1999 Lake Desire Survey: The Warmwater Fish Community of a Productive Inland Lake Historically Managed for Trout

by

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Abstract

In order to manage the mixed species fishery of Lake Desire (King County) more effectively, the WDFW Warmwater Enhancement Program conducted a stock assessment in spring 1999. The fish community in the littoral zone of Lake Desire was dominated by warmwater species, particularly pumpkinseed and largemouth bass. Rapid growth and low numbers characterized the community. Growth of largemouth bass was above average and PSD values were within ranges generally accepted for balanced communities. Growth of pumpkinseed, the dominant forage species, was also above average, but PSD values were lower than those generally accepted for balanced communities. The alternative forage species, yellow perch, demonstrated rapid growth, but while age classes were more evenly distributed, their density was much lower. The largemouth bass population may be limited by a small forage base. Rainbow trout inhabiting the pelagic zone of the lake were relatively abundant and demonstrated high relative weights. These findings suggest Lake Desire should continue to be managed as a mixed species fishery. Options that might improve the warmwater component of this fishery include, but are not limited to, assessment and identification of critical habitat, change existing fishing rules to alter size structure of largemouth bass, or change existing fishing rules to increase populations of forage fish.

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Introduction and Background

Lake Desire is a small (29 ha), shallow (maximum depth = 6.4 m, mean depth = 4 m), productive lake located in the Maple Valley area of southeast King County, Washington. Geologic materials underlying the lake are sedimentary and metamorphic, and the surrounding catchment basin is small (487 ha). The lake adjoins 12 ha of peat bog and both inflows and outflow are intermittent (Figure 1). The lake substrate is predominantly a mixture of silt and detritus with moderate quantities of coarse woody debris scattered throughout the littoral zone.

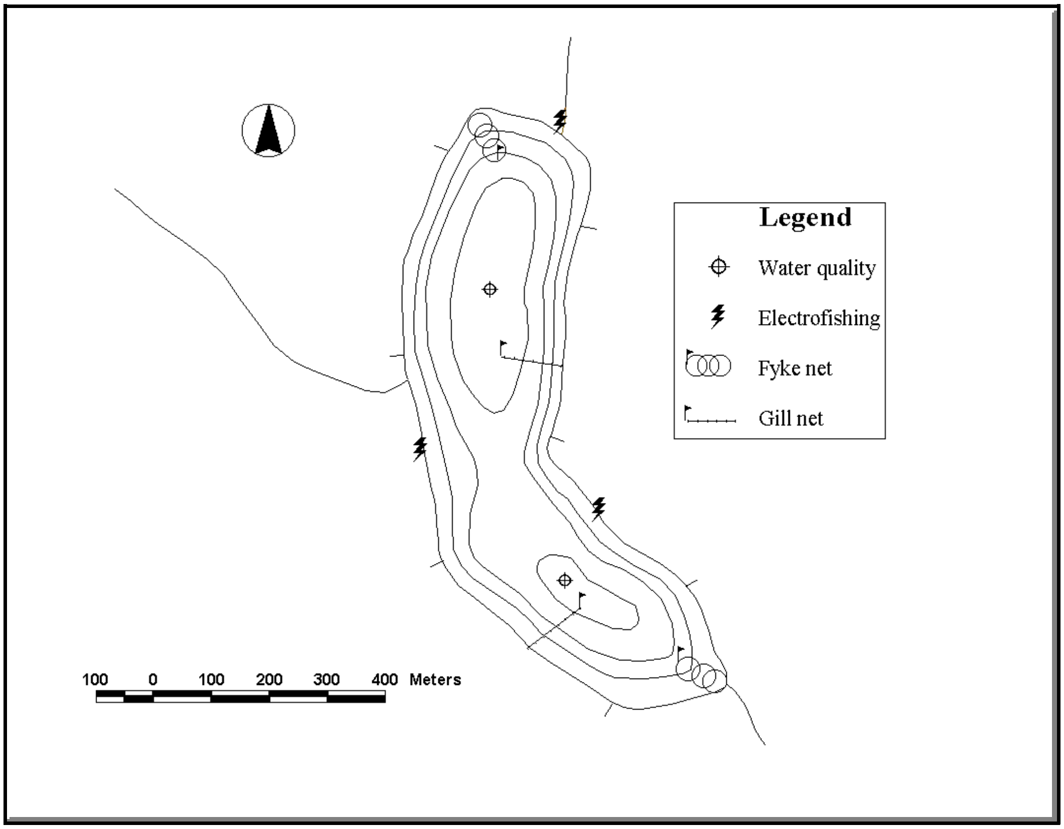

Figure 1. Hydrology, bathymetry, and 1999 sampling sites on Lake Desire (King County).

Land use in the basin is a mosaic of residential and undeveloped second growth forest, and these land uses are equally distributed along the shoreline of the lake. Approximately 5% of the shoreline is bulkheaded and 60 docks currently exist on the lake. Currently, one Washington Department of Fish and Wildlife (WDFW) access exists at the north end of the lake and provides some boat and shore fishing access.

Small watershed size, shallow basin, and underlying geology support naturally high productivity and human activity and development tend to exacerbate this state. Since the 1970s, water quality of Lake Desire has been characterized by elevated concentrations of phosphorus and chlorophyll-*a* which indicate eutrophic conditions (King County 1997). Early warming of surface layers of the water column and rapid decomposition of organic materials in the hypolimnion have resulted in predictable patterns of oxygen depletion which are further evidence of eutrophication.

Approximately 1.2 ha of the lake is covered by floating plant assemblages of *Nitella* and *Nuphar* spp. while submergent communities of *potamogeton*, *myriophyllum*, and *elodea* spp. comprise 5.2 ha. In most areas, however, percent cover is typically less than 25%. Emergent vegetation coverage is somewhat limited by development but heavy infestations of purple loosestrife (*Lythrum salicaria*) are scattered along the lake margin (Metro 1995).

Historically, Lake Desire was managed as a trout fishery and was rehabilitated in 1968 and 1972 to remove introduced yellow perch, pumpkinseed, and largemouth bass. More recently, the lake has been managed as a mixed species fishery for annually stocked rainbow and cutthroat trout, as well as for persistent populations of warmwater species. In order to manage these fisheries more effectively, the WDFW Warmwater Enhancement Program conducted a stock assessment in spring 1999. We assessed species composition, abundance, size structure, growth, and condition of fish in the lake. We also evaluated habitat, access, and the effects of current fishing rules, then outlined options for enhancing the fishery and fishing opportunity on the lake.

Materials and Methods

Two WDFW biologists and one scientific technician surveyed Lake Desire during 14 and 15 June 1999. 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 electrofishing boat set to a DC current of 120 cycles/sec at 6 amps current. 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 a single 30.4-m lead and two 15.2 m-wings of 130 mm nylon mesh with the body of the nets stretched around four 1.2 m aluminum rings in each of two sections.

