1997 FAZON LAKE SURVEY: CROWDING OF THE WARMWATER FISH COMMUNITY IN A SMALL, LOWLAND LAKE

by

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INTRODUCTION AND BACKGROUND

Fazon Lake is a small, eutrophic body of water [13.8 hectares; mean depth = 3 meters (m); max depth = 5.2 m] located northeast of Bellingham in Whatcom County. The tannic lake, which lies within the Nooksack River basin, is fed by rainfall and groundwater. Surface water exits the lake through a small, unnamed outlet located along the northeast shore. A private, man-made drainage channel (152 m long) is located mid-lake along the eastern shore. Dense stands of cattail (*Typha latifolia*), willows (*Salix* sp.) and, unfortunately, purple loosestrife (*Lythrum salicaria*) surround roughly 40% of the lake, whereas marsh cinquefoil (*Potentilla* sp.), common nightshade (*Solanum dulcamara*), and submersed woody debris can be found along the entire shoreline. Emergent aquatic plants include yellow waterlily (*Nuphar polysepala*), Richardson's or clasping-leaved pondweed (*Potamogeton richardsonii*) and, to a lesser degree, watershield (*Brasenia schreberi*). The dominant submersed aquatic plants are waterweed (*Elodea canadensis*) and coontail (*Ceratophyllum demersum*).

Development on the lake is minimal. Two private homes are located within 200 m of the lake; however, most of the shoreline remains completely natural. The Washington Department of Fish and Wildlife (WDFW) maintains a public access and boat launch located at the southwest end of the lake. Recreational activities include fishing and small water craft use.

For years, Fazon Lake was managed by the WDFW, then acting as the Department of Game (WDG), as a rainbow trout (*Oncorhynchus mykiss*) fishery. In 1960, the lake was 'rehabilitated' for this purpose by eliminating unwanted minnows (Cyprinidae) and catfish (Ictaluridae) with rotenone, a natural piscicide. During the 1970's, the structure of the sport fish community underwent a dramatic change after the unauthorized introduction of warmwater fish species such as yellow perch (*Perca flavescens*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*). Consequently, the lake was rehabilitated during fall 1976 and again in 1980. However, at the time, it was apparent that angler preference was shifting toward warmwater species. Thus, in 1981, the WDG began planting largemouth bass, bluegill (*Lepomis macrochirus*) and channel catfish (*Ictalurus punctatus*) into the lake.

Throughout the 1980's, a local sport group sponsored many successful bluegill fishing contests at Fazon Lake. In 1986, fishermen began capturing large channel catfish. Today, the lake supports a popular largemouth bass-bluegill fishery. In fact, two experimental fish attraction devices (FAD) were placed in the lake during fall 1997 and spring 1998 to enhance this fishery. The dome- and basket-style structures, which measure 1.5 - 2.1 m in height, are constructed of 102 mm (or 4") ABS plastic. The FAD are anchored at a depth of 3.7 m and located approximately 45 m offshore from the opening of the private, man-made channel.

Given its physical characteristics, Fazon Lake is well suited for warmwater fish species. However, in recent years, local anglers have expressed concern about the declining quality of the fishery (Jim Johnston, WDFW, personal communication). Therefore, in order to evaluate the warmwater fish community at Fazon Lake, personnel from the WDFW's Warmwater Enhancement Program conducted a fisheries survey during late summer 1997.

MATERIALS AND METHODS

Fazon Lake was surveyed by a three-person investigation team during August 4 - 7, 1997. Fish were captured using two sampling techniques: electrofishing and gill netting. The electrofishing unit consisted of a 5.5 m Smith-Root 5.0 GPP 'shock boat' using a DC current of 120 cycles sec^{-1} at 3 to 4 amps power. Experimental gill nets (45.7 m long $\times$ 2.4 m deep) were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable-size (1.3, 1.9, 2.5, and 5.1 cm stretched) monofilament mesh.

Sampling locations were selected by arbitrarily dividing the shoreline into 17 consecutively numbered equidistant sections of 61 m each (determined visually from a map). Using the random numbers table from Zar (1984), four of these sections were then randomly selected as gill net sampling locations. While electrofishing, the boat was maneuvered through the shallows (depth range = 0.2 - 1.5 m), adjacent to the shoreline, at a rate of approximately 18.3 m minute^{-1} (linear distance covered over time). Gill nets were set perpendicular to the shoreline. The small-mesh end was attached onshore while the large-mesh end was anchored offshore.

Sampling occurred during evening hours to maximize the type and number of fish captured. Nighttime electrofishing occurred along the entire shoreline (about 1 kilometer), whereas gill nets were set overnight at four locations around the lake (Figure 1). To reduce bias between techniques, the sampling time for each gear type was standardized so that the 'ratio' of electrofishing to gill netting was 1:1 (Fletcher et al. 1993). Total electrofishing time was 3,646 seconds ('pedal-down' time), or roughly two standard units of 0.5 hours each; total gill netting time was 55.5 hours, or roughly two standard units of 24 hours each.

All fish captured were identified to the species level. Each fish was measured to the nearest millimeter (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 gram (g). Furthermore, scales were removed from these fish for aging. Scale samples (up to six per size class) were mounted and pressed, and the fish aged according to Jearld (1983) and Fletcher et al. (1993). However, members of the catfish family (Ictaluridae) were not aged.

Water quality data was collected during midday from three locations on August 7, 1997 (Figure 1). Using a Hydrolab® probe and digital recorder, information was gathered on dissolved oxygen, redox, temperature, pH, and conductivity. Secchi disc readings were recorded in feet and then converted to m (Table 1).
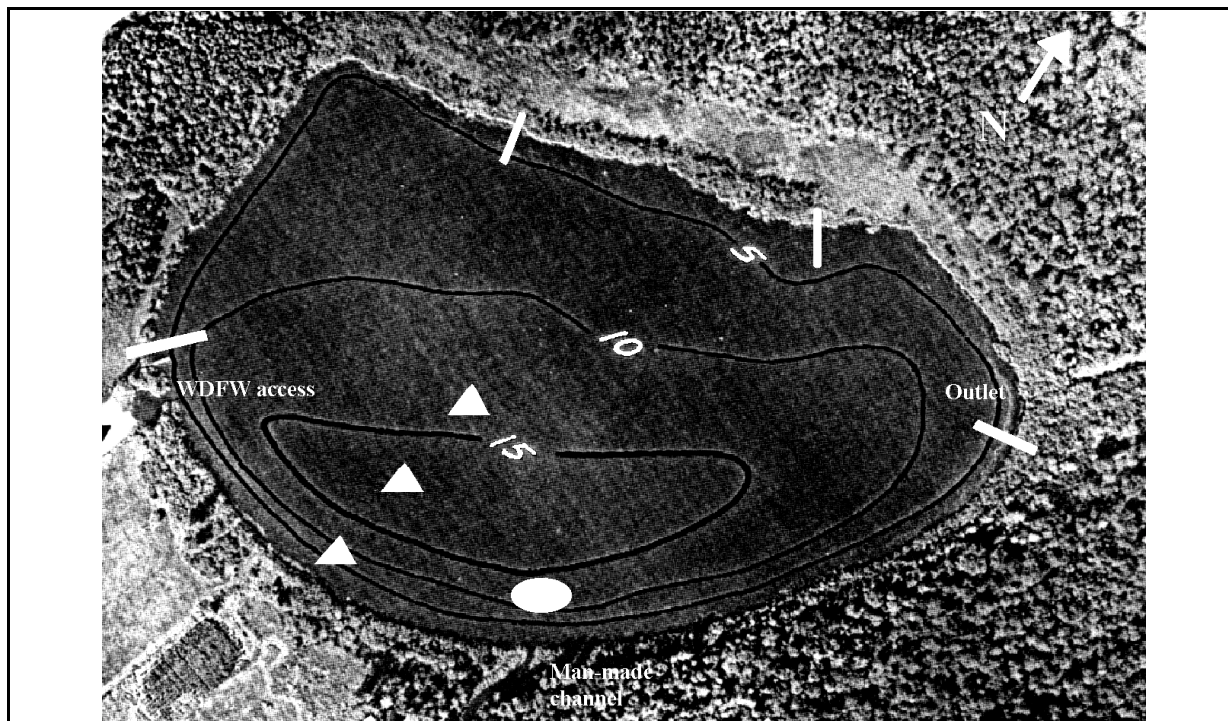
Figure 1. Map of Fazon Lake (Whatcom County) showing sampling locations. Electrofishing occurred along the entire shoreline. Bars extending into lake indicate placement of gill nets. Triangles indicate water quality stations. Oval indicates placement of fish attraction devices. Numbers indicate depth in feet. Redrawn from a 1973 U.S. Geological Survey map.

