North Twin Lake in Snohomish county (0.5 fish/hr) (Downen and Mueller 2000b). The smallmouth bass electrofishing catch rate of 3.9 fish/hr was higher than that of four other western Washington state lakes but lower than that of Lake Sawyer (7.9 fish/hr) (Downen and Mueller 2000c). Few sculpin were captured during the survey.

Table 9. Mean catch per unit effort (number of fish/hour electrofishing and number of fish/net night), including 80% confidence intervals for stock size warmwater fish, salmonids, and non-game fish collected from Lake Meridian (King County) while electrofishing, gill netting, and fyke netting during fall 2000.

	Gear type					
Species	**Electroshocking (#fish/hour)**	**Shock sites**	**Gill netting (# fish/hour)**	**n (net nights)**	**Fyke netting (# fish/hour)**	**n (net nights)**
Bluegill	0.99[a]	6	0	4	0	4
Brown bullhead	1.55[a]	6	0	4	0	4
Channel catfish	0	6	0.25[a]	4	0	4
Kokanee	0.95[a]	6	1.25 ± 0.96	4	0	4
Largemouth	14.5 ± 5.25	6	0.5 ± 0.37	4	0	4
bass	24.66 ± 8.91	6	1 ± 0.91	4	0	4
Pumpkinseed	0	6	0.5[a]	4	0	4
Rainbow trout	0.99[a]	6	0	4	0	4
Sculpin	3.89 ± 2.5	6	1 ± 0.91	4	0	4
Smallmouth bass	145.93 ± 54.98	6	28.25 ± 19.12	4	0	4
Yellow perch						

[a] Sample size too small or catch rates too variable to permit calculation of reliable confidence intervals

Stock density indices

Stock density indices suggest a predator and prey population out of balance (Table 5 and 10). No quality-length bluegill, brown bullhead, or largemouth bass were captured. Gill netting PSD and RSD values for pumpkinseed, smallmouth bass, and yellow perch were similar to those of populations managed under the “big bass” option (Table 5). For predators such as smallmouth bass, the generally accepted stock density index ranges for "big bass" option fish populations are PSD values of 50 to 80, RSD-P values of 30 to 60, and RSD-M values of 10 to 25. For balanced panfish populations, PSD values range from 30 to 60 (Gabelhouse 1984; Willis et al. 1993). The PSD and RSD values for brown bullhead, largemouth bass, and rainbow trout (Table 10) should be viewed with caution, especially given the low catch rates for stock-size fish and small sample sizes used to determine these indices (Divens et al. 1998).

Table 10. Traditional stock density indices including 80% confidence intervals for cold and warmwater fishes collected from Lake Meridian (King County) while electrofishing, gill netting and fyke netting during fall 1999. PSD = proportional stock density, whereas RSD = relative stock density of preferred length fish (RSD-P), memorable length fish (RSD-M), and trophy length fish (RSD-T). EB = electrofishing, GN = gill netting and FN = fyke netting.

Species	Gear type	# Stock length fish	PSD	RSD-P	RSD-M	RSD-T
Bluegill	EB	1				
	GN					
	FN					
Brown bullhead	EB	2				
	GN					
	FN					
Channel catfish	EB					
	GN	1	100			
	FN					
Kokanee	EB	1	100	100		
	GN	5	100	100	100	
	FN					
Largemouth bass	EB	15				
	GN	2				
	FN					
Pumpkinseed	EB	27	7 ± 6			
	GN	4				
	FN					
Rainbow trout	EB					
	GN	2				
	FN					
Smallmouth bass	EB	4				
	GN	4	100	100	50 ± 32	
	FN					
Yellow perch	EB	162	35 ± 5	1 [a]		
	GN	113	84 ± 4	2 ± 1		
	FN					

[a] Sample size too small or catch rates too variable to permit the calculation of reliable confidence intervals.

Bluegill

We captured one stock length bluegill (99 mm TL) while electrofishing. This fish was determined to be age 1+. Length at age for this individual (32.5 mm) was lower than the western Washington state average for age 1+ bluegill (37.3 mm). The bluegill population in Lake Meridian appears to be held in check at low densities, possibly because it is a recent reintroduction, or because of predation. It is also possible, that given the abundant submersed aquatic vegetation throughout much of the littoral zone of the lake, bluegill were able to evade our sampling efforts. However, the lack of young-of-year bluegill in any sample suggests limited reproduction.

Brown bullhead

Two brown bullhead were captured while electrofishing along the broad littoral shelf on the south side of the lake (Figure 3). Both fish were between 150 and 200 mm TL (Figure 4). Relative weights were below the national average for this species (Figure 5).

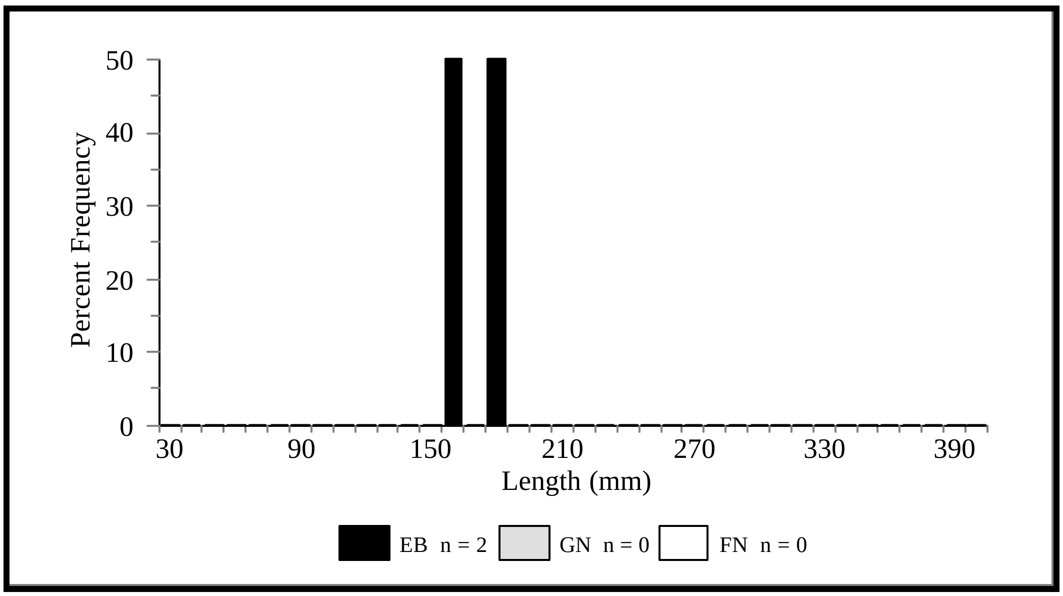

Figure 4. Length frequency histogram of brown bullhead sampled from Lake Meridian (King County) during fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