Sampling locations were selected by dividing the shoreline into 6 consecutively numbered sections of about 400 m each as determined from a 1:24,000 USGS map (Figure 1). A portion of the shoreline was sampled by electrofishing 3 randomly selected sections for a total of 1,800 seconds. While electrofishing, the boat was maneuvered through the shallows (depth range: 0.2 - 1.5 m), adjacent to the shoreline, at a rate of 18 m/minute. Two gill nets were set perpendicular to the shoreline with the small-mesh end attached onshore and the large-mesh end anchored offshore. Two fyke nets were set in water less than three meters deep, perpendicular to the shoreline with wings extended at 70º angles from the lead. Sampling occurred during evening hours to maximize the type and number of fish captured. In order to reduce bias between techniques and to standardize effort, the sampling time for each gear type was standardized to a ratio of 1:1:1 (Fletcher et al. 1993). One unit of electrofishing time equal to three 600-second sections (actual pedal-down time) was applied for each 24 hour unit (= 2 net nights) of gill netting time and fyke netting time so that three sites were electrofished for every two sites of gill netting and fyke netting.

All fish captured were identified to species. Each fish was measured to the nearest millimeter 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. Fish were weighed to the nearest 0.5 g. If a sample included several hundred individuals of a given species, then a sub-sample ($n \geq 100$ fish) was measured and weighed while the remainder was counted overboard. The length frequency distribution of the sub-sample was then applied to the total number collected. Weights of individuals counted overboard were estimated using the linear regression of $\log_{10}$-length on $\log_{10}$-weight of fish from the sub-sample. Scales were removed from up to five 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). Scales were also measured for standard back-calculation of growth. However, a lack of technical resources precluded aging members of the family Ictaluridae (catfish).

Water quality data was collected during midday from two locations on June 14, 1999 using a Hydrolab® probe and digital recorder. We measured dissolved oxygen, total dissolved solids, temperature, pH, and specific conductance and recorded secchi disc readings in meters (Table 1).

Table 1. Water quality from the north and south end of Lake Desire (King County) collected mid-day on June 14, 1999.

Basin	Depth (m)	Temp (°C)	DO (mg/L)	pH	Conductance (uS/cm)	TDS (g/L)
South	0	24.00	8.85	7.85	34.7	0.0223
	1	23.84	8.89	7.58	34.9	0.0223
	2	18.49	9.70	7.61	34.1	0.0218
Secchi depth = 2.8 m	3	15.48	9.58	7.78	34.4	0.022
	4	14.22	3.67	7.25	36.7	0.0234
	4.5	12.04	0.51	6.97	44.6	0.0291
North	0	23.67	8.99	7.71	35.1	0.0225
	1	23.27	8.97	7.62	34.9	0.0224
	2	18.9	9.62	7.63	34.1	0.0218
Secchi depth = 2.5 m	3	16.4	10.21	7.77	34.2	0.0219
	4	13.43	1.72	7.25	37.5	0.0240
	5	12.09	0.47	6.94	39.6	0.0254
	6	11.39	0.31	6.79	43.6	0.0275

Data Analysis

Balancing predator and prey fish populations is an important axiom of managing warmwater fisheries. According to Bennett (1962), the term ‘balance’ is used loosely to describe a system in which omnivorous forage fish or prey maximize food resources to produce harvestable-size stocks for fishermen while maintaining an adequate forage base for piscivorous fish or predators. Predators must reproduce and grow to control overproduction of both 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, size structure, growth, and condition (plumpness or robustness) of fish provide useful information on population age class structures, relative species abundances, the potential for species interactions, and the adequacy of the food supplies for various foraging niches (Ricker 1975; Kohler and Kelly 1991; Olson et al. 1995). Balance and productivity of the community may also be addressed based upon these evaluations (Swingle 1950, Bennett 1962).

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.

Catch per unit effort (CPUE) by gear type was determined for all fish species (number of fish/hour electrofishing and number of fish/net night). Only stock size fish and larger were used to determine CPUE for warmwater and other game species. Stock length, which varies by species (see Table 3 and discussion below), refers to the minimum size of fish having recreational value. Since sample locations were randomly selected, which can 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 ± $t_{(\alpha, N-1)} \times SE$, where t = Student's t for α confidence level with n -1 degrees of freedom (two-tailed) and SE = standard error of the mean. Since it is standardized, CPUE is a useful index for comparing relative abundance of stocks between lakes and the confidence intervals express the relative uniformity of species distributions throughout a given lake. CPUE values for Lake Desire were then compared to western Washington State averages compiled by the WDFW Inland Fisheries Research Unit (Table 2).

Table 2. Mean catch per unit effort (number of fish /hour electrofishing and number of fish/net night) for stock size fish collected from several western Washington Lakes while electrofishing, gill netting, and fyke netting during 1997 and 1998.

Species	Gear Type					
	Electrofishing (fish/hr)	# lakes	Gillnetting (fish/hr)	# lakes	Fyke netting (fish/hr)	# lakes
Largemouth bass	41.6	12	1.9	8	0.3	1
Bluegill	169.1	7	1.6	4	20.7	5
Pumpkinseed	70.8	11	3.8	9	7.9	4
Yellow perch	97.5	8	13.7	6	0.2	2
Brown bullhead	7.8	10	14.4	7	12.7	6

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.

The proportional stock density (PSD) of each warmwater fish species was determined following procedures outlined in Anderson and Neumann (1996). PSD, calculated as the number of fish$\geq$quality length/number of fish$\geq$stock length$\times$100, is a numerical descriptor of length frequency data that provides useful information about size class structure. 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 warmwater 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 3). Preferred length (45-55% of world-record length) refers to the minimum size fish anglers would prefer to catch. Memorable length (59-64% of world-record length) refers to the minimum size fish most anglers are likely to 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 size class structure, but is more sensitive to changes in year-class strength. RSD was calculated as the number of fish$\geq$specified length/number of fish$\geq$stock length x100. 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 3. Length categories for warmwater fish species and rainbow trout by Gabelhouse (1984) used to calculate stock density indices (PSD, RSD) for fish captured at Lake Desire (King County) during spring 1999 based on numbers from Anderson and Neumann (1996) and Bister et al. (*In press*).

	Total Length (mm)				
Species	Stock	Quality	Preferred	Memorable	Trophy
Largemouth bass	200	300	380	510	630
Bluegill	80	150	200	250	300
Pumpkinseed	80	150	200	250	300
Yellow perch	130	200	250	300	380
Brown bullhead	130	200	280	360	430
Rainbow trout	250	400	500	650	800

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 4).

Table 4. Stock density index ranges for largemouth bass and bluegills under three commonly implemented management options (from Willis et al. 1993).

Option	Largemouth Bass			Bluegill	
	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

We compared PSD and RSD values for warmwater species in Lake Desire with western Washington State averages compiled by the WDFW Inland Fisheries Research Unit (Table 5).