Table 1. Water quality from three locations (near shore, offshore, and mid-lake) at Fazon Lake (Whatcom County). Samples were collected midday on August 7, 1997.

Location	Secchi (m)	Depth (m)	DO	Temp (°C)	pH	Conductivity	Redox
				Parameter			
Near shore	1.3	1	6.5	23.6	7.0	299	396
Offshore	1.7	1	6.9	23.5	7.3	296	386
		2	3.6	21.4	7.1	292	397
		3	0.9	16.4	6.6	310	419
		4	0.5	12.5	6.7	377	185
		5	0.4	11.3	6.8	460	151
Mid-lake	1.7	1	7.4	23.9	7.4	299	323
		2	4.4	21.9	7.3	293	335
		3	1.5	15.6	6.8	308	361
		3.8	0.8	13.6	6.6	345	259

Data analysis

The species composition by number of fish captured was determined using procedures outlined in Fletcher et al. (1993). Species composition by weight (kg) of fish captured was determined using procedures adapted from Swingle (1950). Percentage of the aggregate biomass for each species provided useful information regarding the balance and productivity of the community (Swingle 1950; Bennett 1962). Only fish estimated to be at least one year old were used to determine species composition. These were inferred from the length frequency distributions described below, in conjunction with the results of the aging process. Young-of-year or small juveniles were not considered because large fluctuations in their numbers may cause distorted results (Fletcher et al. 1993). For example, the length frequency distribution of largemouth bass may suggest successful spawning during a given year, as indicated by a preponderance of fish in the smallest size classes. However, most of these fish would be subject to natural attrition during their first winter (Chew 1974), resulting in a different size distribution by the following year.

The catch per unit effort (CPUE) of electrofishing for each warmwater species was determined by dividing the number of fish captured in each size class by the total electrofishing time (Reynolds 1983). The CPUE of gill netting was determined similarly, except that the number of fish captured in each size class was divided by the total soak time of all nets deployed (Royce 1972). These proportions (fish/hour) were then used to make length frequency histograms to evaluate the size structure of the warmwater fish species and their relative abundance in the lake. Furthermore, since it is standardized, the CPUE is useful for comparing stocks between lakes.

A relative weight (W_r) index was used to evaluate the condition (plumpness or robustness) of fish in the lake. A W_r value of 1.0 generally indicates that a fish is in good condition when compared to the national average for that species. Furthermore, relative weights are 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 for the W_s equations of many warmwater fish species, including the minimum length recommendations for their application, are listed in Anderson and Neumann (1996).

With the exception of brown bullhead (*Ameiurus nebulosus*) and channel catfish, the W_r values from this study were compared to both the Washington State average (Scott Bonar, WDFW, unpublished data) and national standard ($W_r = 1.0$). Since the W_s equations for the species above were lacking, their condition was evaluated according to Fletcher et al. (1993). Condition factors (*C*) were calculated as $C = W*10^4*L^{-3}$, where W is the weight of an individual fish in pounds, and L is the total length in inches. When possible, C was compared to the state average (listed in Fletcher et al. 1993).

Age and growth of warmwater fish in Fazon Lake were evaluated according to Fletcher et al. (1993). 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. Mean back-calculated lengths at age *n* for each species were presented in tabular form for easy comparison between year classes. Differences in growth between the Fazon Lake fish and the state average for the same species (listed in Fletcher et al. 1993) were compared by plotting their overall mean back-calculated lengths versus age *n*.

RESULTS

Species composition

The dominant species in terms of biomass and number of fish captured were largemouth bass and bluegill (Table 2; Figures 2 and 3). Although less abundant than bluegill, largemouth bass still represented roughly 60% of the biomass captured. Species other than largemouth bass and bluegill accounted for less than 16% of the biomass and number of fish captured during late summer 1997 (Table 2; Figures 2 and 3).

Table 2. Species composition by weight (kg) and number of fish captured (excluding young-of-year) at Fazon Lake (Whatcom County) during a late summer 1997 survey of warmwater fish.