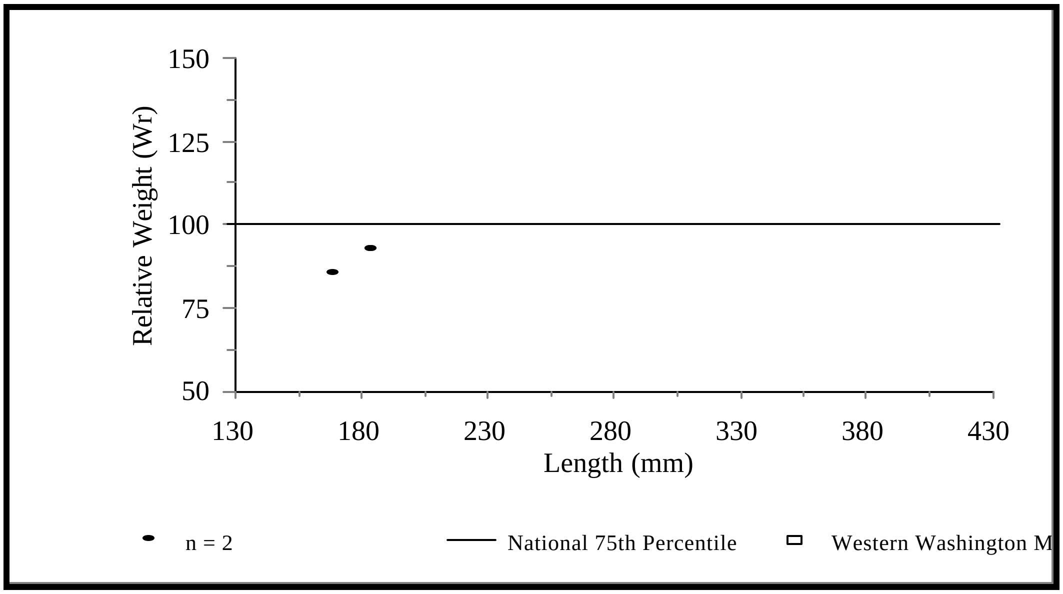

Figure 5. Relationship between total length and relative weight (*Wr*) of brown bullhead from Lake Meridian (King County) compared with means from up to 25 western Washington lake and the national 75th percentile.

Channel catfish

One channel catfish was captured while gill netting in the shallows of the northeast side of the lake (Figure 3). This fish measured 460 mm TL (1.03 kg) and had a relative weight consistent with western Washington State averages and above the national average. It is unclear how channel catfish came to be in Lake Meridian. Though WDFW has stocked channel catfish in a number of western Washington state lakes in recent years, there is no record of the department placing them in Lake Meridian. More likely, the fish was part of an unauthorized introduction.

Kokanee

Five adult kokanee, ranging in size from 392 to 429 mm TL, were captured while electrofishing (Figure 6). These fish were determined to be age 2+ and 3+. Though these fish appeared silvery and without blemish, their scales had resorbed. Relative weights were slightly below the national 75th percentile (Figure 7). Kokanee are stocked annually in Lake Meridian as fry and generally fair well in this relatively large, deep lake.

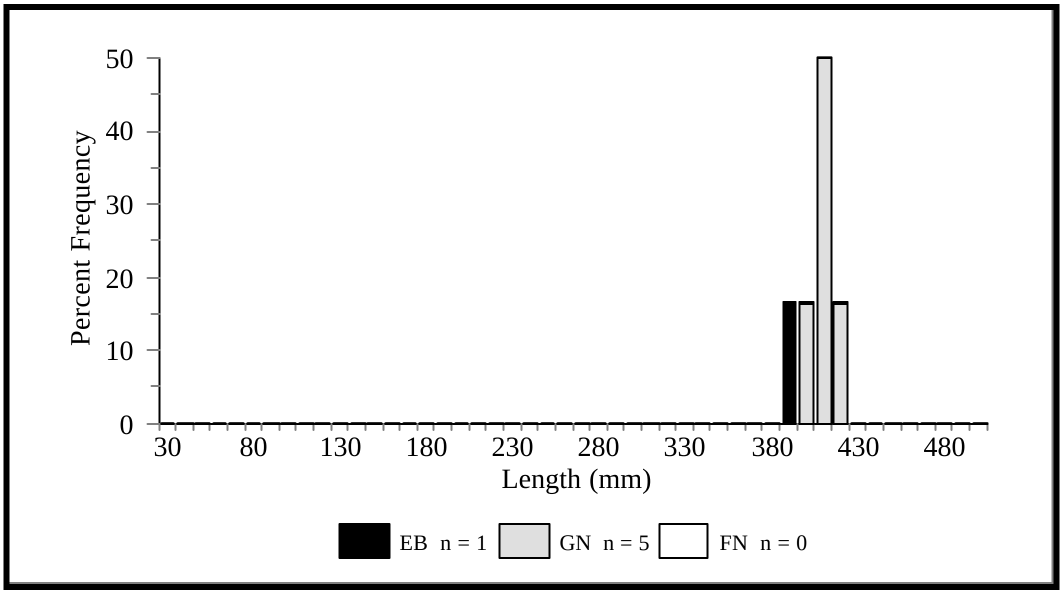

Figure 6. Length frequency histogram of cutthroat trout sampled from Lake Meridian (King County) in fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, FN = fyke netting.

