1997 MASON LAKE SURVEY: THE WARMWATER FISH COMMUNITY OF A LAKE DOMINATED BY NON-GAME FISH

by

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INTRODUCTION AND BACKGROUND

Mason Lake is a moderate size (surface area = 417 hectares) body of water [mean depth = 14.6 meters (m); max. depth = 27.4 m] located near the base of the Olympic Peninsula in Mason County. Schumacher Creek, a perennial stream, feeds the lake at the south end, whereas water flows out Sherwood Creek at the north end and eventually discharges into Case Inlet. The watershed supports the modest spawning activities of two anadromous fishes.

During fall, adult coho salmon (*Oncorhyncus kisutch*) pass through Mason Lake on their way to spawning grounds in Schumacher Creek. The Washington Department of Fish and Wildlife (WDFW) conducts annual spawner surveys along a 322 m stretch of the creek, from the mouth to the first county road above the lake. Coho salmon spawning activity, as indicated by the number of ‘fishdays’ within the index area, has been variable over the years. Peak activity occurred during 1981, 1985, and 1987. However, since 1989, coho salmon spawning activity has been nominal in Schumacher Creek (Figure 1).

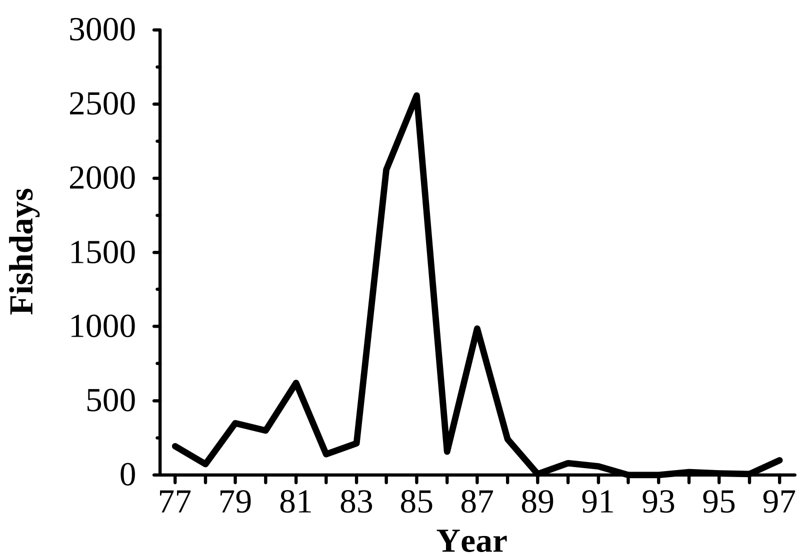

FIGURE 1.---Spawning activity of coho salmon (*Oncorhyncus kisutch*) in Schumacher Creek above Mason Lake, Mason County. Values are fishdays derived from stream surveys conducted during a 20-year period from 1977 to 1997 (Washington Department of Fish and Wildlife, unpublished data).

For the past 30 years, summer-run chum salmon (*Oncorhynchus keta*) have displayed fairly regular even- and odd-year variations in abundance upon returning to Sherwood Creek spawning grounds below Mason Lake (Figure 2). This is not unusual for chum salmon (Salo 1991). Summer chum spawning activity peaked during the 1970's but declined during the 1980's;

however, in recent years, summer chum spawning activity appears to be rising again. Peak spawning activity for fall chum salmon occurred during 1972, 1984, 1990, and 1994 (Figure 2; WDFW, unpublished data).

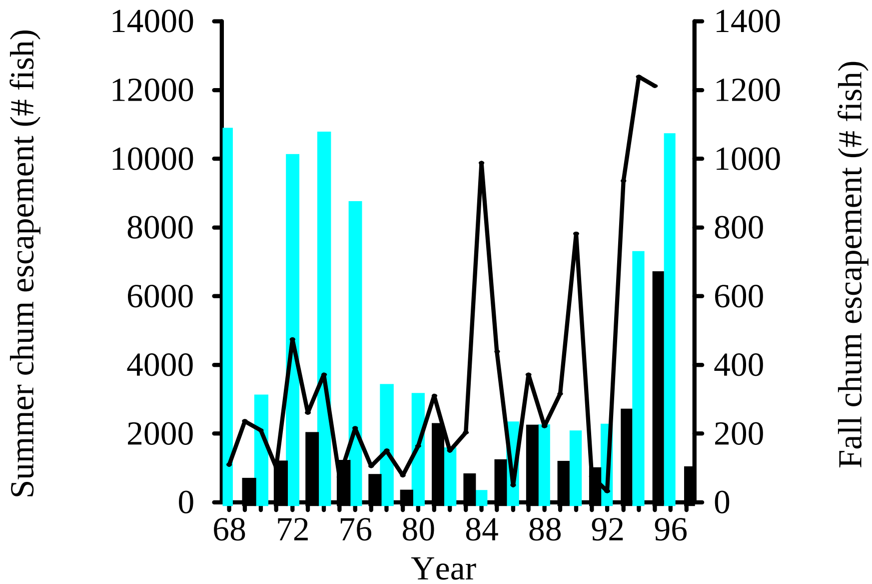

FIGURE 2.---Spawning activity of chum salmon (*Oncorhyncus keta*) in Sherwood Creek below Mason Lake, Mason County. Values are escapement estimates (# fish) for summer chum during even (grey bars) and odd (black bars) years, and for fall chum (black line). Escapement estimates were derived from stream surveys conducted during a 30-year period from 1968 to 1998 (Washington Department of Fish and Wildlife, unpublished data).