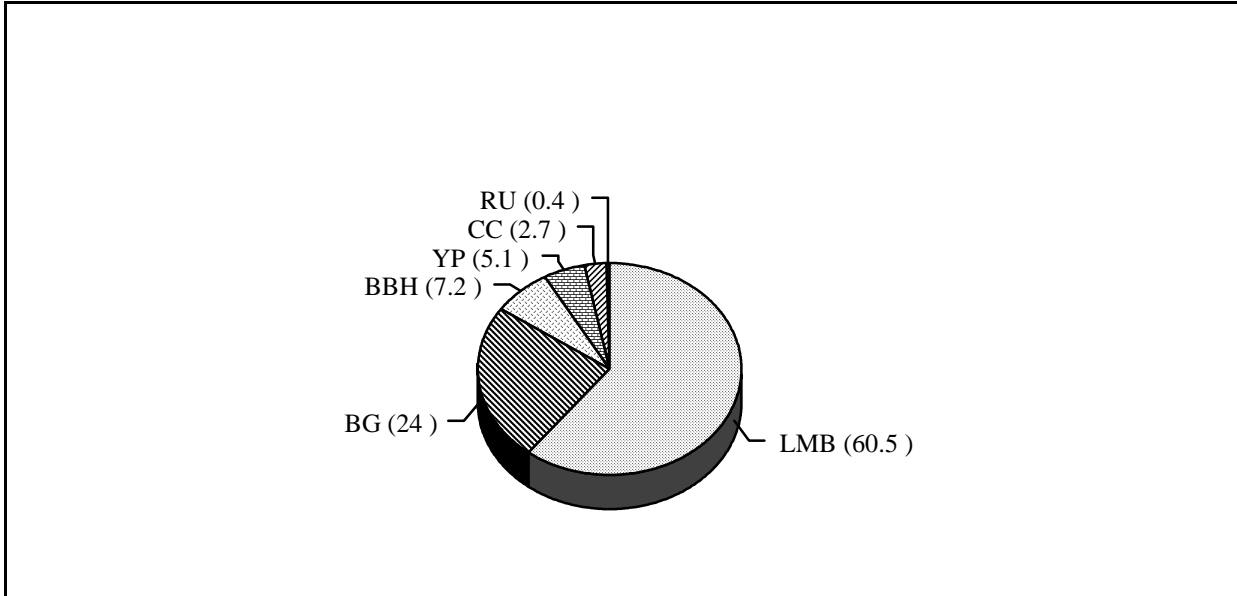|	Species composition		
Type of fish	by weight (kg)	by number	Size range (mm TL)
Largemouth bass (*Micropterus salmoides*)	28.8	205	91 - 480
Bluegill (*Lepomis macrochirus*)	11.4	319	56 - 207
Brown bullhead (*Ameiurus nebulosus*)	3.4	14	195 - 300
Yellow perch (*Perca flavescens*)	2.4	24	107 - 260
Channel catfish (*Ictalurus punctatus*)	1.3	16	116 - 250
Rainbow trout (*Oncorhynchus mykiss*)	0.2	1	276
Total	47.5	579	

Figure 2. Species composition expressed as percent of total biomass captured (47.5 kg, excluding young-of-year) at Fazon Lake (Whatcom County) during late summer 1997. LMB = largemouth bass, BG = bluegill, BBH = brown bullhead, YP = yellow perch, CC = channel catfish, and RU = rainbow trout (unknown race).
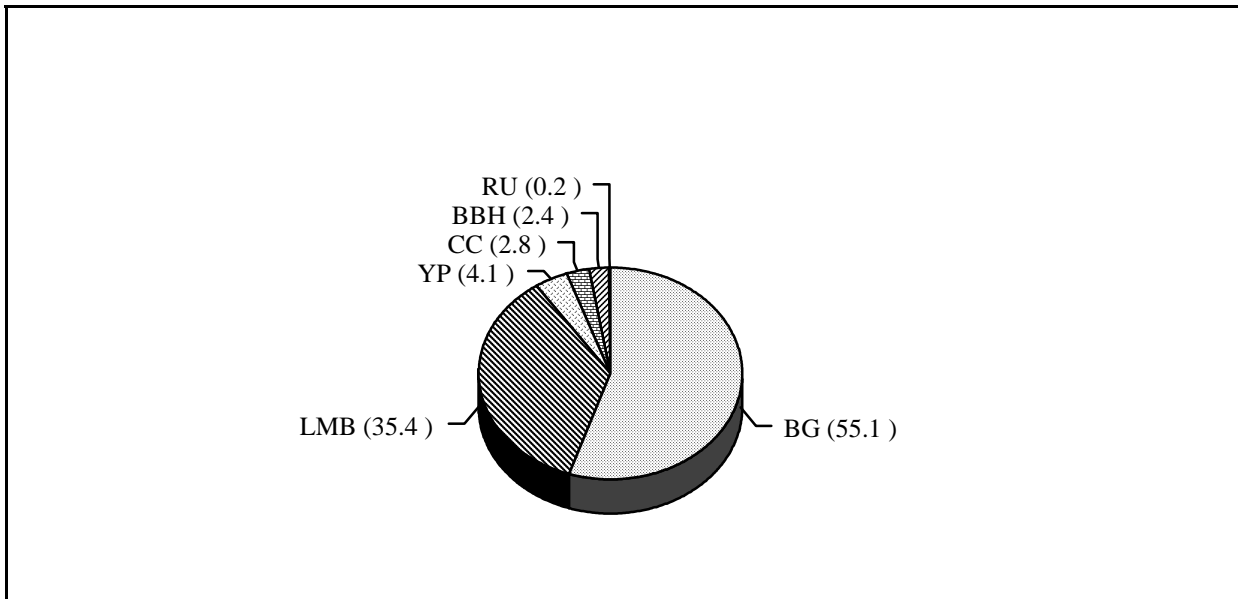

Figure 3. Species composition expressed as percent of total number captured (N = 579, excluding young-of-year) at Fazon Lake (Whatcom County) during late summer 1997. BG = bluegill, LMB = largemouth bass, YP = yellow perch, CC = channel catfish, BBH = brown bullhead, and RU = rainbow trout (unknown race).

Largemouth bass

Fazon Lake largemouth bass ranged from 42 to 480 mm TL (age 0+ to 12+). Most of these were between 140 and 220 mm TL (age 2+ to 4+) (Table 3; Figures 4 and 5). Less than 3% of the fish were of quality size ($\geq$ 305 mm TL). Quality size varies by species, and is defined as the minimum size which most anglers would like to catch (Anderson 1980 cited in Fletcher et al. 1993). Only three young-of-year (42 to 69 mm TL) were observed (Figure 4), whereas only two sizeable largemouth bass were captured during the study. One measured 440 mm TL and weighed 1,350 g, the other measured 480 mm TL and weighed 1,800 g. In general, growth of Fazon Lake largemouth bass was slow, and their condition, expressed as W_r, was below average when compared to largemouth bass statewide (Table 3; Figures 6 and 7).