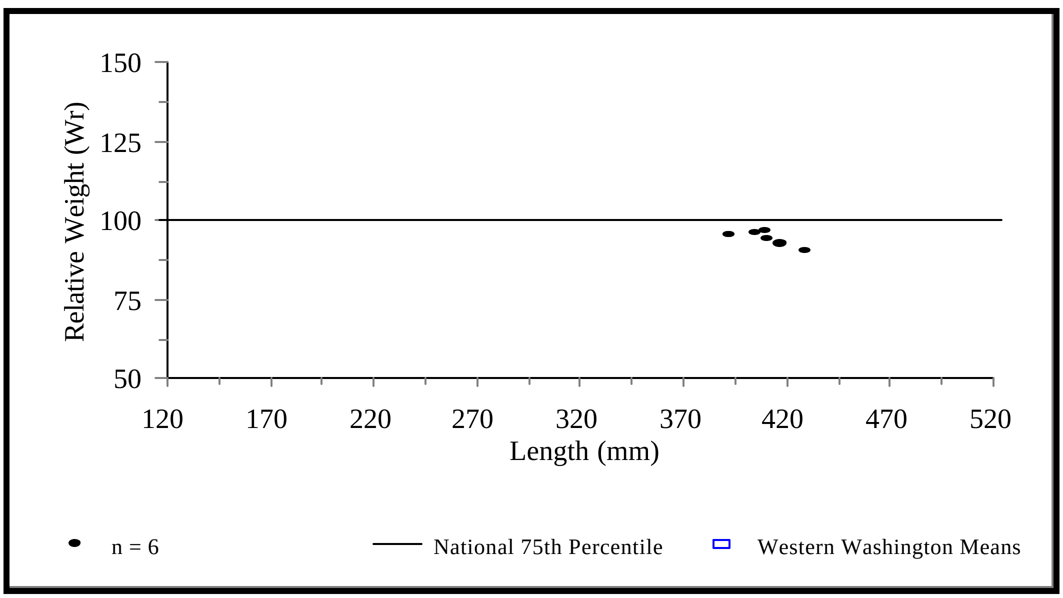

Figure 7. Relationship between total length and relative weight (*Wr*) of cutthroat trout from Lake Meridian (King County) compared to the national 75th percentile.

Largemouth bass

Though survival of older, larger fish seems to be limited, successful reproduction of largemouth bass in Lake Meridian was evident given the numerous YOY captured during our survey. Of the 247 largemouth bass captured, 214 or 86% of them, were YOY which ranged in size from 56 to 116 mm TL. The remaining 33 fish examined were aged at 1+ and 2+ and ranged between 123 to 284 mm TL (Table 11 and Figure 8). Age 1+ largemouth bass were smaller at age (mean length 56.6 mm) than the western Washington state average, however mean length at age of age 2+ fish exceeded the state average. Instantaneous growth rates followed a similar trend with faster growth in two year old fish. Largemouth bass relative weights were consistent with or slightly below the western Washington State averages and slightly above the national 75th percentile (Figure 9). Because of the lake's oligotrophic status, largemouth bass may not be able to achieve their full growth potential (Carline 1986). Largemouth bass prefer more fertile waters. Also, production of largemouth bass is optimal when plant coverage is moderate (Wiley et al. 1984). Lake Meridian is characterized by extreme aquatic plant coverage (Table 7).

Table 11. Age and growth of largemouth bass (*Micropterous salmoides*) captured at Lake Meridian (King County) during fall 2000. Unshaded values are mean back-calculated lengths at annulus formation using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age	
Year class	# fish	1	2
1999	21	56.6	
		70.8	
1998	9	56.5	156.8
		72.3	165.1
Overall mean		56.6	156.8
Weighted mean		71.3	165.1
Western WA average		60.4	145.5
G		1.96	3.15
Gavg		2.16	2.72

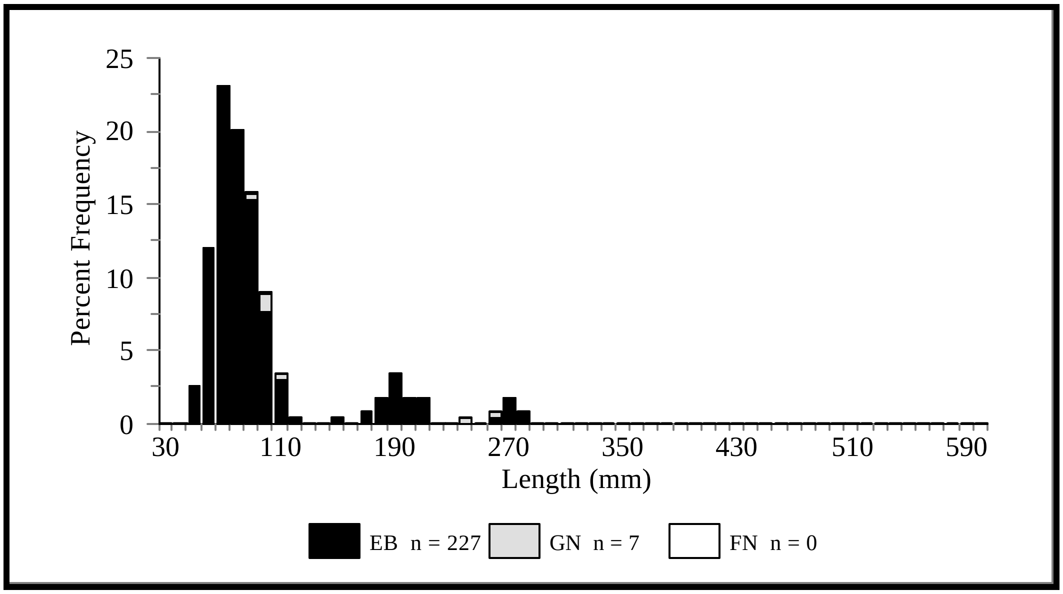

Figure 8. Length frequency histogram of largemouth bass sampled from Lake Meridian (King County) in fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

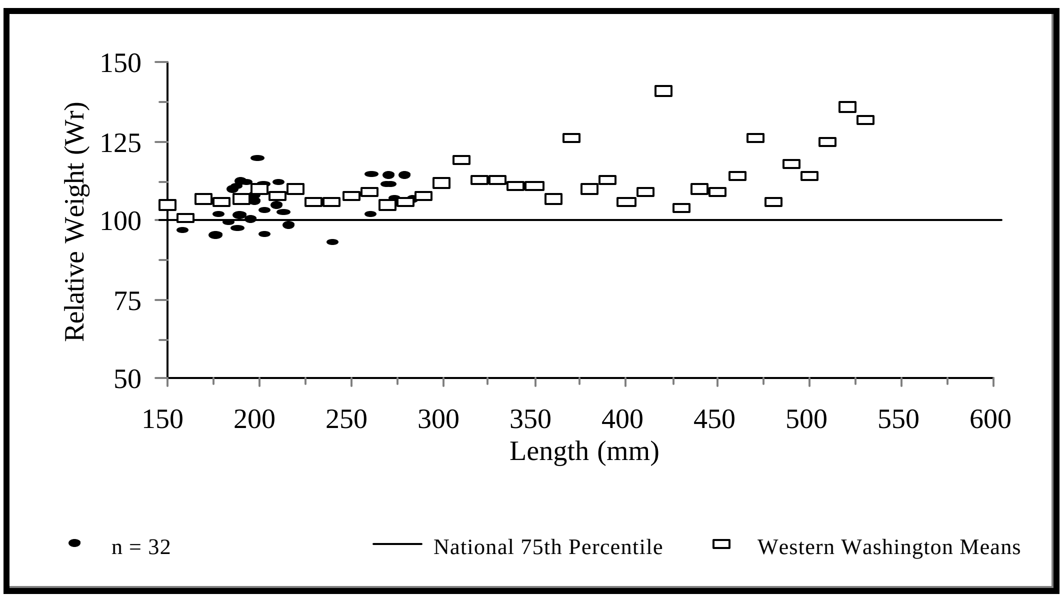

Figure 9. Relationship between total length and relative (*Wr*) of largemouth bass from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Pumpkinseed

A total of 39 pumpkinseed, ranging in size from 42 to 153 mm TL, were captured while electrofishing and gill netting (Figure 10). Of these, 31 were determined to be age 1+ and 2+ (Table 12), and the remaining eight were young-of-year, indicating successful reproduction. Overall length at age of pumpkinseed exceeded western Washington state averages, particularly for age 2+ fish. Relative weights of pumpkinseed were slightly below the western Washington State average and the national 75th percentile (Figure 11).