Mason Lake supports a diverse aquatic plant community as well, including several varieties of floating leaf pondweed (*Potamogeton* sp.) and the rare, native water gladiole (*Lobelia dortmanna*; Jenifer Parsons, Washington Department of Ecology, personal communication). Submersed vegetation includes common elodea (*Elodea canadensis*), water nymph (*Najas flexilis*), and bladderwort (*Utricularia* sp.). Emergent vegetation includes horsetail (*Equisetum* sp.), rushes (family Juncaceae), and sedges (family Cyperaceae).

Although the spawning activities of the watershed's anadromous fishes have been monitored for decades, no recent information exists regarding the resident fish community of Mason Lake. Therefore, in an effort to assess the warmwater fishery, especially given the potential recreational opportunities at the lake (Dan Collins, WDFW, personal communication), personnel from WDFW's Warmwater Enhancement Program conducted a fisheries survey at Mason Lake in fall 1997.

MATERIALS AND METHODS

Mason Lake was surveyed by a three-person team during September 15 - 18, 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 at 3 to 4 amps power. 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 (1.3, 1.9, 2.5, and 5.1 cm stretched) monofilament mesh.

Sampling locations were selected by dividing the shoreline into 62 consecutively numbered sections of about 274 m each (determined visually from a map). Using the random numbers table from Zar (1984), 12 of these sections were then randomly selected as 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 (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 9.3% (~ 1.6 km) of the available shoreline, whereas gill nets were set overnight at six locations (= six ‘net nights’) around the lake (Figure 3). In order 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 5,446 seconds (‘pedal-down’ time), or six units of about 900 seconds each; total gill netting time was 84.9 hours, or six units of about 12 hours each.

With the exception of sculpin (family Cottidae), 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). However, 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 a simple 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, salmonid and non-game fish were not aged.

Water quality data was collected during midday from two locations on September 17, 1997 (Figure 3). Using a Hydrolab® probe and digital recorder, information was gathered on dissolved oxygen, redox, temperature, pH, and specific conductance. Secchi disc readings were recorded in feet and then converted to m (Table 1).

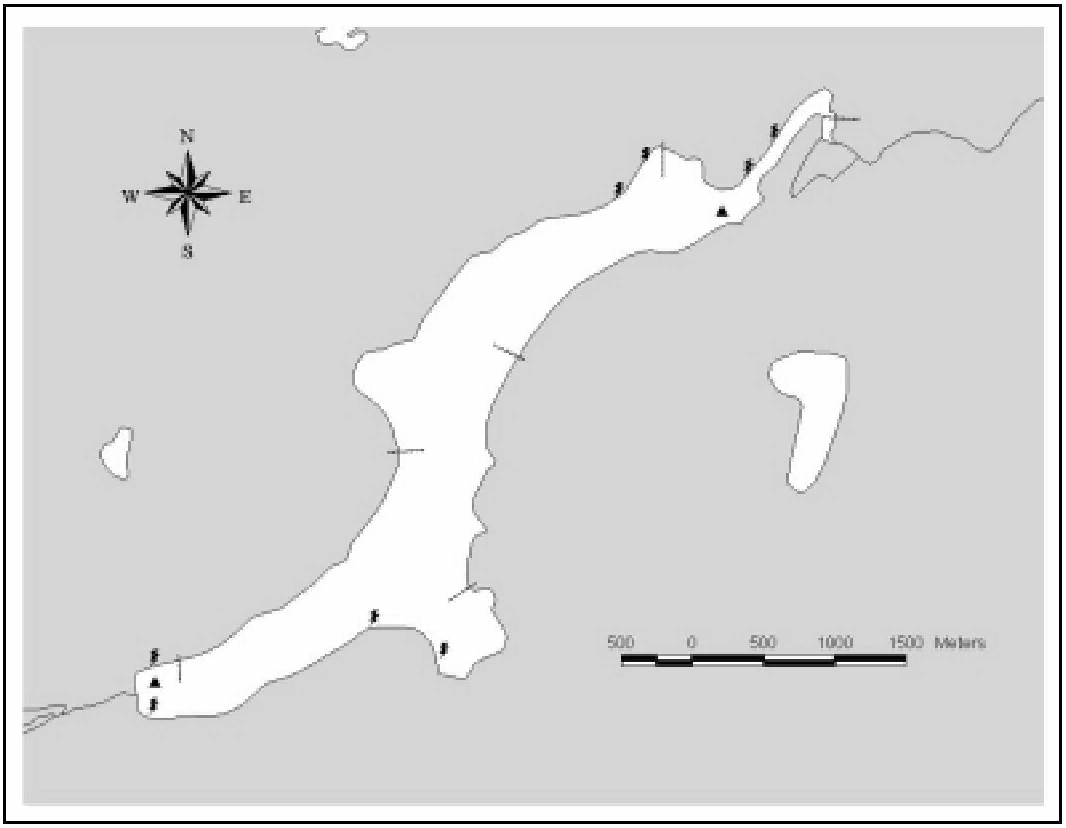

FIGURE 3.---Map of Mason Lake (Mason County) showing sampling locations. Bolts indicate sections of shoreline where electrofishing occurred. Bars extending into lake indicate placement of gill nets. Triangles indicate water quality stations.

TABLE 1.---Water quality from two locations (north and south end) at Mason Lake (Mason County). Samples were collected midday on September 17, 1997.