Table 5. Mean stock density indices for available warmwater fishes from western Washington lakes with the most effective sampling method for a given species during 1997 and 1998 (WDFW Inland Fisheries Research Unit, unpublished data). 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.

Species	Gear type	# lakes	PSD	RSD-P	RSD-M	RSD-T
Largemouth bass	EB	12	29	13	0	0
Black crappie	EB	3	100	5	0	0
Bluegill	EB	9	16	0	0	0
Pumpkinseed	EB	12	8	0	0	0
Yellow perch	GN	12	53	1	0	0

Age and growth of warmwater fishes in Lake Desire were evaluated 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 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 Desire fish and the western Washington State average (listed in Fletcher et al. 1993) for the same species. Instantaneous growth rates, G, were calculated according to Ricker (1975), by estimating weights from average total lengths using the linear regression of $\log_{10}$-length on $\log_{10}$-weight. Mean annual G was then compared to the state average, G_{avg}, derived from the data listed in Fletcher et al. (1993).

A relative weight (W_r) index was used to evaluate the condition of fish in the lake. A W_r value of 100 generally indicates that a fish has a condition value equal to the national standard (75th percentile) for that species. Furthermore, W_r is useful for comparing the condition of different size classes within a single population to determine if all sizes are finding adequate forage (ODFW 1997). Following Murphy et al. (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 for the W_s equations of many cold- and warmwater fish species, including the minimum length recommendations for their application, are listed in Anderson and Neumann (1996). The W_r values from this study were compared to the national standard ($W_r = 100$) and where available, with mean W_r values from up to 25 western Washington warmwater lakes sampled during 1997 and 1998 (Steve Caromile, WDFW, unpublished data). Trends in the dispersion of points on the relative weight graph have been used to infer ecological dynamics of fish populations (Willis 1999). For example, a decrease in relative weight with increasing total length often occurs where competition is high among larger size classes. Conversely, lower relative weights occurring with smaller fish suggests competition and crowding for these fish. Testing the statistical significance of the relationship between total length and relative weight, standard transformation failed to normalize the length data. Moreover, we make no assumption that relationships would be linear. We therefore used a nonparametric correlation, Spearman's Rho (Zar 1984), to assess the significance of correlations between total length and relative weight where relationships were suggested by the graphs.

Results and Discussion

Species Composition

Largemouth bass was the dominant species in our sample from Lake Desire by weight (54%), while pumpkinseed was the dominant species by number (34%). Yellow perch accounted for nearly the same percentage of the sample by weight and number at 12% and 8%, respectively (Table 6). Although brown bullhead only accounted for 2.5 % of our sample by number, they made up 8 % of our sample by weight. Rainbow trout were the most abundant salmonid making up 19 % of our sample by weight and 9 % by number. We sampled three coho salmon parr from Lake Desire during our survey.

Table 6. Species composition by weight (kg) and number of fish captured at Lake Desire (King County) during spring 1999.

	Species composition				
	by weight		by number		Size range (mm TL)
Species	(kg)	(%)	(#)	(%)	
Largemouth bass (*Micropterus salmoides*)	10.835	53.986	73	30.802	60 - 498
Bluegill (*Lepomis macrochirus*)	0.052	0.257	31	13.080	32 - 72
Pumpkinseed (*Lepomis gibbosus*)	1.198	5.969	82	34.599	41 - 145
Yellow perch (*Perca flavescens*)	2.467	12.293	20	8.439	130 - 278
Brown bullhead (*Ameiurus nebulosus*)	1.583	7.888	6	2.532	208 - 312
Rainbow trout (*Oncorhynchus mykiss*)	3.812	18.994	21	8.861	137 - 290
Cutthroat trout (*Oncorhynchus clarki*)	0.107	0.531	1	0.422	204
Coho salmon (*Oncorhynchus kisutch*)	0.017	0.082	3	1.266	49 - 96

CPUE

Catch rates for all stock length warmwater species were below western Washington State averages for all gear types. Catch rates for largemouth bass and pumpkinseed both were about half the state average. Gill netting and fyke netting catch rates were very low for all stock length fish compared with state averages. (Table 7).

Table 7. Mean catch per unit effort (number of fish /hour electrofishing and number of fish/net night), including 80% confidence intervals, for stock size fish collected from Lake Desire (King County) while electrofishing, gill netting, and fyke netting during spring 1999.

Species	Gear Type					
	Electrofishing (fish/hr)	n (sites)	Gillnetting (fish/hr)	n (net nights)	Fyke netting (fish/hr)	n (net nights)
Largemouth bass	17.81 ± 7.6	0	0.5[a]	2	0	2
Bluegill	0	0	0	2	0	2
Pumpkinseed	47.51 ± 4.48	0	0	2	3 ± 2.56	2
Yellow perch	29.74 ± 27.5	0	2.5 ± 0.64	2	0	2
Brown bullhead	1.98[a]	0	0	2	2.5 ± 1.92	2
Rainbow trout	0	0	4 ± 2.56	2	0	2
Cutthroat trout	0	0	0.5[a]	2	0	2
Coho salmon	0	0	0.5[a]	2	1[a]	2

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

Stock Density Indices

Proportional stock indices for largemouth bass were generally above the western Washington State average while electrofishing and within the range generally accepted for balanced predator/prey populations (Table 8). However, the PSD for largemouth bass was low in relation to the RSD-P due to a paucity of quality-length fish that were not also of preferred length. The weakness of the quality size class is also apparent in the length frequency distribution (see Figure 2). These indices should be viewed with caution due to low sample size (Divens 1998). No quality size bluegill or pumpkinseeds were sampled. Yellow perch and brown bullhead demonstrated stock density values above the western Washington State averages, but low sample size requires that these indices be viewed with caution as well.

Table 8. Traditional stock density indices, including 80% confidence intervals, for warmwater fishes collected from Lake Desire (King County) while electrofishing, gill netting, and fyke netting during spring 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	n	PSD	RSD-P	RSD-M	RSD-T
Largemouth bass	EB	9	67 ± 20	56 ± 21	0	0
	GN	1	0	0	0	0
	FN	0	0	0	0	0
Bluegill	EB	0	0	0	0	0
	GN	0	0	0	0	0
	FN	0	0	0	0	0
Pumpkinseed	EB	24	0	0	0	0
	GN	0	0	0	0	0
	FN	6	0	0	0	0
Yellow perch	EB	15	40 ± 16	20 ± 13	0	0
	GN	5	80 ± 23	20[a]	0	0
	FN	0	0	0	0	0
Brown bullhead	EB	1	100	100	0	0
	GN	0	0	0	0	0
	FN	5	40 ± 28	0	0	0
Rainbow Trout	EB	0	0	0	0	0
	GN	8	0	0	0	0
	FN	0	0	0	0	0

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

Largemouth Bass

Largemouth bass ranged from 60 to 498 mm TL (age 1+ to 8+) (Figure 2). The 1998 year-class was dominant, but the 1995 year-class was not sampled (Table 9). Other year classes were equally represented. Growth was above average for age 0+ and 1+, average for age 2+, and above average through ages 3+ and 4+. Despite slower than average growth rates at some ages, mean total lengths were above average for all age classes. Relative weights were generally consistent with western Washington State averages across the entire range of size classes during the sampling period (Figure 3). The Spearman correlation coefficient (Rho) for largemouth bass length and relative weight was 0.387 ($p = 0.239$).