Table 12. Age and growth of pumpkinseed (*Lepomis gibosus*) captured at Lake Meridian (King County) during fall 2000. Unshaded values are mean back-calculated lengths at annulus formation using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age	
Year class	# fish	**1**	**2**
1999	18	24.3	
		42.8	
1998	11	23.3	87.6
		44.2	97.1
Overall mean		23.8	87.6
Weighted mean		43.3	97.1
Western WA average		23.6	72.1
	G	0.52	3.92
	Gavg	0.50	3.36

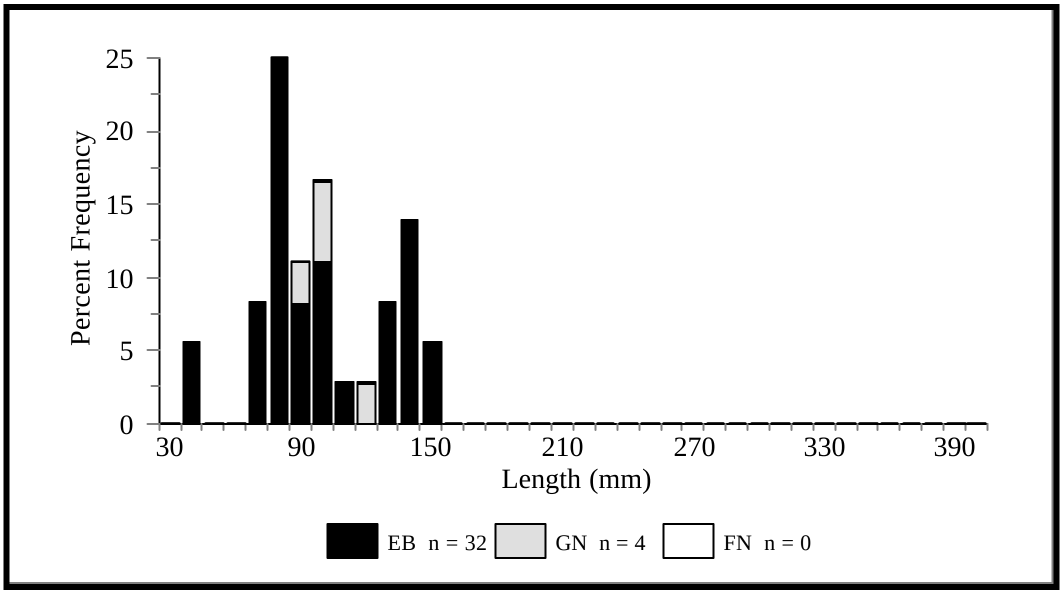

Figure 10. Length frequency histogram of pumpkinseed sampled from Lake Meridian (King County) in fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

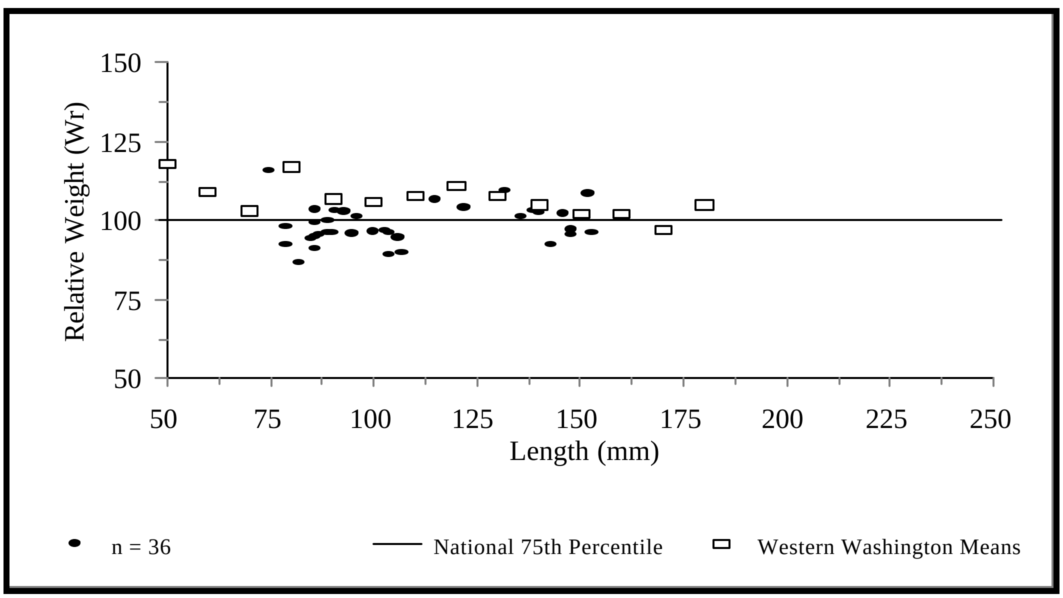

Figure 11. Relationship between total length and relative weight (*Wr*) of pumpkinseed from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Rainbow trout

Two rainbow trout were captured while gill netting (Figure 14). Though we did not determine the age of these fish, they were likely planted in the lake by WDFW during the previous season. Relative weights for rainbow trout were below the national 75th percentile (Figure 12).