		Parameter					
Location	Secchi (m)	Depth (m)	DO	Temp (°C)	pH	Conductance	Redox
North end	6 m	1	8.5	19.3	7.5	44	409
		3	8.6	19.3	7.5	44	408
		6	8.7	19.3	7.5	44	413
		9	8.7	19.2	7.4	43	419
		12	5.6	11.6	6.7	42	473
		15	4.1	10.4	6.4	40	489
		18	3.4	9.9	6.3	40	498
South end	6 m	1	8.7	19.0	7.4	45	406
		3	8.8	19.0	7.5	45	408
		6	8.7	19.0	7.3	44	421
		9	8.6	18.9	7.3	42	426
		11	8.5	18.5	7.1	42	440

Data analysis

Species composition by weight (kg) of fish captured was determined using procedures adapted from Swingle (1950). Percentage of the aggregate biomass for each species provides useful information regarding the balance and productivity of the community (Swingle 1950; Bennett 1962). The species composition by number of fish captured was also determined, but using procedures outlined in Fletcher et al. (1993). 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 (*Micropterus salmoides*) 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.

Catch per unit effort (CPUE) by gear type was determined for each species (number of fish/hour electrofishing and number of fish/net night). The CPUE for warmwater species was determined using stock size fish and larger. Stock length, which varies by species (see Table 2 and discussion below), refers to the minimum size fish with 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 $\pm\, t_{(\alpha,\, N\text{-}1)} \times SE$, 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.

With the exception of sculpin (family Cottidae) and cutthroat trout (*Oncorhynchus clarki*), the size structures of all fishes captured were evaluated by constructing length frequency histograms (number of fish captured by gear type per size class). Absolute numbers of individuals in each size class were standardized to CPUE by gear type (number of fish/hour electrofishing and number of fish/net night). Standardization adjusts for differences in sampling effort between sampling times or locations (Anderson and Neumann 1996). For the same reasons described above, only fish estimated to be at least one year old were used when constructing length frequency histograms. These were inferred from the results of the aging process.

The proportional stock density (PSD) for each warmwater fish species was determined following procedures outlined in Anderson and Neumann (1996). PSD, which was 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 population dynamics. 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) 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 2). 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 $\geq$ specified length/number of fish $\geq$ stock length $\times$ 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 2.---Length categories for warmwater fish species captured at Mason Lake (Mason County) during fall 1997. Measurements are minimum total lengths (mm) for each category (Willis et al. 1993).

	Size				
Type of fish	Stock	Quality	Preferred	Memorable	Trophy
Rock bass	100	180	230	280	330
Largemouth bass	200	300	380	510	630
Yellow perch	130	200	250	300	380

Age and growth of warmwater fishes in Mason Lake were evaluated using the direct proportion method (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 Mason Lake fish and the state average (listed in Fletcher et al. 1993) for the same species.

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 100 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 rock bass (*Ambloplites rupestris*), the W_r values from this study were compared to the Washington State average (Scott Bonar, WDFW, unpublished data) and national standard (W_r = 100) for each species. Since average W_r values for rock bass were lacking, their condition was compared to the national standard only.

RESULTS

Species composition

The dominant species in terms of biomass and number of fish captured was peamouth, *Mylocheilus caurinus* (Table 3). Together, largescale sucker (*Catostomus macrocheilus*) and northern pikeminnow (*Ptychocheilus oregonensis*) accounted for nearly 50% of the biomass captured, but less than 8% by number. Warmwater fishes accounted for about 13% of the biomass and 38% of the number captured. Of these, rock bass was dominant (Table 3).

TABLE 3.---Species composition (excluding young-of-year) by weight (kg) and number of fish captured at Mason Lake (Mason County) during a fall 1997 survey of warmwater fish.

	Species composition				
	by weight		by number		
Type of fish	(kg)	(%)	(#)	(%)	Size range (mm TL)
Peamouth (*Mylocheilus caurinus*)	59.76	40.17	464	51.67	101 - 315
Largescale sucker (*Catostomus macrocheilus*)	48.67	32.71	37	4.12	430 - 579
Northern pikeminnow (*Ptychocheilus oregonensis*)	21.43	14.40	32	3.56	109 - 585
Rock bass (*Ambloplites rupestris*)	7.59	5.10	172	19.15	70 - 215
Yellow perch (*Perca flavescens*)	5.65	3.80	74	8.24	136 - 242
Largemouth bass (*Micropterus salmoides*)	5.52	3.71	94	10.47	90 - 432
Sculpin (*Cottus* sp.)	---	---	18	2.00	---
Cutthroat trout (*Oncorhynchus clarki*)	0.08	0.06	1	0.11	230
Coho salmon (*Oncorhynchus kisutch*)	0.05	0.04	6	0.67	87 - 135
Total	148.75		898		

CPUE

Catch rates were highest for peamouth and stock-size rock bass and yellow perch, *Perca flavescens* (Table 4). The electrofishing CPUE for each of these fish was about twice as high as their gill netting CPUE. Gill netting was the most effective method for capturing large non-game fish such as largescale sucker and northern pikeminnow, whereas electrofishing proved better for sculpin and stock-size largemouth bass. The CPUE for members of the family Salmonidae (cutthroat trout and coho salmon) was low (Table 4).

TABLE 4.---Mean catch per unit effort (number of fish /hour electrofishing and number of fish/net night), including 80% confidence intervals, for fish collected from Mason Lake (Mason County) while electrofishing and gill netting during fall 1997.