Table 9. Age and growth of largemouth bass captured at Lake Desire (King County) during fall 1999. 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	7	8
1998	32	65.9							
		71.3							
1997	4	49.0	161.7						
		63.4	163.9						
1996	2	57.1	160.6	224.7					
		72.4	167.5	226.5					
1995	0								
1994	1	97.9	211.7	336.3	380.7	427.0			
		113.4	222.2	341.1	383.5	427.7			
1993	2	66.8	187.6	248.3	283.5	311.8	347.9		
		83.1	197.1	254.5	287.7	314.4	348.5		
1992	2	73.1	219.8	311.0	371.9	426.8	448.0	467.3	
		90.1	230.8	318.1	376.6	429.2	449.6	468.1	
1991	1	90.6	171.6	257.4	295.5	338.4	362.2	386.0	433.7
		106.5	183.9	265.9	302.3	343.3	366.0	388.8	434.3
Overall mean		71.5	185.5	275.5	332.9	376.0	386.1	426.7	433.7
Weighted mean		73.8	187.7	275.6	335.7	376.4	392.4	441.7	434.3
State Average		60.4	145.5	222.2	261.1	289.3	319	367.8	396
	G	2.683	2.947	1.223	0.585	0.376	0.082	0.309	0.050
	G_{avg}	2.162	2.717	1.308	0.498	0.317	0.302	0.440	0.228

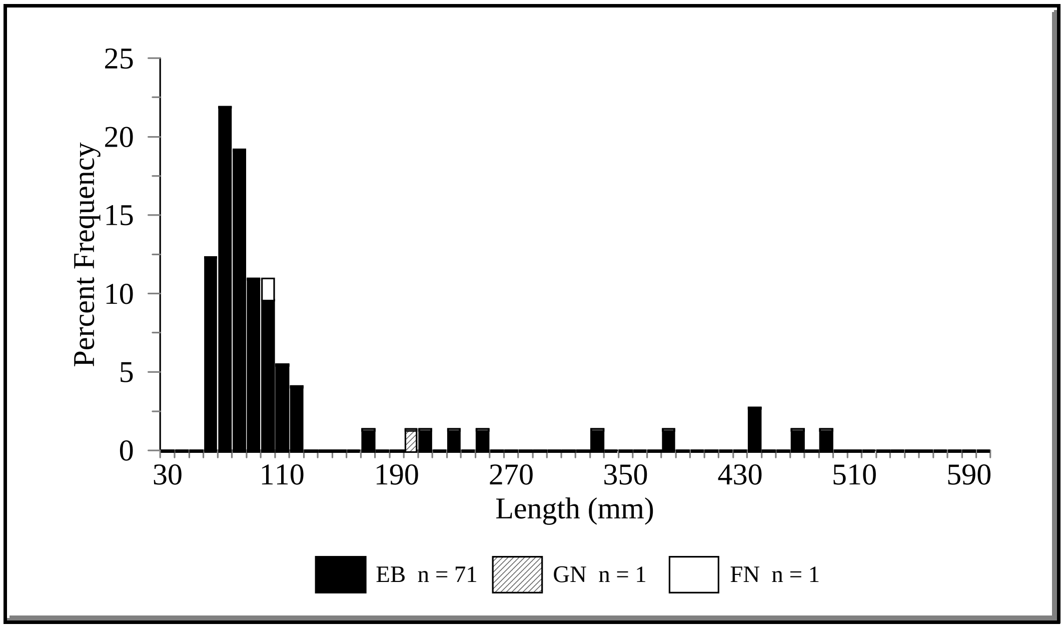

Figure 2. Length frequency histogram of largemouth bass sampled from Lake Desire in spring 1999. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

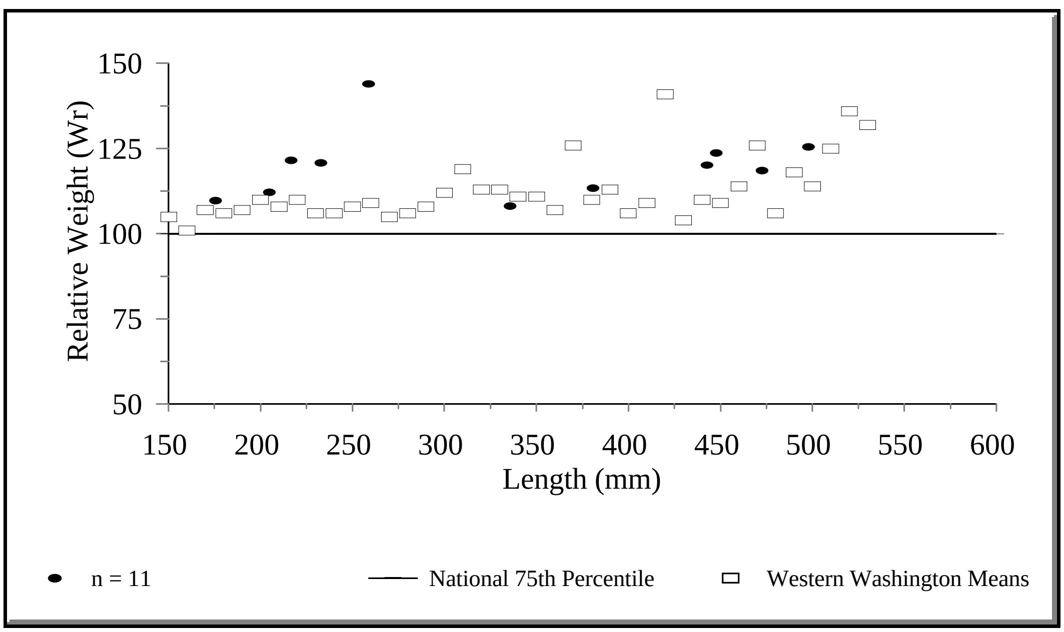

Figure 3. Relationship between total length and relative weight (W_r) of largemouth bass from Lake Desire (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Bluegill

Bluegill ranged from 32 to 72 mm TL (age 1+) (Figure 4). No stock length bluegill nor individuals older than age 1+ were sampled during this survey, suggesting this species may be a recent addition to the warmwater community (Table 10). Initial growth rates of bluegill in Lake Desire were very low. Relative weights of bluegill could not be calculated due to the paucity of larger individuals.