Table 3. Age and growth of largemouth bass (*Micropterus salmoides*) captured at Fazon Lake (Whatcom County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| Year class	# fish	Mean length (mm) at age											
		1	2	3	4	5	6	7	8	9	10	11	12
1997	3	84.8											
1996	23	78.3	125.8										
1995	13	66.3	105.1	148.1									
1994	24	73.9	120.3	163.6	198.6								
1993	8	81.4	127.1	165.0	198.1	233.9							
1992	5	79.6	125.4	171.2	208.1	242.2	259.2						
1991	4	76.2	125.6	174.5	222.1	253.4	279.6	294.9					
1990	9	70.9	111.5	157.4	210.0	253.1	281.4	303.2	319.0				
1989	2	65.6	99.5	140.5	184.9	227.1	255.1	284.4	304.3	319.5			
1988	2	61.1	111.8	157.8	199.1	235.1	262.3	295.2	316.0	330.1	345.2		
1987	1	77.5	112.5	172.5	225.0	250.0	285.0	320.0	337.5	367.5	395.0	425.0	
1986	1	63.2	113.7	151.6	199.6	224.8	265.3	300.6	328.4	363.8	406.7	442.1	462.3
Overall mean		74.5	119.0	160.3	202.9	242.9	272.2	299.4	318.5	338.4	373.0	433.6	462.3
State average		65.3	140.0	202.9	254.0	295.4	334.3	389.4	414.5	439.9	484.6	471.7	495.6
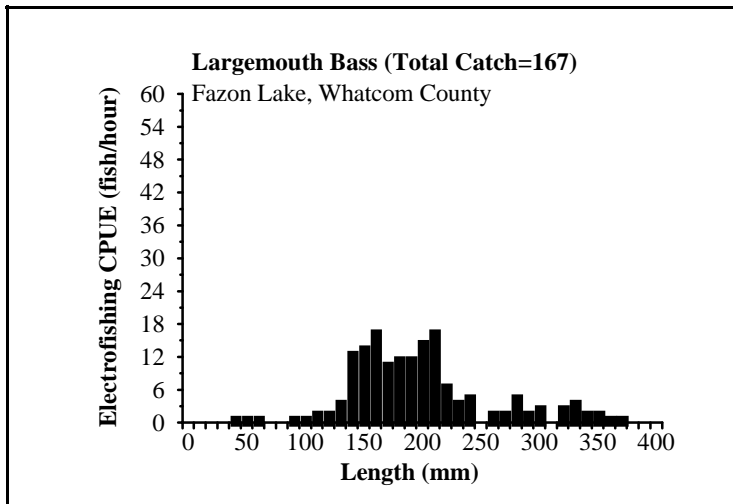
Figure 4. Relationship between total length and catch per unit effort of electrofishing for largemouth bass (*Micropterus salmoides*) at Fazon Lake (Whatcom County) during late summer 1997.
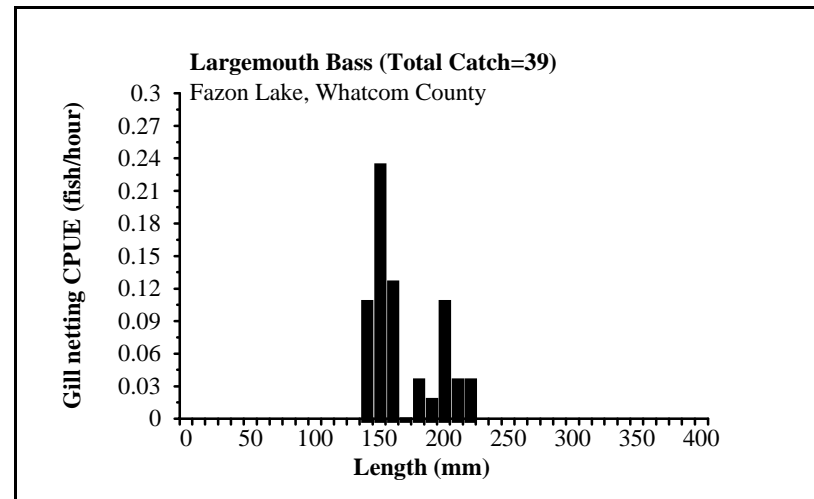

Figure 5. Relationship between total length and catch per unit effort of gill netting for largemouth bass (*Micropterus salmoides*) at Fazon Lake (Whatcom County) during late summer 1997.
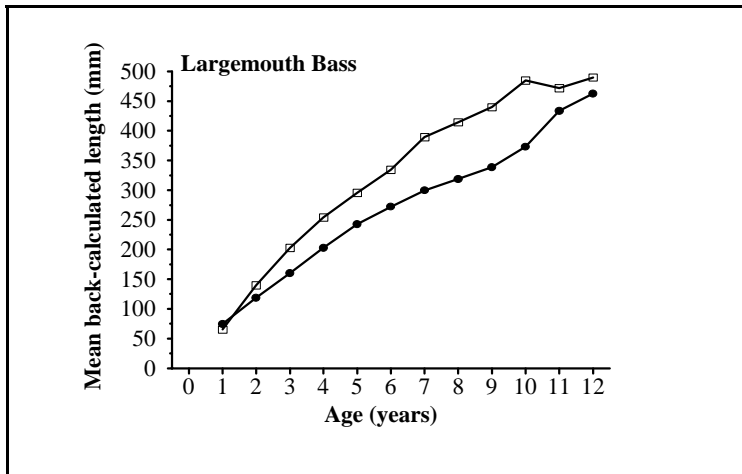

Figure 6. Growth of largemouth bass (*Micropterus salmoides*) from Fazon Lake, Whatcom County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.
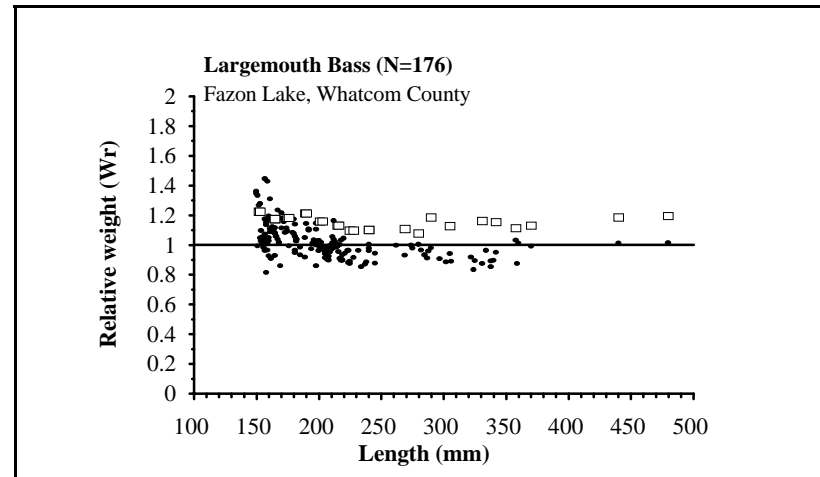
Figure 7. Relationship between total length and relative weight (W_r) of largemouth bass (*Micropterus salmoides*) from Fazon Lake, Whatcom County (closed, black circles) compared to the Washington State average (open, clear rectangles) and national standard (horizontal line at 1.0).

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Bluegill

The size of bluegill ranged from 56 to 207 mm TL (age 1+ to 11+; Tables 2 and 4). Most of these were between 90 and 130 mm TL (age 3+ to 5+; Table 4; Figures 8 and 9). Less than 8% of the fish were of quality size ($\geq$ 152 mm TL). No young-of-year were observed; furthermore, two year classes (1988 and 1989) were missing (Table 4; Figures 8 and 9). Like largemouth bass, growth of the Fazon Lake fish was slower than bluegill statewide (Table 4; Figure 10); however, their condition, expressed as W_r, was consistent with the state average (Figure 11).