	Gear type			
Type of fish	Electrofishing (# fish/hour)	Shock sites	Gill netting (# fish/net night)	Net nights
Peamouth	115.1 ± 32.2	6	48.3 ± 15.0	6
Largescale sucker	1.3 [b]	6	5.8 ± 3.2	6
Northern pikeminnow	1.3 [b]	6	5.0 ± 3.4	6
Rock bass	37.7 ± 12.9 [a]	6	14.7 ± 4.7 [a]	6
Largemouth bass	4.0 ± 1.5 [a]	6	0.2 [a, b]	6
Yellow perch	15.2 ± 8.3 [a]	6	8.5 ± 4.3 [a]	6
Sculpin	11.9 ± 4.6	6	none captured	6
Cutthroat trout	none captured	6	0.2 [b]	6
Coho salmon	3.3 [b]	6	0.2 [b]	6

[a] only stock size fish and larger were used to determine these values.
[b] sample size was insufficient to calculate confidence intervals.

Stock density indices

Few quality size warmwater fish were captured; PSD was relatively low but similar for all species. The only preferred length fish captured was a 432 mm TL largemouth bass, which resulted in a RSD P of 14 for this species (Table 5). However, the PSD and RSD for largemouth bass should be viewed with caution given the low catch rate and small sample size used to determine these indices (Table 5).

TABLE 5.---Traditional stock density indices, including 80% confidence intervals, for warmwater fishes collected from Mason Lake (Mason County) during fall 1997. 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).

Type of fish	Number of stock length fish captured	Stock density index			
		PSD	RSD P	RSD M	RSD T
Rock bass	145	27 ± 6	0	0	0
Largemouth bass	7	29 [a]	14 [a]	0	0
Yellow perch	74	30 ± 8	0	0	0

[a] sample size was insufficient to calculate confidence intervals.

Rock bass

Mason Lake rock bass ranged from 70 to 215 mm TL (age 1+ to 9+) and displayed variable year-class strength. For example, the 1992 and 1995 year-classes were dominant, whereas recruitment was lower in recent years. No juveniles or young-of-year were observed during the study (Table 6, Figure 4). Growth of Mason Lake rock bass was slow when compared to rock bass statewide (Table 6), and their relative weights tended to decrease with length or age (Figure 5).

TABLE 6.---Age and growth of rock bass (*Ambloplites rupestris*) captured at Mason Lake (Mason County) during fall 1997. 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 length (mm) at age								
Year class	# fish	1	2	3	4	5	6	7	8	9
1997	9	44.2 53.2								
1996	9	35.8 48.4	70.1 75.6							
1995	10	34.7 48.6	66.9 75.1	98.4 100.9						
1994	6	37.6 51.8	69.0 78.2	94.7 99.9	111.6 114.2					
1993	8	35.0 50.2	68.6 79.2	93.0 100.3	115.9 120.1	132.9 134.8				
1992	11	40.2 55.0	67.3 78.6	95.7 103.4	113.0 118.5	130.8 134.0	144.6 146.0			
1991	4	36.5 52.1	66.5 78.5	97.8 106.1	121.1 126.6	137.0 140.7	148.1 150.5	158.7 159.8		
1990	3	34.1 50.6	61.9 75.6	93.8 104.1	121.1 128.7	140.7 146.3	157.1 161.0	173.0 175.3	184.1 185.3	
1989	1	42.2 58.2	63.2 77.4	84.3 96.5	111.0 120.7	137.7 144.9	154.6 160.2	165.8 170.4	189.7 192.1	199.5 201.0
	Overall mean	37.8 51.4	67.6 77.2	95.5 101.9	115.1 120.1	133.7 137.0	147.8 150.1	164.9 166.9	185.5 187.0	199.5 201.0
	State average	29.0	69.6	117.6	151.6	178.1	192.8	202.7	---	---

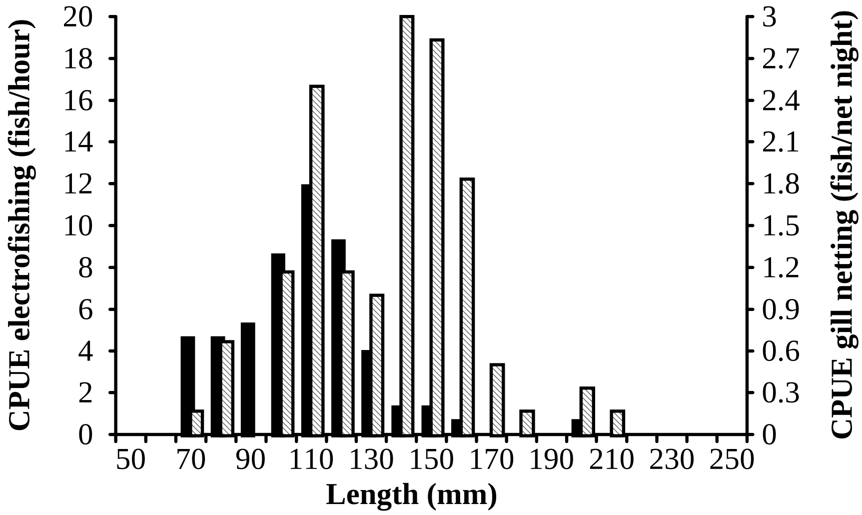

FIGURE 4.---Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for rock bass (*Ambloplites rupestris*) at Mason Lake (Mason County) during fall 1997.