Table 10. Age and growth of bluegill captured at Lake Desire (King County) during spring 1999. 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
1998	10	29.1
		38.1
Overall mean		29.1
Weighted mean		38.1
State Average		37.3
	G	1.24
	G_{avg}	2.08

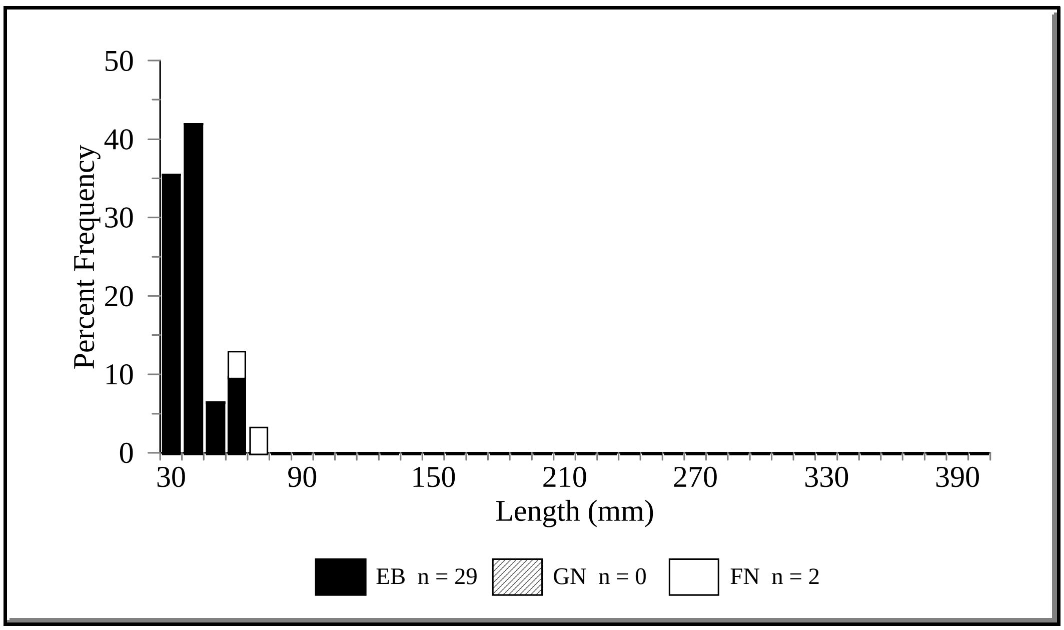

Figure 4. Length frequency histogram of bluegill sampled from Lake Desire in spring 1999. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

Pumpkinseed

Pumpkinseed ranged from 41 to 145 mm TL (age 1+ to 2+) (Figure 5, Table 11). Growth of pumpkinseed was above the western Washington State average for the first two years. Relative weights of pumpkinseed varied greatly among individuals. These values were loosely distributed around the western Washington State average and showed no trend with increasing TL (Figure 6). The Spearman correlation coefficient (Rho) for pumpkinseed length and relative weight was –0.102 (p = 0.378).

Table 11. Age and growth of pumpkinseed captured at Lake Desire (King County) during spring 1999. 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
1998	28	42.8	
		52.8	
1997	15	22.9	103.6
		43.3	107.8
Overall mean		32.9	103.6
Weighted mean		49.5	107.8
State Average		23.6	72.1
	G	1.50	3.46
	G_{avg}	0.50	3.36

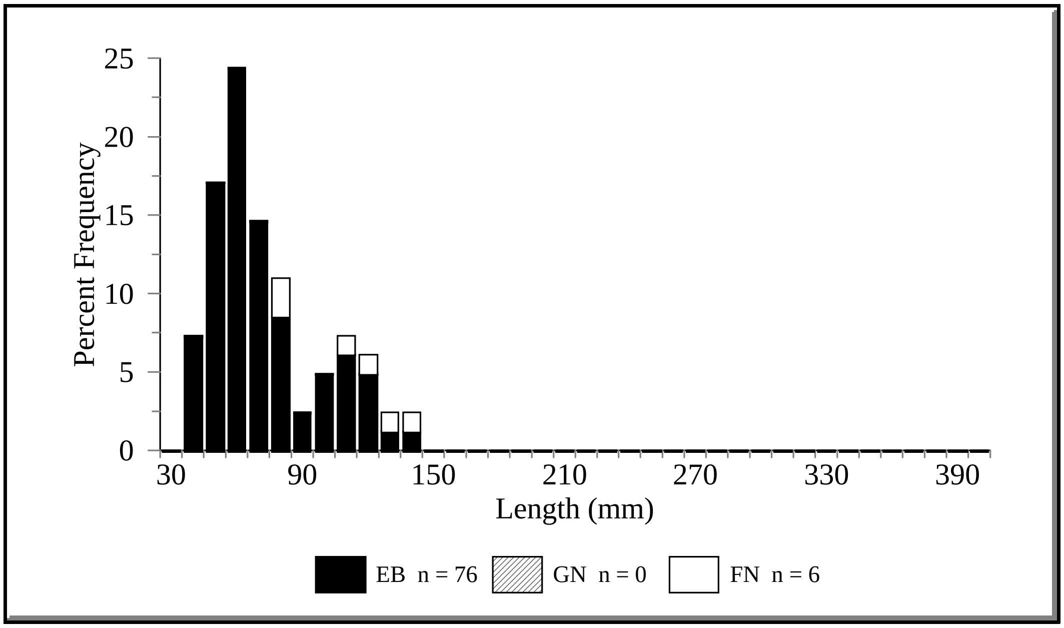

Figure 5. Length frequency histogram of pumpkinseed sampled from Lake Desire in spring 1999. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