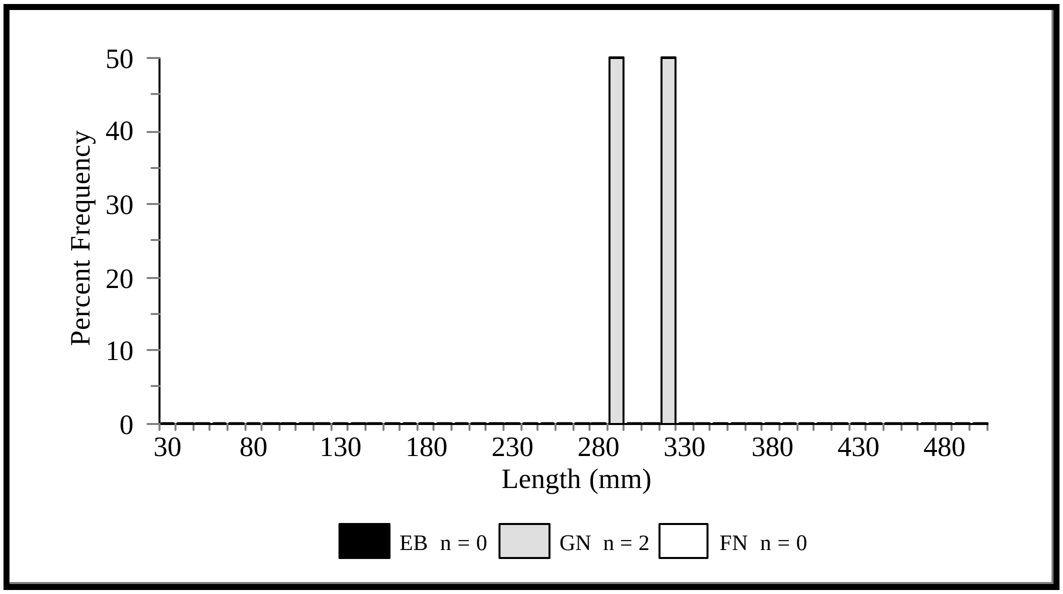

Figure 12. Length frequency histogram of cutthroat trout sampled from Lake Meridian (King County) in fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, FN = fyke netting.

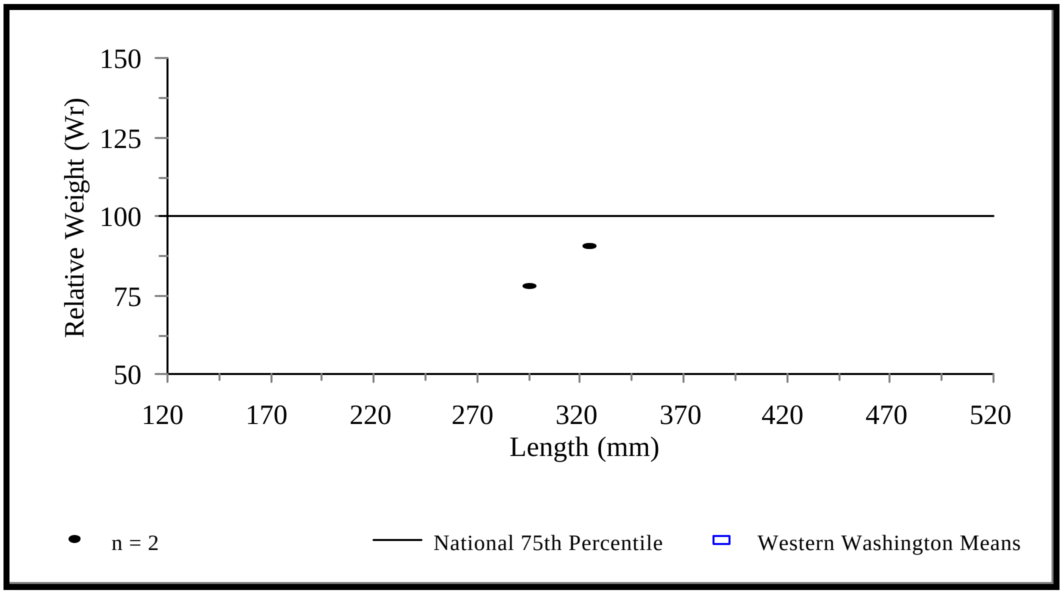

Figure 13. Relationship between total length and relative weight (*Wr*) of rainbow trout from Lake Meridian (King County) compared with the national 75th percentile.

Sculpin

One sculpin that measured 80 mm TL was captured while electrofishing.

Smallmouth bass

A total of 125 smallmouth bass were captured while electrofishing and gill netting (Figure 14). Of these 112 fish, or 90%, were YOY (65 -110 mm TL), suggesting successful reproduction. Of the remaining 13 larger fish, sizes ranged between 134 and 504 mm TL and ages were determined to be 1+ through 6+ (Table 13). No fish from the 1997 or 1998 year classes were captured, suggesting possible year class failures. However, sample sizes were small and, except for YOY fish, no year class was adequately represented. Mean length at age of age 2+ and older fish exceeded averages for western Washington State. However, growth rates, *G*, of 1995 and 1996 year class fish were lower than or merely consistent with state averages. Relative weights of smallmouth bass were consistent with or slightly below state averages and the national 75th percentile (Figure 15).

Table 13. Age and growth of smallmouth bass (*Micropterus dolomieu*) captured at Lake Meridian (King County) during fall 2000. Unshaded values are mean back-calculated lengths at annulus formation using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths 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**
1999	9	52.4					
		76.6					
1998	0						
1997	0						
1996	2	65.1	213.1	348.8	410.1		
		94.8	231.2	356.1	412.3		
1995	1	51.4	121.4	253.7	301.9	358.0	
		81.9	145.8	266.5	310.5	361.7	
1994	1	56.0	119.7	195.0	341.8	426.8	478.9
		87.1	146.4	216.5	353.1	432.1	480.6
Overall mean		56.2	151.4	265.9	351.3	392.4	478.9
Weighted mean		80.6	188.7	298.8	372.1	396.9	480.6
Western WA average		70.4	146.3	211.8	268.0	334.0	356.1
	G	3.32	3.18	1.81	0.89	0.35	0.64
	G_{avg}	4.04	2.35	1.19	0.76	0.71	0.21