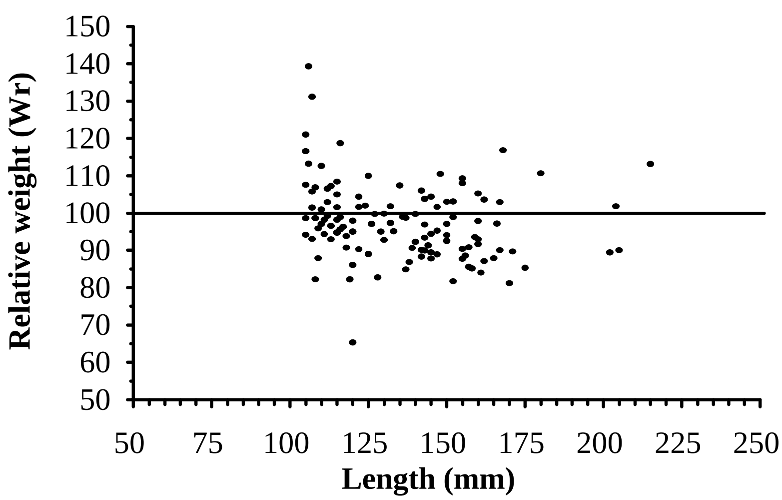

FIGURE 5.---Relationship between total length and relative weight (W_r) of rock bass, *Ambloplites rupestris* (n = 129), from Mason Lake, Mason County (closed, black circles), compared to the national standard (horizontal line at 100).

Largemouth bass

The largemouth bass in Mason Lake ranged from 37 to 432 mm TL (age 0+ to 10+). Although year-class contributions to the total catch showed a quasi-stepwise decline in recent years, year-class strength was still variable. For example, year-class contributions beyond 1994 declined sharply; the 1991 and 1992 year-classes were conspicuously absent from samples collected in fall 1997 (Table 7, Figure 6). Like rock bass, growth of largemouth bass was slow when compared to the state average for the species (Table 7); however, relative weights were well above the national standard, yet consistent with largemouth bass statewide (Figure 7).

TABLE 7.---Age and growth of largemouth bass (*Micropterus salmoides*) captured at Mason Lake (Mason County) during fall 1997. 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 length (mm) at age									
Year class	# fish	1	2	3	4	5	6	7	8	9	10
1997	8	65.1 71.4									
1996	11	55.0 66.4	96.4 101.4								
1995	11	51.7 64.8	93.4 100.8	125.5 128.7							
1994	15	53.8 67.7	101.0 109.4	127.5 132.9	150.7 153.4						
1993	1	78.1 90.7	109.3 119.0	131.7 139.2	165.1 169.6	185.2 187.7					
1992	0										
1991	0										
1990	2	46.3 63.0	99.2 112.1	131.1 141.8	159.8 168.4	192.8 199.1	222.6 226.8	242.4 245.2	262.3 263.6		
1989	1	63.1 79.1	105.1 118.5	151.8 162.3	186.9 195.2	228.9 234.6	256.9 260.9	285.0 287.1	296.6 298.1	308.3 309.1	
1988	1	61.7 78.9	101.2 116.5	148.1 161.3	192.5 203.6	234.5 243.7	276.5 283.7	335.7 340.2	375.2 377.8	399.9 401.4	414.7 415.5
Overall mean		55.9 68.1	98.0 105.8	128.6 134.0	156.2 160.3	206.9 212.8	244.6 249.5	276.4 279.4	299.1 300.8	354.1 355.2	414.7 415.5
State average		65.3	140.0	202.9	254.0	295.4	334.3	389.4	414.5	439.9	484.6

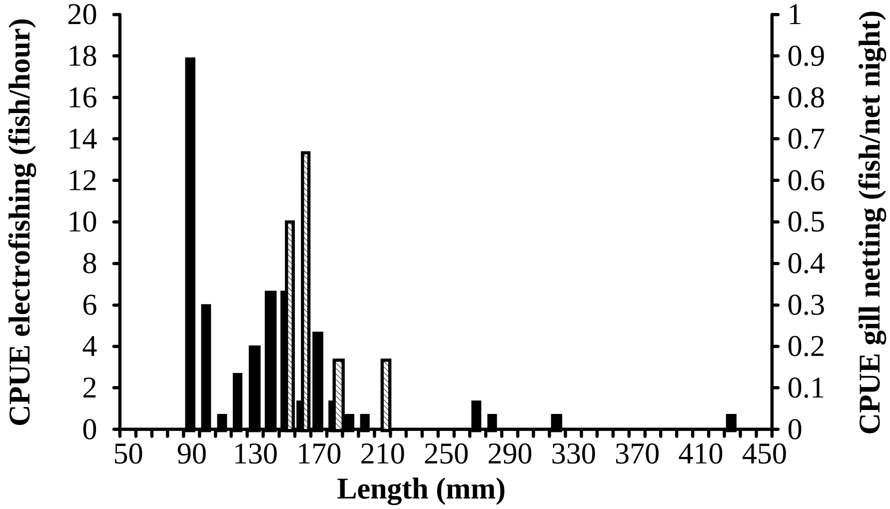

FIGURE 6.---Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for largemouth bass (*Micropterus salmoides*) at Mason Lake (Mason County) during fall 1997.