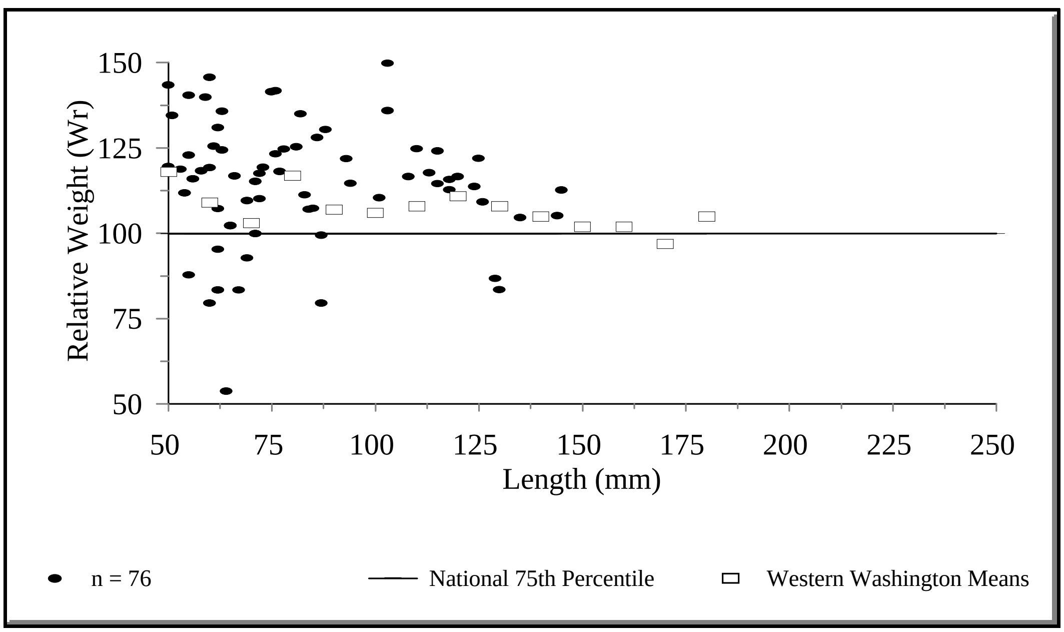

Figure 6. Relationship between total length and relative weight (W_r) of pumpkinseed from Lake Desire (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Yellow Perch

Yellow perch ranged from 130 to 278 mm TL (age 1+ to 5+) (Figure 7, Table 12). Age 1+ and 2+ yellow perch were relatively abundant. Growth of yellow perch varied from well above the western Washington State average for the first year to slightly below average from age 3+ to age 4+, but was generally consistent with the average overall. Relative weights of yellow perch were above the western Washington State average, particularly for larger fish, with no apparent relationship between relative weight and TL (Figure 8). The Spearman correlation coefficient (Rho) for yellow perch length and relative weight was 0.086 (p = 0.718).

Table 12. Age and growth of yellow perch captured at Lake Desire (King County) during spring 1999. 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
1998	11	97.5				
		106.0				
1997	6	85.7	172.1			
		104.0	178.7			
1996	1	117.3	203.5	231.7		
		133.3	209.2	234.0		
1995	2	78.0	168.6	216.0	247.8	
		99.1	179.4	221.5	249.7	
1994	1	62.2	160.9	215.8	241.4	264.6
		85.5	173.6	222.5	245.4	266.0
Overall mean		88.1	176.3	221.2	244.6	264.6
Weighted mean		105.1	181.4	224.9	248.3	266.0
State Average		59.7	119.9	152.1	192.5	206
	G	4.76	2.23	0.73	0.32	0.25
	G_{avg}	3.51	2.24	0.76	0.76	0.22

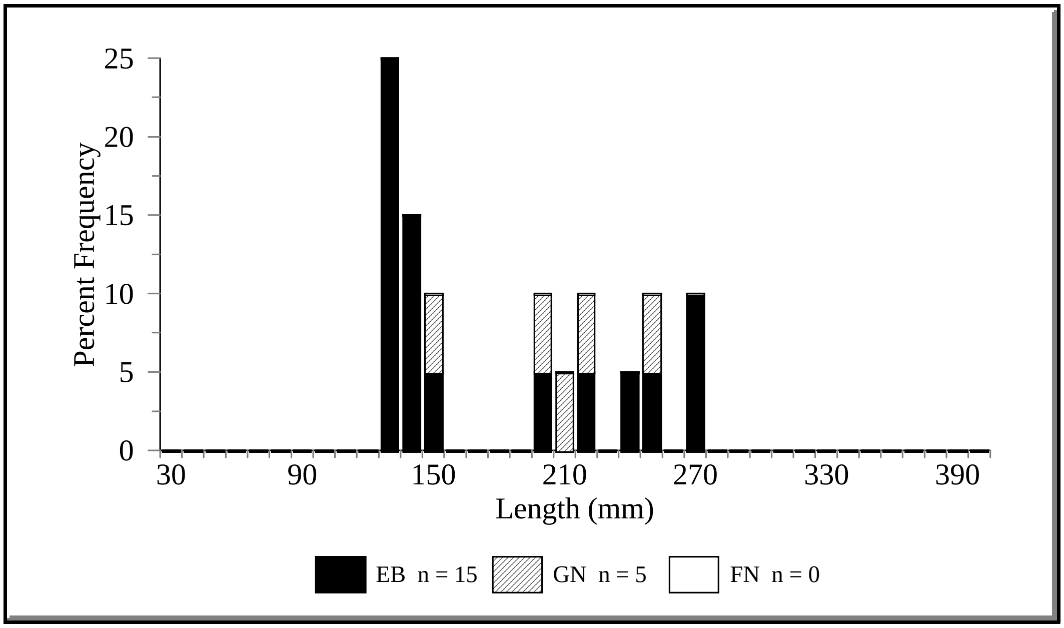

Figure 7. Length frequency histogram of yellow perch sampled from Lake Desire in spring 1999. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

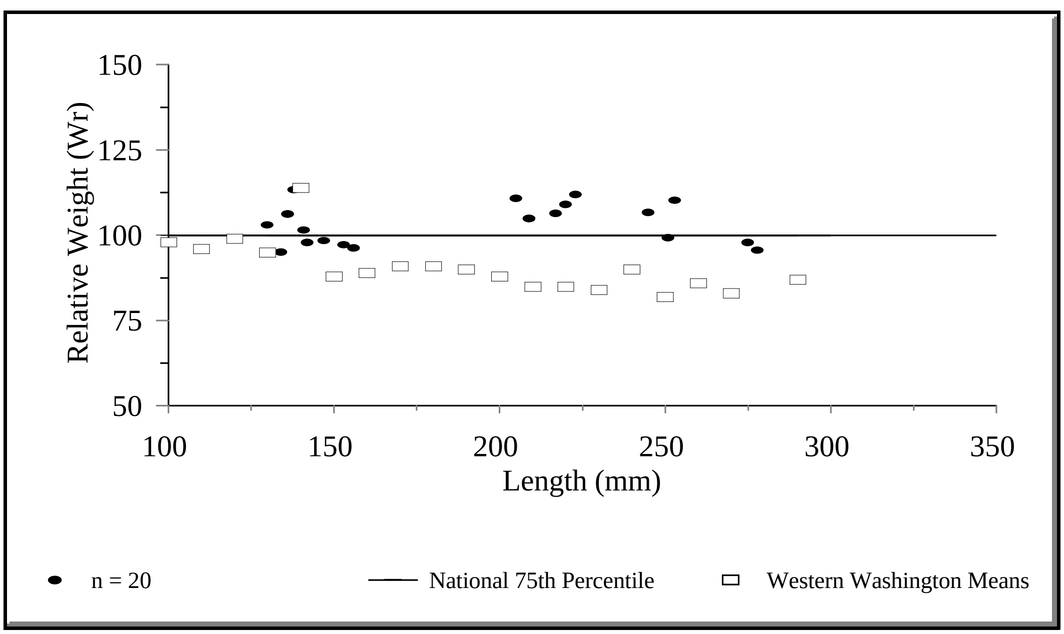

Figure 8. Relationship between total length and relative weight (W_r) of yellow perch from Lake Desire (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Brown Bullhead

We captured six brown bullhead ranging from 208 to 312 mm TL (Figure 9). Relative weights of brown bullhead were above the national 75th percentile and demonstrated no apparent trend with increasing length (Figure 10). The Spearman correlation coefficient (Rho) for brown bullhead length and relative weight was 0.543 (p = 0.266).