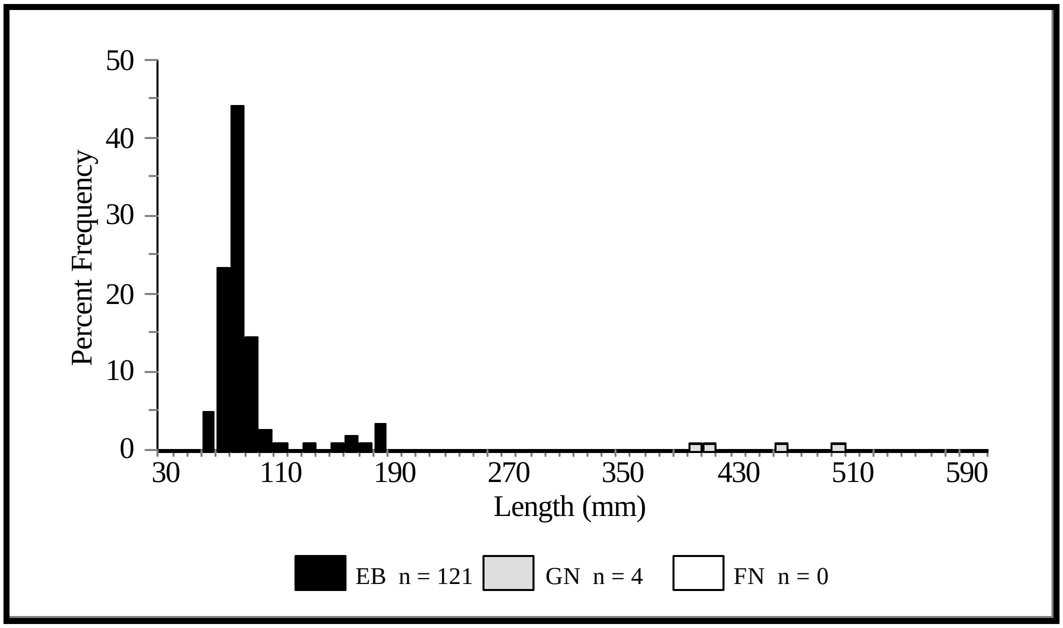

Figure 14. Length frequency histogram of smallmouth bass sampled from Lake Meridian (King County) in fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

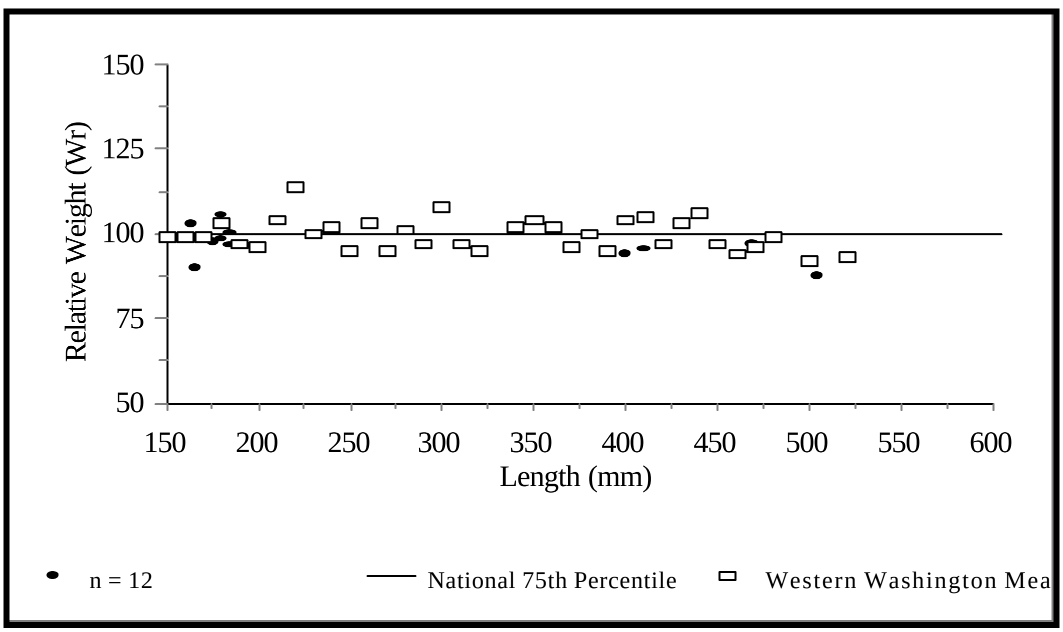

Figure 15. Relationship between total length and relative weight (*Wr*) of smallmouth bass from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Yellow perch

A total of 680 yellow perch were captured while electrofishing and gill netting (Figure 16). Of these, 402 (59%) were YOY which ranged in size from 45 to 102 mm TL. The remaining 278 fish were determined to be age 1+ through age 5+ and ranged in size from 103 mm and 253 mm TL (Table 14). Yellow perch aged 1+ and 3+ were in greatest abundance while age 4+ and 5+ fish were less well represented. Mean length at age of fish age 2+ and older exceeded state averages. Growth rates, *G*, also were higher than state averages except for fish in the 1999 and 1996 year classes. Relative weights were low when compared with the national standard but consistent with western Washington averages (Figure 17).

Table 14. Age and growth of yellow perch (*Perca flavescens*) captured at Lake Meridian (King County) during fall 2000. Unshaded values are mean back-calculated lengths at annulus formation using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age				
Year class	**# fish**	**1**	**2**	**3**	**4**	**5**
1999	25	62.1				
		79.8				
1998	12	60.5	146.0			
		81.2	153.7			
1997	20	44.9	120.4	179.7		
		68.7	133.7	184.6		
1996	7	40.3	140.6	183.7	216.7	
		65.4	153.3	191.1	220.0	
1995	1	32.3	115.3	186.9	215.1	240.4
		58.5	131.6	194.8	219.6	241.9
Overall mean		48.0	130.6	183.4	215.9	240.4
Weighted mean		74.8	143.0	186.6	220.0	241.9
Western WA average		59.7	119.9	152.1	192.5	206.0
	G	2.81	3.21	1.09	0.52	0.35
	G_{avg}	3.51	2.24	0.76	0.76	0.22

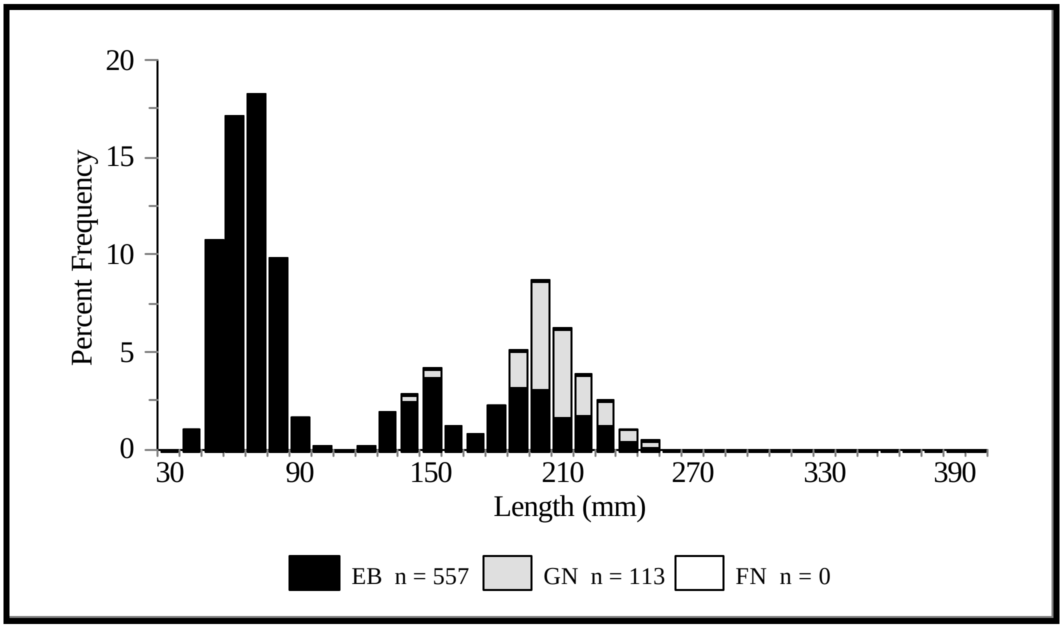

Figure 16. Length frequency histogram of yellow perch sampled from Lake Meridian (King County) in fall 2000. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