Table 4. Age and growth of bluegill (*Lepomis macrochirus*) captured at Fazon Lake (Whatcom County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

| Year class	# fish	Mean length (mm) at age										
		1	2	3	4	5	6	7	8	9	10	11
1997	2	39.5										
1996	10	42.2	58.5									
1995	10	40.3	64.2	86.9								
1994	11	43.8	67.9	88.2	108.5							
1993	13	47.9	73.1	95.4	118.4	128.9						
1992	6	48.9	71.8	91.0	110.3	125.8	137.6					
1991	10	43.5	70.6	96.3	117.5	136.4	150.3	160.6				
1990	2	43.2	69.3	92.6	112.4	130.0	149.8	160.4	169.5			
1989	0											
1988	0											
1987	1	37.8	50.9	61.5	71.0	88.7	106.5	124.2	141.9	165.6	177.4	195.2
Overall mean		44.0	67.5	91.2	113.1	129.5	143.9	157.7	160.3	165.6	177.4	195.2
State average		37.3	96.8	132.1	148.3	169.9	200.9	195.8	---	---	---	---
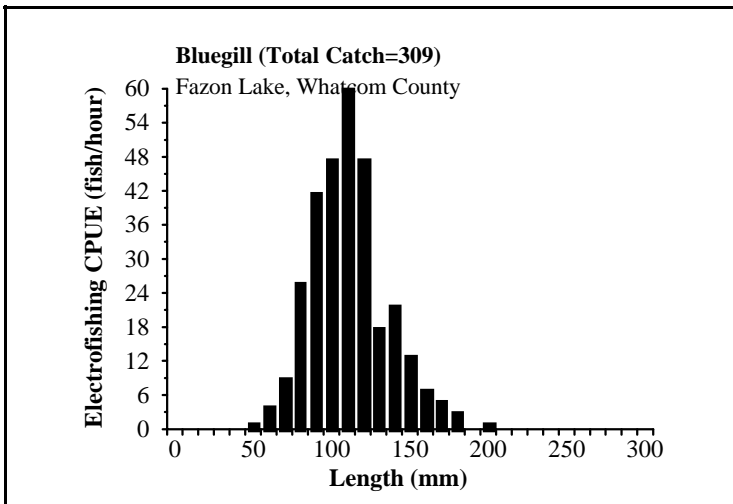
Figure 8. Relationship between total length and catch per unit effort of electrofishing for bluegill (*Lepomis macrochirus*) at Fazon Lake (Whatcom County) during late summer 1997.
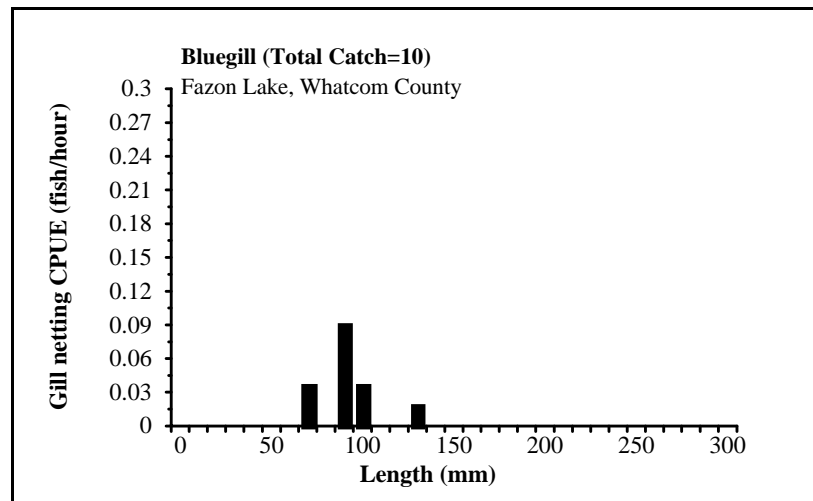

Figure 9. Relationship between total length and catch per unit effort of gill netting for bluegill (*Lepomis macrochirus*) at Fazon Lake (Whatcom County) during late summer 1997.
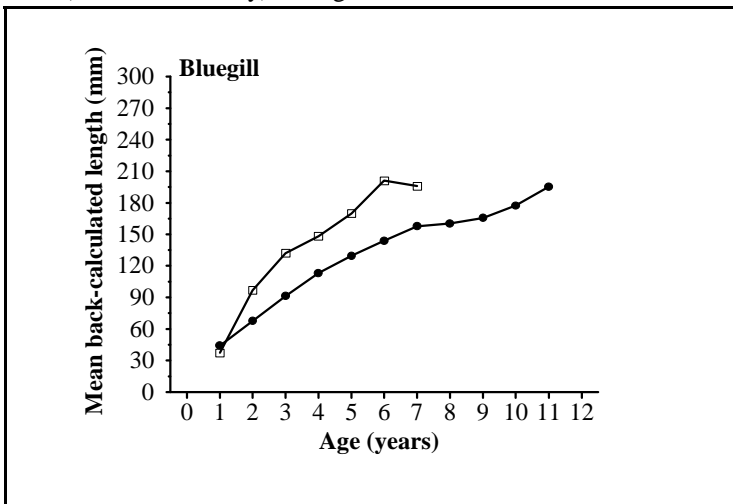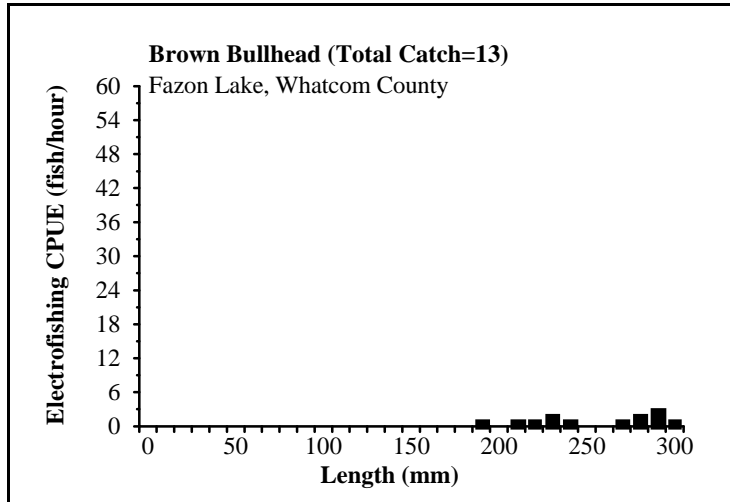

Figure 10. Growth of bluegill (*Lepomis macrochirus*) from Fazon Lake, Whatcom County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.
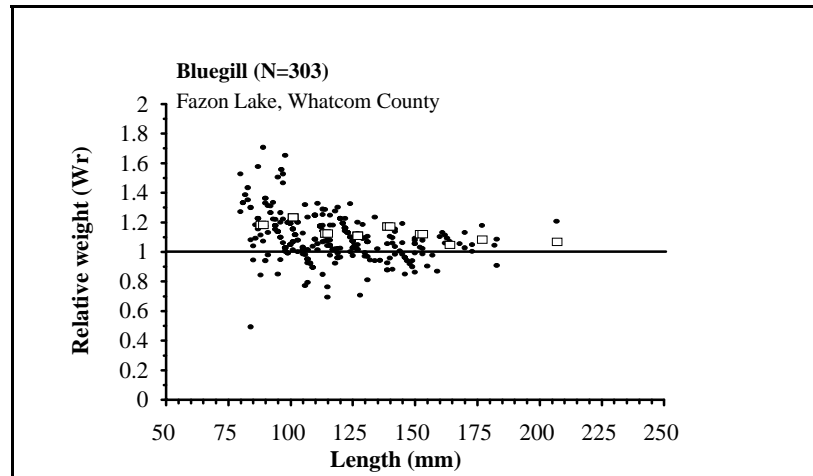
Figure 11. Relationship between total length and relative weight (W_r) of bluegill (*Lepomis macrochirus*) from Fazon Lake, Whatcom County (closed, black circles) compared to the Washington State average (open, clear rectangles) and national standard (horizontal line at 1.0).