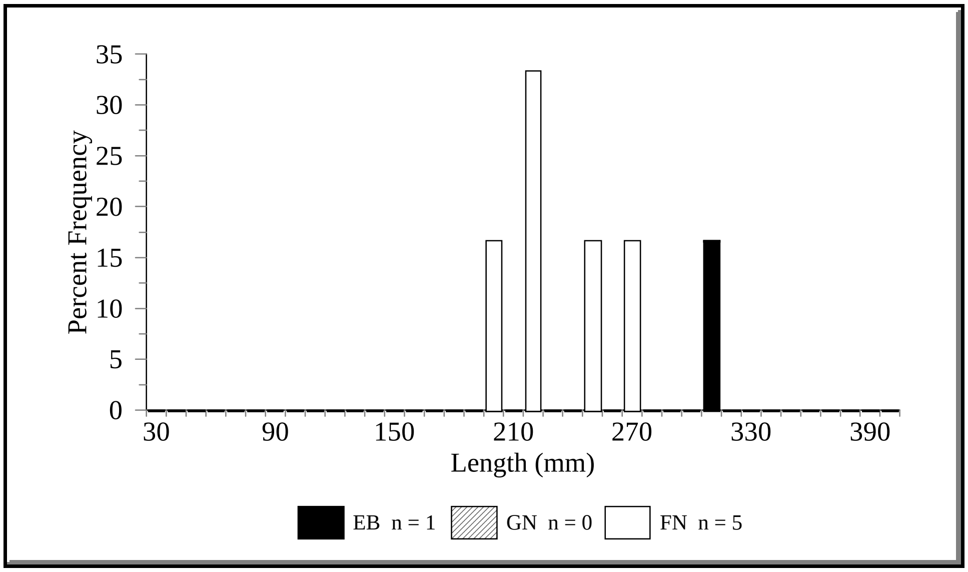

Figure 9. Length frequency histogram of largemouth bass sampled from Lake Desire in spring 1999. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

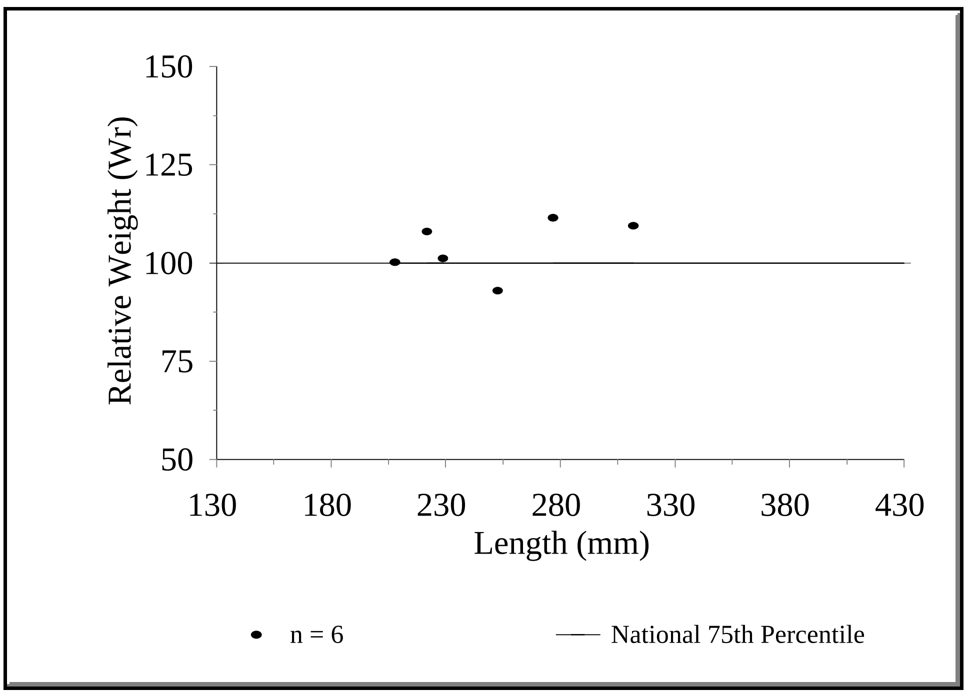

Figure 10. Relationship between total length and relative weight (W_r) of brown bullhead from Lake Desire (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Members of the Family Salmonidae

Rainbow trout appeared to be the dominant salmonid species in Lake Desire during spring 1999. We captured 21 individuals ranging from 130 to 290 mm TL (Figure 11) which were probably stocked earlier in the spring. Relative weights of rainbow trout were generally above the national 75th percentile (Figure 12) and higher than populations sampled in other lowland lakes (Mueller 1999; Mueller and Downen 1999; Downen and Mueller 2000). We also captured one cutthroat trout measuring 204 mm TL (age 1+), and three coho salmon measuring 49, 74, and 96 mm FL (all age 0+).

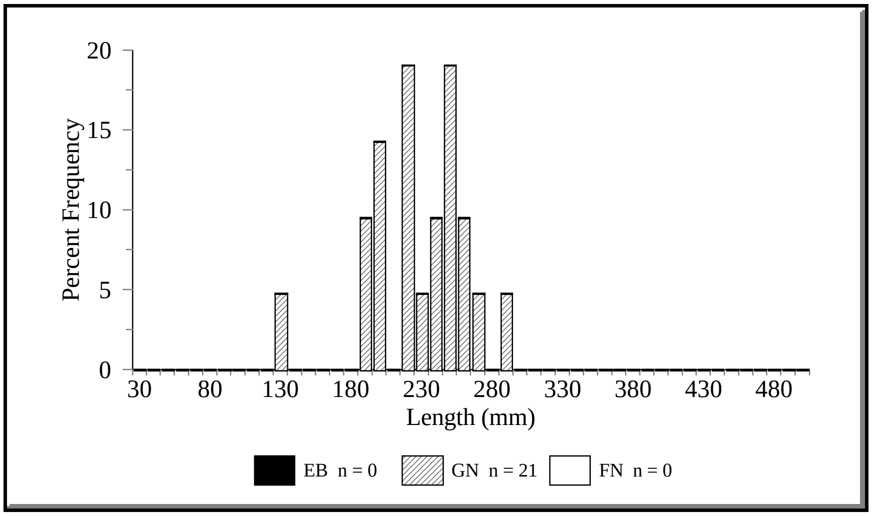

Figure 11. Length frequency histogram of rainbow trout sampled from Lake Desire in spring 1999. Stacked bars show relative contribution of each gear type to size classes. Length frequencies can be viewed collectively or by gear type. EB = electrofishing, GN = gill netting, and FN = fyke netting.