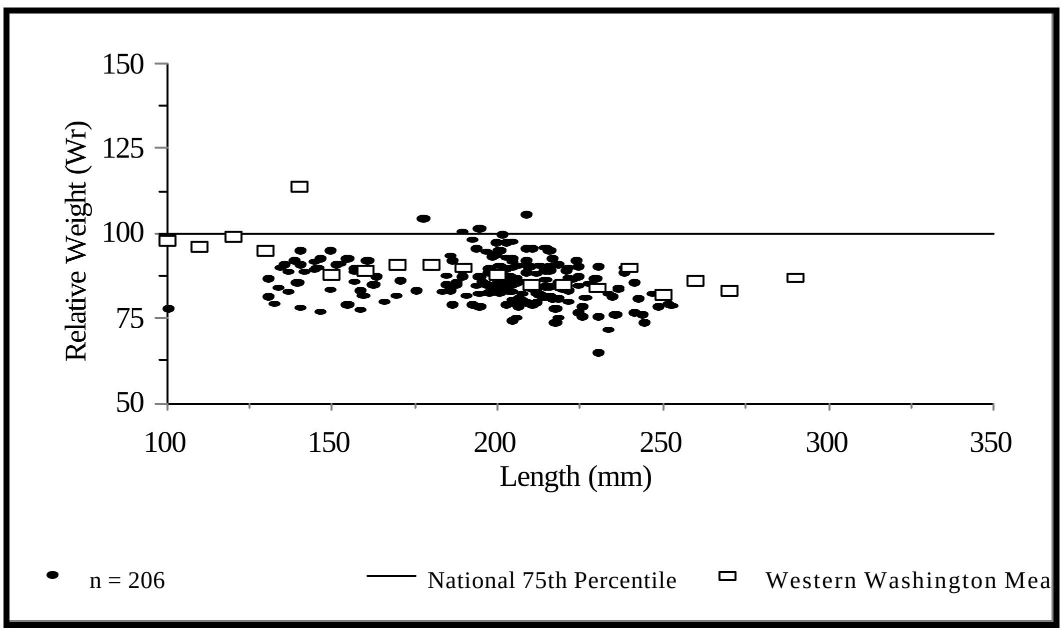

Figure 17. Relationship between total length and relative weight (*Wr*) of yellow perch from Lake Meridian (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Warmwater Enhancement Options

The Lake Meridian fish population sampled in the littoral zone during our fall 2000 survey was dominated by yellow perch. Although growth rates of predators such and largemouth and smallmouth bass were consistent with western Washington state averages, abundance of larger individuals was low. Sample sizes for species other than yellow perch and pumpkinseed were small, suggesting low abundance for those species. It is also possible that the types of gear used to collect the samples failed to capture representative numbers of fish of each species. Management options that might improve the warmwater fishery at Lake Meridian include, but are not limited to, the following:

Change Existing Fishing Rules to Improve Size Structure of Largemouth and Smallmouth Bass

Currently, Lake Meridian anglers are allowed to harvest five bass daily. Although there is no minimum size limit, no more than three fish can measure over 381 mm (15") TL. Implementing a 305 – 432 mm (12 – 17") slot limit for bass might succeed where the current rule failed to achieve balance in Lake Meridian. The main objective of a slot limit is to improve the size structure of bass. Under this rule, only fish less than 305 or greater than 432 mm TL may be kept. Decreasing the creel limit from three fish over 381 mm TL to one fish over 432 mm TL would stimulate harvest of small fish while still protecting large fish. A reduction of small fish may improve growth and production of predator and prey species alike (McHugh 1990). In Arkansas, an outstanding largemouth bass fishery was developed by adjusting the slot and the creel limits to stimulate harvest of small fish while protecting large fish (Turman and Dennis 1998).

A simpler alternative to protect bass would be to implement catch-and-release fishing on the lake. Under this rule, all bass captured must be released back into Lake Meridian alive. Increased numbers of larger fish would act as a control on the abundant yellow perch. Furthermore, the rule is simpler for anglers and easier for wildlife agents to enforce.

The success of any rule change, though, depends upon angler compliance. Reasons for non-compliance include lack of angler knowledge of the rules for a particular lake, a poor understanding of the purpose of the rules, and inadequate enforcement (Glass 1984). Therefore, clear and concise multilingual posters or signs should be placed at the lake describing the new regulations. Press releases should be sent to local papers, magazines, and sport fishing groups detailing the changes to, and purpose of, the rules. Furthermore, increasing the presence of WDFW enforcement personnel at Lake Meridian during peak harvest periods would encourage compliance.

Consider Stocking Channel Catfish to Control Abundant Yellow Perch

Temperature-sensitive channel catfish (*Ictalurus punctatus*) have been stocked into a number of Washington lakes in the past decade. These non-reproducing populations were introduced in an attempt to increase predation of over-abundant forage fish, such as yellow perch, and to add diversity to mixed-species fisheries (WDFW 1999). Lake Meridian's abundant forage base (i.e., yellow perch), and clear water make it suitable for stocking channel catfish. However, the lake's trophic status makes it difficult to predict the success of stocking the predator (Bonar et al. 1995).

Manage Lake Meridian for Panfish

The panfish population (yellow perch) at Lake Meridian is thriving. Therefore, the simplest management strategy might be developing the panfish fishery at the lake. Minimum length limits on predators, such as largemouth bass, are often used to develop quality panfish fisheries (Willis 1989). Under a minimum length rule, all fish below a designated length must be released. For example, a minimum length limit of 432 mm (17") TL on largemouth bass in Lake Meridian should increase the number of predators below 432 mm TL. Consequently, these fish would then thin out the abundant yellow perch 'making room' for the remaining forage fish to achieve their full growth potential.