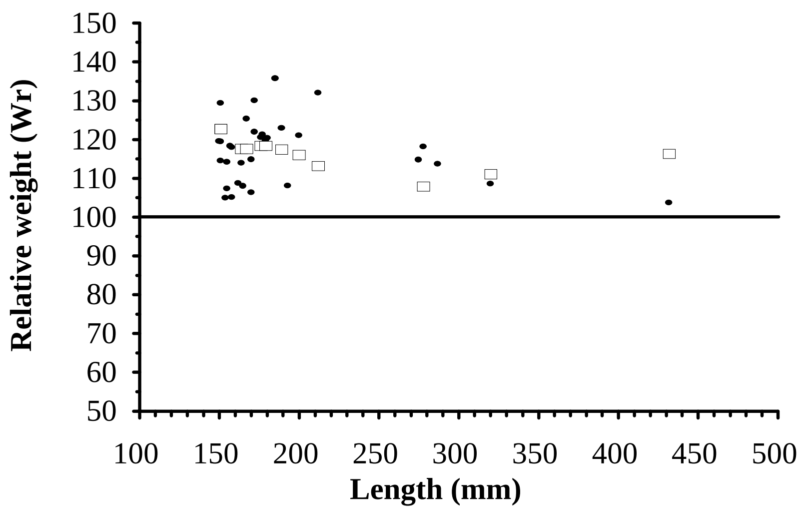

FIGURE 7.---Relationship between total length and relative weight (W_r) of largemouth bass, *Micropterus salmoides* (n = 35), from Mason Lake, Mason County (closed, black circles), compared to the national standard (horizontal line at 100).

Yellow perch

Size of yellow perch ranged from 66 to 242 mm TL (age 0+ to 7+). Like rock bass and largemouth bass, yellow perch showed variable year-class strength. The 1993 and 1995 year-classes were dominant, whereas the 1997 year-class was not observed (Table 8, Figure 8). During their first two years, growth of Mason Lake yellow perch was consistent with or slightly above the state average. However, after age 3, growth was slower than yellow perch statewide (Table 8) and relative weights were well below the state average and national standard for the species (Figure 9).

TABLE 8.---Age and growth of yellow perch (*Perca flavescens*) captured at Mason Lake (Mason County) during fall 1997. 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).

Year class	# fish	Mean length (mm) at age 1	2	3	4	5	6	7
1997	0							
1996	9	74.1 90.5	121.0 127.1					
1995	11	77.2 94.3	127.8 135.0	151.0 154.2				
1994	5	78.3 95.6	118.3 129.2	140.1 147.4	169.8 172.3			
1993	12	79.4 98.0	123.4 135.6	151.2 159.3	174.9 179.6	193.4 195.5		
1992	5	72.7 92.9	108.2 123.6	146.3 156.5	171.5 178.2	193.0 196.9	207.3 209.3	
1991	2	81.9 101.5	122.3 136.9	153.7 164.3	170.9 179.3	200.2 204.9	214.7 217.6	227.2 228.5
	Overall mean	77.3 94.6	121.7 131.7	149.0 155.9	172.8 177.8	194.0 196.8	209.4 211.6	227.2 228.5
	State average	59.7	119.9	152.1	192.5	206.0	---	---

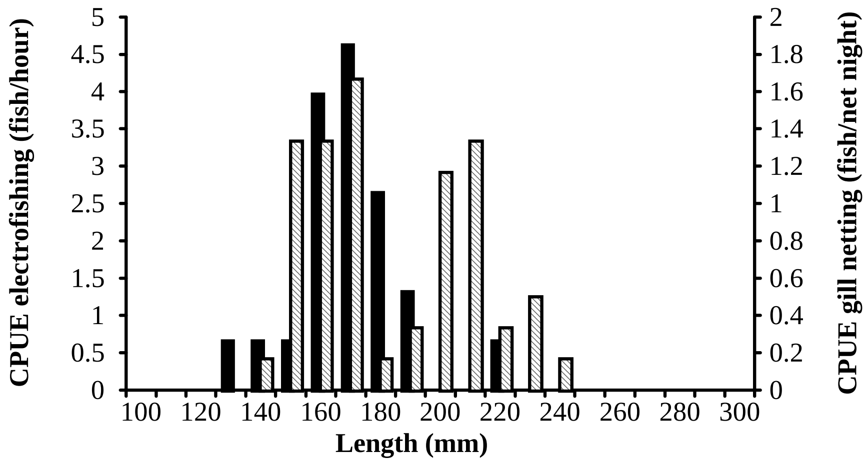

FIGURE 8.---Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for yellow perch (*Perca flavescens*) at Mason Lake (Mason County) during fall 1997.

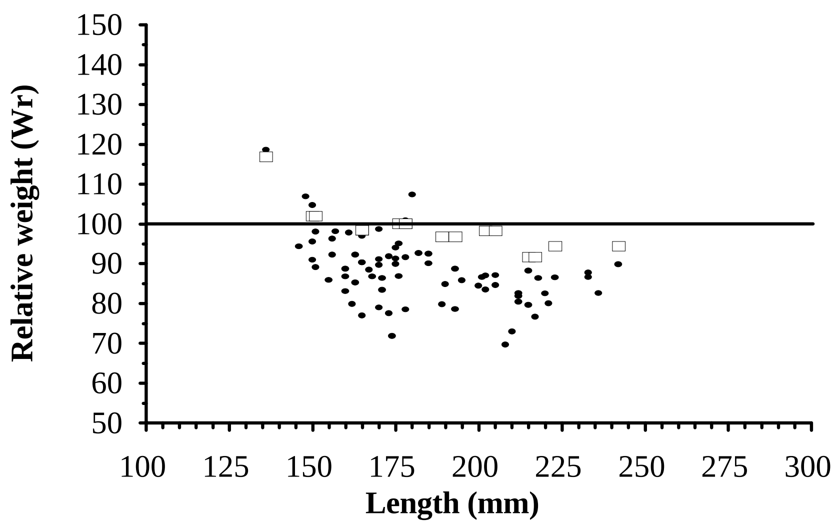

FIGURE 9.---Relationship between total length and relative weight (W_r) of yellow perch, *Perca flavescens* (n = 74), from Mason Lake, Mason County (closed, black circles), compared to the Washington State average (open, clear rectangles) and national standard (horizontal line at 100).