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Brown bullhead

Brown bullhead ranged in size from 195 to 300 mm TL (Table 2), and while captured fish were of quality size (≥ 229 mm TL), the sample was insufficient to describe the population. Electrofishing proved to be the best sampling method for these fish, although one individual (268 mm TL @ 220 g) was captured while gill netting. At least two year classes were evident from the length frequency shown in Figure 12; however, their actual ages were unknown. In general, Fazon Lake brown bullhead displayed below average condition when compared to fish statewide (Figure 13).

Figure 12. Relationship between total length and catch per unit effort of electrofishing for brown bullhead (*Ameiurus nebulosus*) at Fazon Lake (Whatcom County) during late summer 1997.
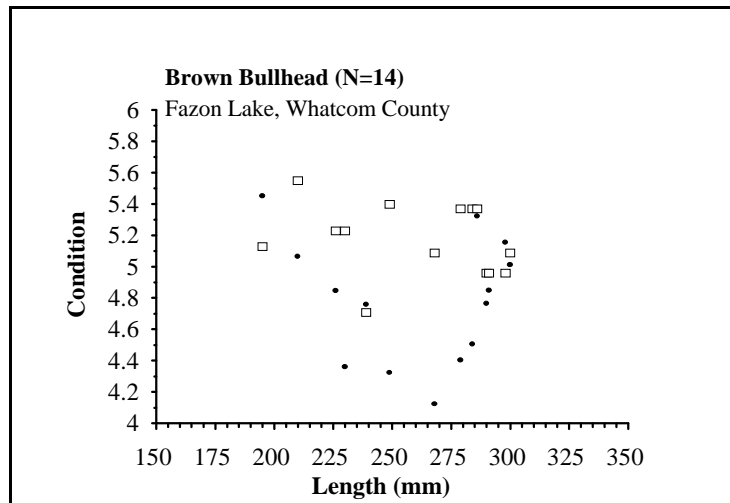

Figure 13. Relationship between total length and condition of brown bullhead (*Ameiurus nebulosus*) from Fazon Lake, Whatcom County (closed, black circles) compared to the Washington State average (open, clear rectangles).

11

Yellow perch

Fazon Lake yellow perch ranged in size from 107 to 260 mm TL (age 2+ to 6+), most of which were quality size ($\geq$ 203 mm TL) and age 5+ (Tables 2 and 5; Figures 14 and 15). No young-of-year or age 1+ fish were observed. Still, growth and relative weights of the Fazon Lake fish were fairly consistent with yellow perch statewide (Figures 16 and 17).

Table 5. Age and growth of yellow perch (*Perca flavescens*) captured at Fazon Lake (Whatcom County) during late summer 1997. Values are mean back-calculated lengths at annulus formation.

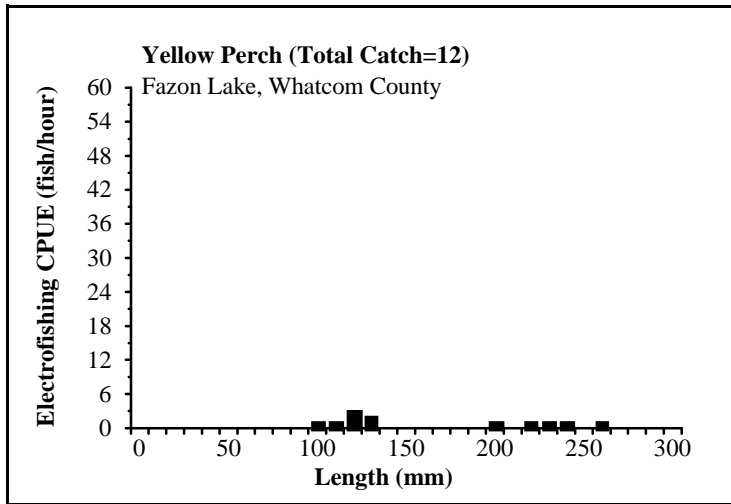| Year class	# fish	Mean length (mm) at age					
		1	2	3	4	5	6
1997	0						
1996	4	69.4	102.3				
1995	3	64.1	101.1	128.4			
1994	1	61.9	117.3	160.0	181.3		
1993	11	64.2	102.6	149.7	182.6	208.7	
1992	1	68.4	107.2	150.5	200.7	221.2	241.8
Overall mean		65.3	103.3	146.4	183.9	209.8	241.8
State average		59.7	119.9	152.1	192.5	206.0	---

Figure 14. Relationship between total length and catch per unit effort of electrofishing for yellow perch (*Perca flavescens*) at Fazon Lake (Whatcom County) during late summer 1997.
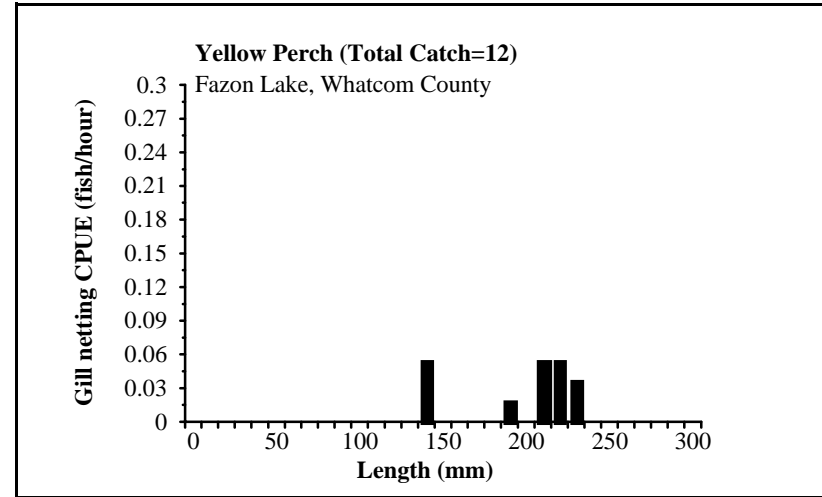

Figure 15. Relationship between total length and catch per unit effort of gill netting for yellow perch (*Perca flavescens*) at Fazon Lake (Whatcom County) during late summer 1997.
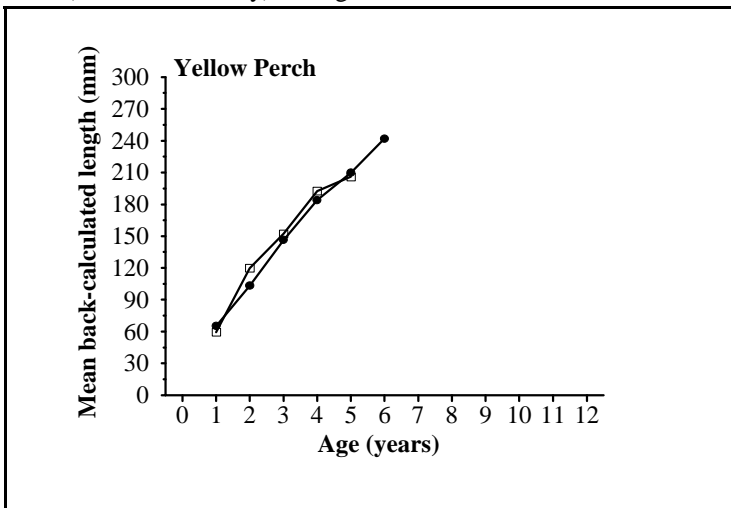