Consider the Potential Impacts of Outlet Modification

Flooding along the outlet channel during periods of high water has been a persistent problem for the city of Kent. In 2000, the city began investigating ways to modify the outlet of Lake Meridian and the channel which forms a ditch along 152nd Avenue to Soos Park and Big Soos Creek. As modification options have not yet been presented, it is unclear how changes of the outlet would effect fish populations in the lake, if at all.

Consider Improvements for WDFW Boat Launch

Though the city of Kent maintains a high quality boat launching facility with concrete ramp and paved parking area, the facility is gated and locked at night. Anglers who want to launch their boats before dawn must use the WDFW public access area. The access area, at approximately 38 feet wide and 150 feet long, has space for only about 6 well-parked vehicles with trailers. And, during periods when the lake level is low, the launch area may be as shallow as 11 inches at a distance of 20 feet from the shore, making it difficult for some anglers to launch their boats. Improvements to the WDFW launch area, such as installation of a concrete ramp, may be of benefit to anglers.

Literature Cited

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

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

Bister, T.J., D.W. Willis, M.L. Brown, S.M. Jordan, R.M. Neumann, M.C. Quist, and C.S. Guy. 2000. Proposed standard weight (W_s) equations and standard length categories for 18 warmwater nongame and riverine fish species. North American Journal of Fisheries Management 20: 570-574.

Bonar, S. A., J. Pahutski, B. Bolding, and J. Webster. 1995. Factors related to survival and growth of stocked channel catfish in Washington Lakes. Washington Department of Fish and Wildlife, Inland Fish Division, Technical Report # IF95-03, 24 p.

Bortelson, G.C., N.P. Dion, J.B. McConnell, and L.M. Nelson. 1976. Reconnaissance Data on Lakes in Washington, Volume 3. Water Supply Bulletin 43, Vol. 3, 259 p. Washington Department of Ecology in cooperation with United States Geological Survey, Olympia, WA.

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

Carline, R.F. 1986. Assessment of fish populations and measurement of angler harvest: indices as predictors of fish community traits. Reservoir Fisheries Management: Strategies of the 80's: 46-56.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22: 361-369.

Chew, R.L. 1974. Early life history of the Florida largemouth bass. Florida Game and Fresh Water Fish Commission, Fishery Bulletin # 7, 76 p.

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.

Downen, M.R., and K.W. Mueller. 2000a. 1999 Campbell Lake survey: the warmwater fish community fifteen years after implementation of a lake restoration plan. Washington Department of Fish and Wildlife, Warmwater Enhancement Program, Technical Report # FPT 00-13, 28 p.

Downen, M.R., and K.W. Mueller. 2000b. 1998 Twin Lakes (Gissburg Ponds) survey: assessment and comparison of the warmwater fish communities in two small, heavily fished ponds. Washington Department of Fish and Wildlife, Warmwater Enhancement Program, Technical Report # FPT 00-04, 33 p.

Downen, M.R., and K.W. Mueller. 2000c. 1999 Lake Sawyer survey: the warmwater fish community in a popular, unregulated fishery. Washington Department of Fish and Wildlife, Warmwater Enhancement Program, Technical Report # FPT 00-23, 32 p.

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, 137 p.

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

Glass, R.D. 1984. Angler compliance with length limits on largemouth bass in an Oklahoma reservoir. North American Journal of Fisheries Management 4: 457-459.

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.

Johansen R. 1999. Top 10 King County bass holes. Washington-Oregon Game and Fish 1999 (5):24.

KCSWM (King County Surface Water Management). 1996. Aquatic plant mapping for 36 King County lakes. King County Department of Natural Resources Surface Water Management Division, Seattle, WA.

KCWLRD (King County Water and Land Resources Division). 1999. King County lake monitoring report: a report on 1998 volunteer lake monitoring in King County, Washington. King County Water and Resources Division, Seattle, WA.

KCWLRD (King County Water and Land Resources Division). 2001. King County lake monitoring report: a report on 1999 volunteer lake monitoring in King County, Washington. King County Water and Resources Division, Seattle, WA.

KNJ (Kent News Journal). 1963. News article. Lake Meridian residents vote for rehabilitation. Kent News Journal, Monday, August 20, 1963.

Kohler, C.C., and A.M. Kelly. 1991. Assessing predator-prey balance in impoundments. Pages 257-260 *in* Proceedings of the Warmwater Fisheries Symposium I, June 4-8, 1991, Scottsdale, Arizona. USDA Forest Service, General Technical Report RM-207.

McHugh, J.J. 1990. Response of bluegills and crappies to reduced abundance of largemouth bass in two Alabama impoundments. North American Journal of Fisheries Management 10: 344-351.

Metro. 1976. Lake Meridian lake rehabilitation phase I. Draft scope of work. Municipality of Metropolitan Seattle. Seattle, WA.

Moore, W.G. 1942. Field studies on the oxygen requirements of certain fresh-water fishes. Ecology 23:319-329.

Mueller, K.M. 1998. 1997 Fazon Lake survey: crowding of the warmwater fish community in a small, lowland lake. Washington Department of Fish and Wildlife, Warmwater Enhancement Program, June 1998 Technical Report, 22 p.

Murphy, B.R., and D.W. Willis. 1991. Application of relative weight (W_r) 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.

Olson, M.H., G.G. Mittelbach, and C.W. Osenburg. 1995. Competition between predator and prey: resource-based mechanisms and implications for stage-structured dynamics. Ecology 76: 1758-1771.

Rudnick, R. 1978. Angle Lake. Fishing and Hunting News, April 22, 1978. 10 p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Board of Canada 191:382 pp.

Swingle, H.S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Auburn University, Alabama Agricultural Experiment Station, Bulletin # 274, 74 p.

Turman, D., and C. Dennis. 1998. Review of largemouth bass minimum length and slot limits on Lake Columbia, Arkansas. American Fisheries Society, Fisheries Management Section Newsletter 17(1): 17.

WDFW (Washington Department of Fish and Wildlife). 1999. Spring 1999 hatchery trout stocking plan for Washington lakes and streams. Report Number IN99-02.

Wiley, M.J., R.W. Gordon, S.W. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sport fish production in Illinois ponds: a simple model. North American Journal of Fisheries Management 4:111-119.

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

Willis, D.W. 1998. Warmwater fisheries sampling, assessment, and management. United States Fish and Wildlife Service. National Conservation Training Center, 262 p.

This program receives Federal financial assistance from the U.S. Fish and Wildlife Service Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972. The U.S. Department of the Interior and its bureaus prohibit discrimination on the bases of race, color, national origin, age, disability and sex (in educational programs). If you believe that you have been discriminated against in any program, activity or facility, please write to:

U.S. Fish and Wildlife Service
Office of External Programs
4040 N. Fairfax Drive, Suite 130
Arlington, VA 22203