Non-game fish and others

During fall 1997, the dominant fish captured at Mason Lake was peamouth. Peamouth ranged in size from 101 to 315 mm TL (Table 3, Figure 10). The population comprised mostly intermediate size fish (~ 210 - 260 mm TL). The largest fish captured were largescale sucker and northern pikeminnow. These fish ranged in size from 430 to 579 mm TL and 109 to 585 mm TL, respectively (Table 3, Figures 11 and 12).

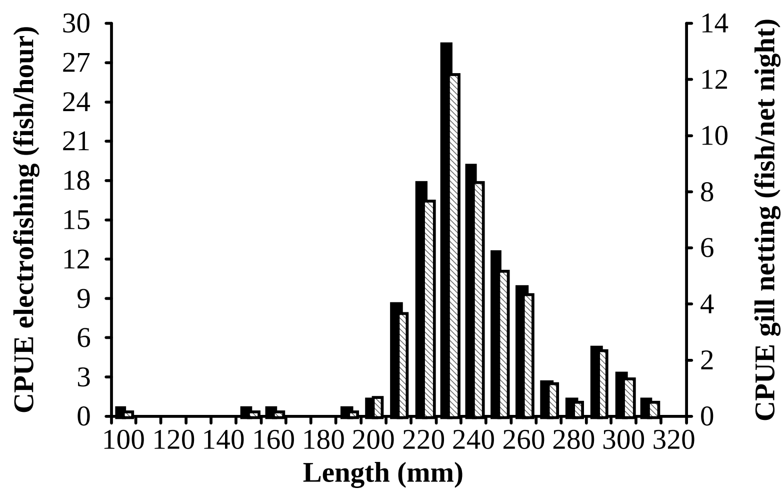

FIGURE 10.---Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for peamouth (*Mylocheilus caurinus*) at Mason Lake (Mason County) during fall 1997.

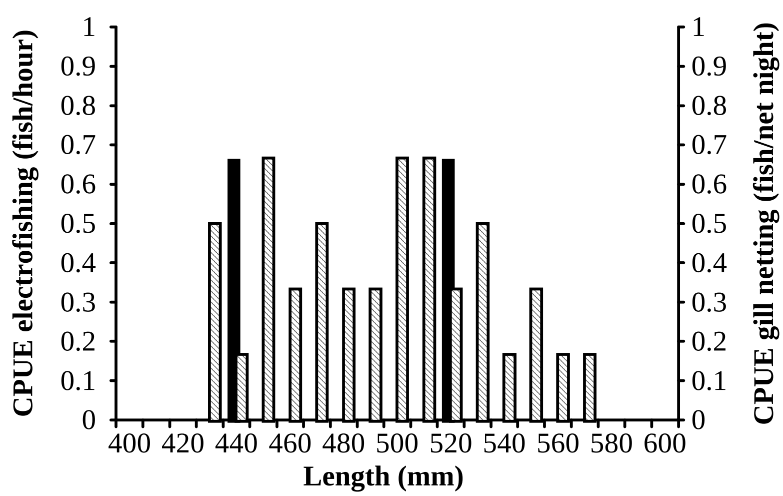

FIGURE 11.----Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for largescale sucker (*Catostomus macrocheilus*) at Mason Lake (Mason County) during fall 1997.

Like peamouth, the catch of northern pikeminnow consisted mostly of intermediate size fish (~260 - 320 mm TL), whereas only large fish contributed to the total catch of largescale sucker (Figures 11 and 12). Not surprisingly, six juvenile coho salmon were captured as well. These ranged from 87 to 135 mm TL, most of which fell in the 90-mm size class (Table 3, Figure 13).

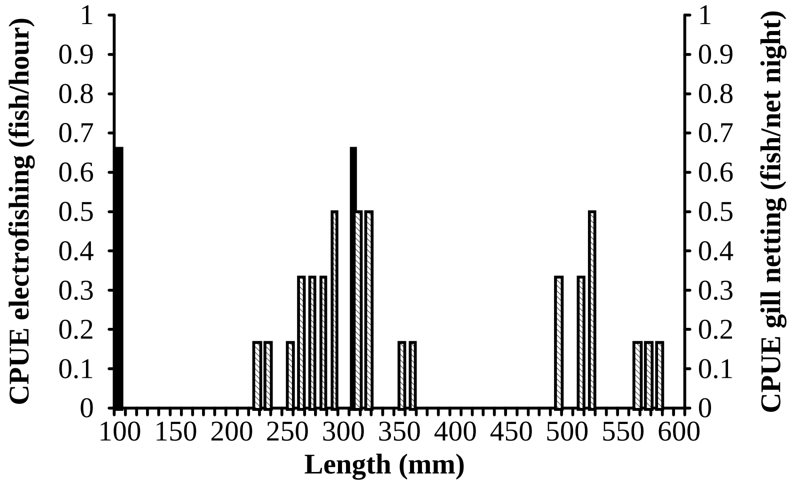

FIGURE 12.-- -Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for northern pikeminnow (*Ptychocheilus oregonensis*) at Mason Lake (Mason County) during fall 1997.