Figure 16. Growth of yellow perch (*Perca flavescens*) from Fazon Lake, Whatcom County (closed, black circles), compared to the Washington State average (open, clear rectangles). Values are mean back-calculated lengths at age.
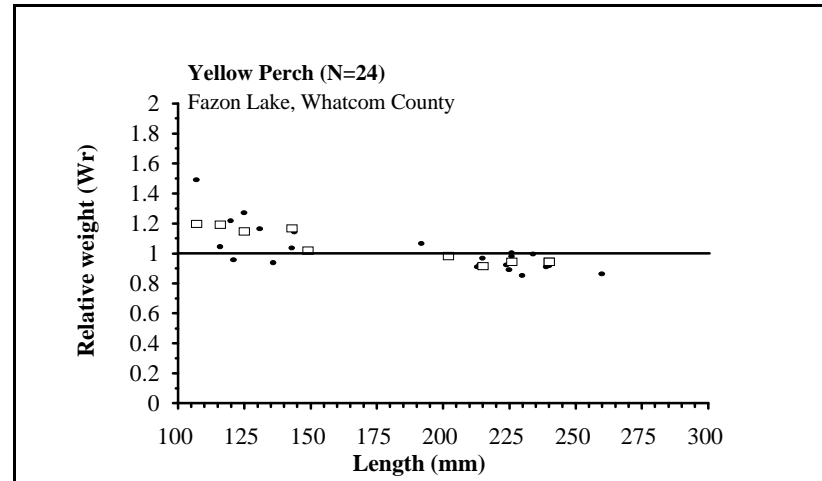

Figure 17. Relationship between total length and relative weight (W_r) of yellow perch (*Perca flavescens*) from Fazon Lake, Whatcom County (closed, black circles) compared to the Washington State average (open, clear rectangles) and national standard (horizontal line at 1.0).

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Channel catfish

The size range of channel catfish was 116 to 250 mm TL (Table 2; Figure 18). Gill netting proved to be the best sampling method for these fish. No channel catfish were captured while electrofishing. No quality size ($\geq$ 406 mm TL) fish were observed. The individuals captured were planted into the lake as fingerlings during fall 1996. Thus, growth of Fazon Lake channel catfish appears to be slow. This is supported by the below average condition of the fish when compared to channel catfish statewide (Figure 19).
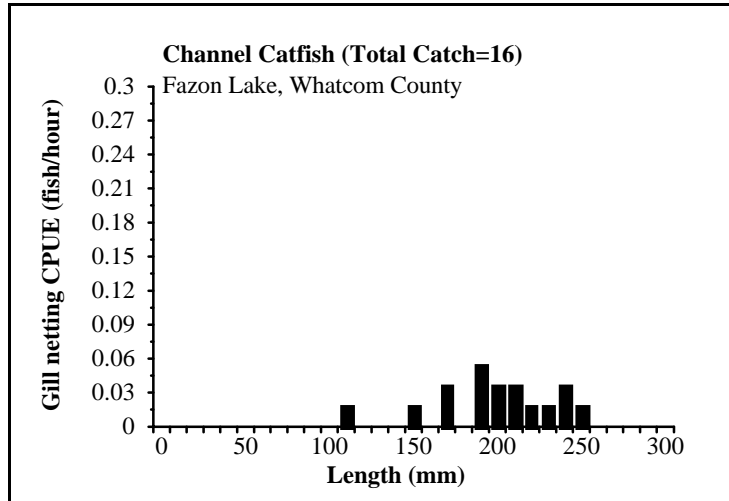

Figure 18. Relationship between total length and catch per unit effort of gill netting for channel catfish (*Ictalurus punctatus*) at Fazon Lake (Whatcom County) during late summer 1997.
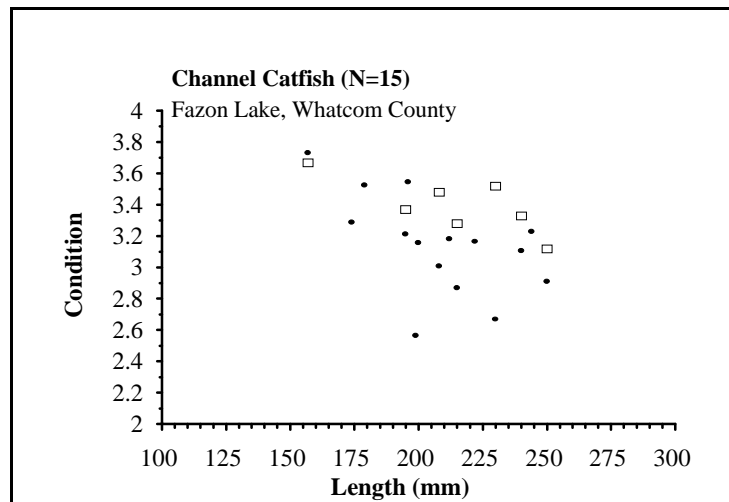

Figure 19. Relationship between total length and condition of channel catfish (*Ictalurus punctatus*) from Fazon Lake, Whatcom County (closed, black circles) compared to the Washington State average (open, clear rectangles).

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DISCUSSION

Balancing predator and prey fish populations is the hallmark of warmwater fisheries management. According to Bennett (1962a), the term 'balance' is used loosely to describe a system in which omnivorous forage fish or prey, such as bluegill, maximize food resources to produce harvestable-size stocks for fishermen and an adequate forage base for piscivorous fish, such as largemouth bass (predator). 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 size structure, growth, and condition (W_r or otherwise) provide useful information on the adequacy of the food supply (Kohler and Kelly 1991) and balance within a body of water. Characteristics of unbalanced populations include poor growth or condition, and low recruitment (Swingle 1950, 1956; Kohler and Kelly 1991; Masser *undated*).

During late summer 1997, Fazon Lake showed indications of having an unbalanced fish community. The size structure, growth pattern, and condition of Fazon Lake fish suggest that the fish were not foraging satisfactorily. The dominant species in the lake (largemouth bass and bluegill) exhibited either below average growth, condition, or both. Few quality size fish of any kind were captured, and juvenile fish (i.e., young-of-year) were conspicuously absent. For example, only three young-of-year largemouth bass were observed, whereas no young-of-year forage fish were captured. Furthermore, largemouth bass accounted for roughly 60% of the biomass. In balanced warmwater fish communities, the desirable range for largemouth bass is 16 to 33% (Swingle 1950, 1956).