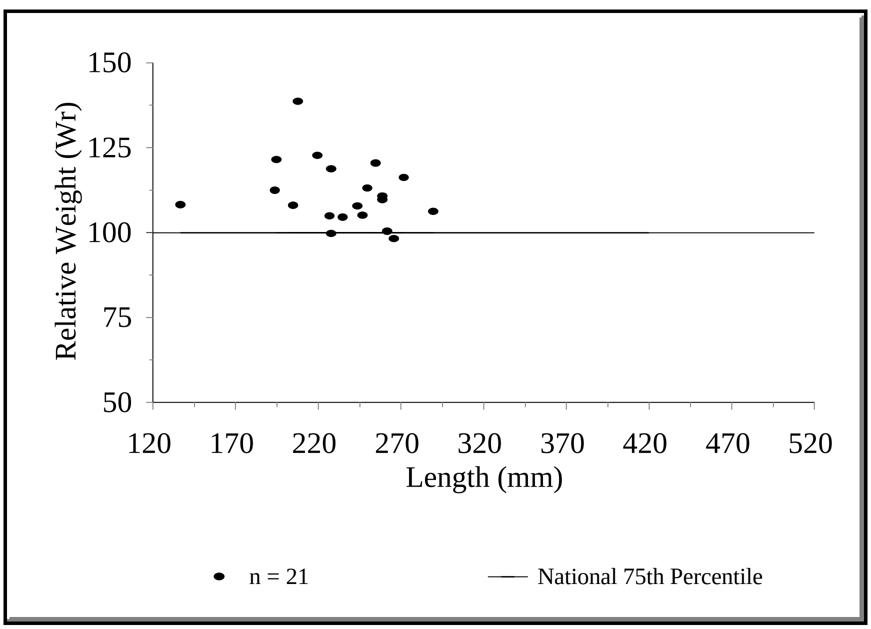

Figure 12. Relationship between total length and relative weight (W_r) of rainbow trout from Lake Desire (King County) compared with means from up to 25 western Washington lakes and the national 75th percentile.

Warmwater Enhancement Options

The fish community in the littoral zone of Lake Desire was dominated by warmwater species, particularly pumpkinseed and largemouth bass. This community was characterized by rapid growth and low numbers. Growth of largemouth bass was above average and PSD values were within ranges generally accepted for balanced communities (Willis 1993). Growth of pumpkinseed, the dominant forage species, was also above average but PSD values were lower than those generally accepted for balanced communities. The alternative forage species, yellow perch, demonstrated rapid growth but while age classes were more evenly distributed, their density was much lower. The largemouth bass population may be limited by a small forage base. Rainbow trout inhabiting the pelagic zone of the lake were relatively abundant and demonstrated high relative weights. These findings suggest Lake Desire should continue to be managed as a mixed species fishery. Options that might improve the warmwater component of this fishery include, but are not limited to, the following.

Assessment and Identification of Critical Habitat

During our survey, we captured several largemouth bass ostensibly guarding nests along the north shore of the lake. We did not observe such activity anywhere else in the lake. This limited area may be critical to the reproduction and subsequent recruitment of largemouth bass in Lake Desire. Further assessment of habitat and its utilization by warmwater species would help answer this question. Subsequently, habitat monitoring and preservation measures could be implemented.

Change Existing Fishing Rules to Alter Size Structure of Largemouth Bass

Currently, a slot limit makes it illegal to retain largemouth bass between 305 and 381 mm from Lake Desire. Of the fish retained outside the slot, no more than three of the five fish allowed per person per day can measure over 381 mm TL. Although the slot and creel limits are intended to improve the size structure of largemouth bass and protect fish required for a balance within the lake, the low abundance of large largemouth bass and paucity of size classes within the slot suggests the rule is not working as intended. The length frequency distribution and age structure for Lake Desire largemouth bass indicate reduced numbers of fish measuring 270 to 370 mm TL. This may result in a lack of recruitment into larger size classes in future years. Delayed mortality from catch-and-release angling may be a factor (Wilde 1998). Likewise, over-harvest prior to or within the slot may also be occurring. For example, in one of the only available studies of harvest rates of largemouth bass in western Washington waters, Kraemer (1992) estimated a harvest rate of 5% for largemouth bass within the slot on Lake Goodwin (Snohomish County).

Widening the slot limit to 254 – 457 mm TL (10 – 18 inches) while reducing the creel limit from three to one fish above 381 mm TL and to three fish/day, might allow more largemouth bass to realize their full growth potential. This limit would protect fish for four to five years. 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).

Currently, the largemouth bass population in Lake Desire is well-structured and demonstrates excellent growth rates. However, the fish exist in low numbers. Catch-and-release fishing for largemouth bass on Lake Desire may increase numbers of fish in the lake. Under this rule, all largemouth bass captured must be released back into Lake Desire alive. Since the rule is indisputable, it would be simpler to enforce than other rules. Moreover, increased numbers of larger fish would act as a control on the number of smaller fish and forage fish of all species.

The success of any rule change on the lake will depend upon angler compliance with the rules. Reasons for illegal harvest 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). Public access to Lake Desire is gained through WDFW access on the north shore of the lake. Rules and their purpose should be posted at the access to inform and encourage anglers in the active management of their resource. The presence of WDFW enforcement personnel during peak harvest periods might lessen the possibility of illegal harvest.

Change Existing Fishing Rules to Increase Populations of Forage Fish

In general, fish communities that are unbalanced with respect to predator and prey fall into one of two categories: the predator-crowded community or the prey-crowded community (Swingle1950). Rule changes are commonly implemented by fisheries managers in either of these situations to affect changes in the number or size structure of the predator species to achieve balance (Anderson 1976, Novinger 1984). Tendencies toward imbalance in Lake Desire include low abundance of yellow perch, as well as low abundance and low PSD values for panfish. Increased numbers of stock length largemouth bass as a result of the previously mentioned rule changes may further tax an already limited forage base and require an increase in numbers of forage species to prevent predator crowding. Low numbers of panfish or forage species in Lake Desire may be related to over-harvest, requiring a rule change to increase their numbers.

Currently, Lake Desire falls under the state-wide rule for bluegill and pumpkinseed of no size limit and no daily limit. These fish are an important forage species for largemouth bass (Carlander 1977). Therefore, we suggest altering the rules to include a 10 fish per day limit on panfish to prevent over-harvest and reduce the long-term impacts on other fish populations in the lake, particularly the largemouth bass.

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