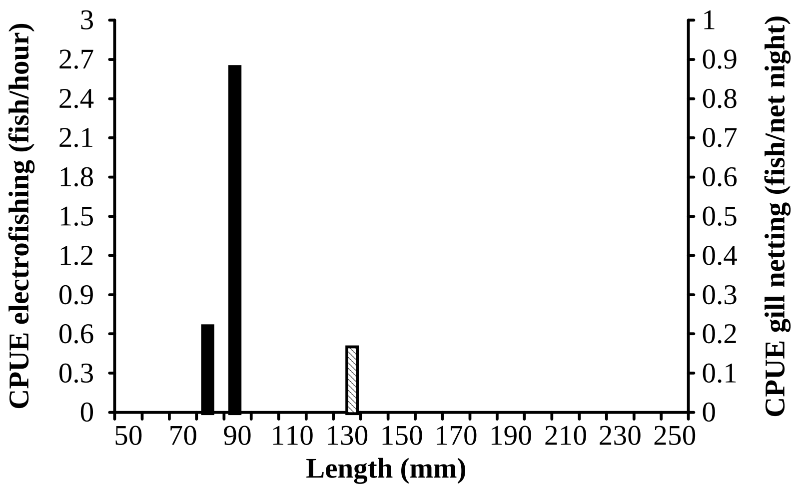

FIGURE 13.---Relationship between total length and catch per unit effort of electrofishing (solid bars) and gill netting (hatched bars) for coho salmon (*Oncorhynchus kisutch*) at Mason Lake (Mason County) during fall 1997.

DISCUSSION

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 or prey maximize food resources to produce harvestable-size stocks for fishermen and 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 size structure, growth, and condition (W_r) 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 fall 1997, Mason Lake showed indications of having an unbalanced fish community. For example, in terms of biomass, the lake was clearly dominated by non-game fish, primarily peamouth. The size structure and growth pattern of largemouth bass suggest that these predators were unable to reach an adequate size to control overproduction of the dominant non-game fish in the lake. The remaining warmwater fish species exhibited either below average growth, condition, or both. Furthermore, few quality size fish were captured, and several year classes were lacking or altogether absent.

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, the conditions observed during fall 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 fish populations results in slow growth (less food per individual) and reduced or inhibited reproduction. This was evident in the warmwater forage fish populations at Mason Lake. Their size structure, growth pattern, and condition suggest that these fish were not able to feed effectively, possibly due to overcrowding and competition with the dominant peamouth.

WARMWATER ENHANCEMENT OPTIONS

Change existing fishing rules to alter size structure of largemouth bass

Currently, anglers are allowed to retain five largemouth bass daily at Mason Lake. Although there is no minimum size limit, no more than three of these fish can measure over 381 mm TL (15"). The size structure of largemouth bass observed during fall 1997 showed that intermediate size classes (203 - 305 mm TL or 8 - 12"), those fish needed to maintain balance within Mason Lake, were lacking. However, the high relative weights of the fish suggest that food was not limited. Still, nearly 95% of the largemouth bass captured measured less than 254 mm TL (10"); the CPUE for stock length fish was low. Implementing a minimum length limit (i.e., fish below the designated length must be released) of 356 - 406 mm TL (14 - 16"), or catch-and-release fishing, might allow more largemouth bass to realize their full growth potential (Willis 1989).

However, the success of any rule changes 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 Mason 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 Mason Lake fish may be reduced by increasing the presence of WDFW enforcement personnel at the lake during peak harvest periods.

Control non-game fish populations with 'super predator'

The balance within Mason Lake may be restored by stocking a sufficient number of 'super predators' to reduce the dominant, non-game fish populations. This technique has been used with varied degrees of success for years (Bennett 1962; Noble 1981; Wahl and Stein 1988; Boxrucker 1992; Bolding et al. 1997). For example, stocking smallmouth bass (*Micropterus dolomieu*) or relatively few ($\leq$ 1,000) sterile, yearling tiger musky (*Esox masquinongy* × *E. lucius*) might improve the density and growth of warmwater fish species through predation of the overabundant peamouth.

The steep, rocky shoreline of Mason Lake would provide a suitable habitat for smallmouth bass (Hubert and Lackey 1980; Pflug and Pauley 1984; Scott and Angermeier 1998). And though tiger musky generally fare well despite the forage base (Kohler and Kelly 1991), the predator prefers fusiform soft-rayed prey, such as peamouth, over deep-bodied spiny-rayed prey, such as rock bass (Tomcko et al. 1984; Wahl and Stein 1988). 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 Mason Lake (Storck and Newman 1992). Still, the risk to the watershed's anadromous fishes should be addressed before stocking either of these predators.

Organize fishing derby for non-game fish, including northern pikeminnow

Besides increased predation, small numbers of non-game fish may be removed by tournament fishermen. Recently, the WDFW issued permits to local sponsors of northern pikeminnow derbies held at Curlew Lake (Ferry County) and Pend Oreille River (Pend Oreille County). Although significant control of nuisance fish is nominal from such events, the opportunity for recreation and increasing angler awareness is excellent (Curt Vail, WDFW, personal communication).

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