The causes for the variation described above are complex and difficult to isolate from a single survey; however, some inferences can be drawn from previous studies. For example, disparate fishing pressure within a lake can lead to an unbalanced fish community. Bennett (1962b) characterized underfished populations by high survival of all year classes, with small intermediate age fish and few, harvestable size fish. Overfished populations were characterized by overabundant, slow-growing young fish and few, large old fish. Additional research may show that bluegill at Fazon Lake are subject to underfishing, while largemouth bass are being overfished.

However, the likely cause of unbalance at Fazon Lake is overcrowding, either by bluegill, largemouth bass, or both. The conditions observed during late summer 1997 resemble those described by Swingle (1956) and Masser (*undated*) for populations experiencing inter- and intraspecific competition because of crowding. According to Swingle (1956), crowding in warmwater fish populations results in slow growth (less food per individual) and reduced or inhibited reproduction. The overabundant, slow-growing intermediate-size bluegill (~ 80 - 130 mm TL) and few, if any, young-of-year observed at Fazon Lake suggest crowding by bluegill. The poor growth and condition of the overabundant, smaller-size (~ 140 - 220 mm TL) largemouth bass are indications of crowding in these fish (Swingle 1956; Masser *undated*). The crowded conditions were likely compounded by the reduction of suitable habitat available to fish because of stratification within the lake (Table 1). For example, at depths below 3 m, dissolved

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oxygen (DO) levels were lethal [< 1 milligram (mg) liter (l)$^{-1}$] for most fish. At depths between 2 and 3 m, where DO levels ranged from 1.5 to 4.4 mg l^{-1}, growth would likely be impaired. Desirable DO levels ($\geq$ 5 mg l^{-1}) were found only near the surface (depth = 1 m). Therefore, during late summer 1997, most Fazon Lake fish were probably 'relegated' to the shallows along the perimeter of the lake, resulting in increased competition for food and shelter.

Whether due to fishing pressure or natural causes, crowding by largemouth bass or crowding by bluegill, the number of large fish needed to control overproduction of both predator and prey species at Fazon Lake was clearly lacking. The resultant crowding was exacerbated by habitat-limiting DO levels within the lake. The fish community at Fazon Lake would benefit from improved water quality and increased predation or removal of bluegill and smaller-size largemouth bass by larger fish or anglers.

RECOMMENDATIONS

Change existing fishing rule to alter size structure of largemouth bass

Currently, a 305 - 381 mm (12 - 15") slot limit is in place at Fazon Lake. In other words, it is illegal to retain largemouth bass measuring 305 - 381 mm TL. Only fish less than 305 or greater than 381 mm TL may be kept. Of these, 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 supposed to protect those fish needed to maintain a balance within Fazon Lake, the size structure of largemouth bass observed during late summer 1997 suggests that the rule is not working as intended. For example, there are too many fish below and not enough within or above the slot. Recently, local anglers complained of illegal harvest practices at the lake (Jim Johnston, WDFW, personal communication). Still, high natural mortality after age 5 (>230 mm TL) cannot be ruled out as a possible contributing factor.

Widening the current slot limit to 254 - 457 mm TL (10 - 18") while reducing the creel limit from three to one fish above the upper length (but still maintaining a daily limit of five fish), may restore the balance in Fazon Lake, and allow more largemouth bass to realize their full growth potential. Under this rule, only fish less than 254 or greater than 457 mm TL may be kept. Of these, no more than one fish can measure over 457 mm TL. In Arkansas, an outstanding largemouth bass fishery was developed by adjusting slot and creel limits to stimulate harvest of small fish while protecting large fish (Turman and Dennis 1998). A reduction in small fish may improve growth and production of predator and prey species alike (McHugh 1990). Similar rule changes were proposed in Texas as well (Anonymous 1998).

A simpler alternative would be to implement catch-and-release fishing on the lake. Under this rule, all largemouth bass captured must be released back into Fazon Lake alive. The rule is indisputable, thus easier to enforce. And although predator-crowded conditions may continue if no largemouth bass are harvested (Masser *undated*), given the overabundance of small fish at Fazon Lake, catch-and-release fishing would at least ensure the likelihood of some individuals reaching larger size classes.

However, the success of any rule changes, whether widening the slot and reducing the creel limit, or implementing catch-and-release of largemouth bass, depends upon angler compliance with the new 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). Therefore, clear, and concise posters or signs should be placed at Fazon Lake describing the fishing rules for the lake. Press releases should be sent to local papers and sport fishing groups detailing the changes to and purpose of the rules. Furthermore, illegal harvest of Fazon Lake fish may be reduced by increasing the presence of WDFW enforcement personnel at the lake during peak harvest periods.

Destratify lake with aerator

The habitat-limiting DO levels at Fazon Lake may be corrected by installing an aerator to destratify the lake. The WDFW routinely aerates a number of lakes throughout the state to improve or maintain DO levels during warm periods. For example, during the early 1980's, an aerator was installed along the shore of Anderson Lake in Jefferson County. Before using the aerator, the lake was subject to periodic fish die-offs because of low DO levels or stratification within the lake. Today, the Anderson Lake aerator runs continuously during summer months only and, since installed, no fish die-offs have occurred (Dan Collins, WDFW, personal communication).

Aerating Fazon Lake will reduce crowding of the warmwater fish community by increasing the area considered hospitable to most fish (i.e., DO ≥ 5 mg l^{-1}). Moreover, as fish densities decrease and DO levels improve, fish growth should increase.   However, until the low DO problem is resolved, placement of the FAD should be adjusted to ensure that most of the structure lies in reasonably oxygenated water (i.e., depth < 3 m). Furthermore, continued stocking of channel catfish should be reconsidered until the lake is aerated, especially given the poor growth and condition of fish planted during fall 1996.

Fazon Lake should be surveyed within four years of the rule change and installation of the aerator to monitor the balance of the fish community and success of the restoration effort.

Control predator and prey fish populations with 'super predator'

If the fish community of Fazon Lake remains unbalanced after altering the size structure of largemouth bass and destratifying the lake, the balance may be restored by stocking a sufficient number of 'super predators' to reduce the predator and prey fish populations. This technique has been used with varied degrees of success for years (Bennett 1962a; Noble 1981; Wahl and Stein 1988; Boxrucker 1992; Bolding et al. 1997). For example, stocking a low number (≤ 25) of sterile, yearling tiger musky (*Esox masquinongy*♀ $\times$ *E. lucius*♂) may improve the density and growth of bluegill and smaller-size largemouth bass. Although the predator prefers fusiform, soft-rayed prey, such as minnows, over deep-bodied, spiny-rayed prey, such as bluegill (Tomcko et al. 1984; Wahl and Stein 1988), it generally fares well irrespective of the forage base (Kohler

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and Kelly 1991). Moreover, tiger musky grow rapidly in Washington (WDFW 1996).
Therefore, in addition to improving balance, stocking tiger musky may also provide a trophy
fishing opportunity at Fazon Lake (Storck and Newman 1992).

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