2000 Warmwater Fisheries Survey of Eloika Lake (Spokane County)

by

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Abstract

Eloika Lake was surveyed by a three person investigation team May 15 - 18, 2000. Fish were captured by boat electrofishing, gill netting, and fyke netting. Twelve fish species were collected. Largemouth bass (*Micropterus salmoides*), pumpkinseed sunfish (*Lepomis gibbosus*), and black crappie (*Pomoxis nigromaculatus*) were the most abundant game fish species. Tench (*Tinca tinca*) were the most abundant species by weight and number. Yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*), yellow bullhead (*Ameiurus natalis*), black bullhead (*Ameiurus melas)*, green sunfish (*Lepomis cyanellus*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and grass pickerel (*Esox americanus*) were also collected. The Eloika Lake largemouth bass population is robust as evidenced by high growth rates and high stock density index values compared to other Washington lakes. Panfish populations including yellow perch, black crappie, and pumpkinseed sunfish are quality as evidenced by high growth rates and high PSD values. The yellow bullhead population is also of a high quality and offers additional angling opportunity. Considering the high density of aquatic vegetation occurring in Eloika Lake at times, it is curious that panfish species are not stunted as is often observed in densely vegetated lakes. One explanation may be the presence of grass pickerel, a small member of the pike family, in the community. The addition of this predator may add to the overall predation on abundant panfish in the lake, thereby keeping those populations from stunting. Stocked brown trout appear to offer a unique opportunity for fish of quality size, whereas rainbow trout offer little. Although largely undesirable to anglers, tench will likely continue as part of the Eloika Lake fish community due to the limited feasibility of applying typical fisheries management control techniques, such as biological controls or rotenone rehabilitation, due to the lakes connectivity to the Little Spokane River. Future management considerations include monitoring the response of populations to the recently imposed slot-limit on largemouth bass and conducting a creel survey to determine angler harvest. Additionally, careful consideration of any plan to modify current levels of aquatic vegetation to improve boater access is advised. Currently and historically, the effect of aquatic plant abundance on the quality of the fish community is unclear and literature suggests that the response of fish populations to vegetation removal is difficult to predict.

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Introduction

Eloika Lake is a moderately sized, shallow body of water located approximately 32 kilometers (km) north of Spokane, Washington, in Spokane County (Table 1; Figure 1). The lake lies on the west branch of the Little Spokane River, which flows through the lake as both the inlet and the outlet. Moon Creek, the outlet of Diamond Lake, begins the west branch of the Little Spokane River, which flows south through Sacheen Lake, Trout Lake, Horseshoe Lake, and Eloika Lake before joining the Little Spokane River. Additionally, Fan Lake is connected to the west fork of the Little Spokane River by a short tributary stream 2 km north of Eloika Lake.

Table 1. Physical parameters of Eloika Lake (Spokane County).

Physical Parameters	Eloika Lake (Spokane County)
Surface Area (hectares)	267
Shoreline Length (kilometers)	9.5
Maximum Depth (meters)	5
Mean Depth (meters)	3
Volume (cubic meters)	7,401,715
Shoreline Development D_L	1.6

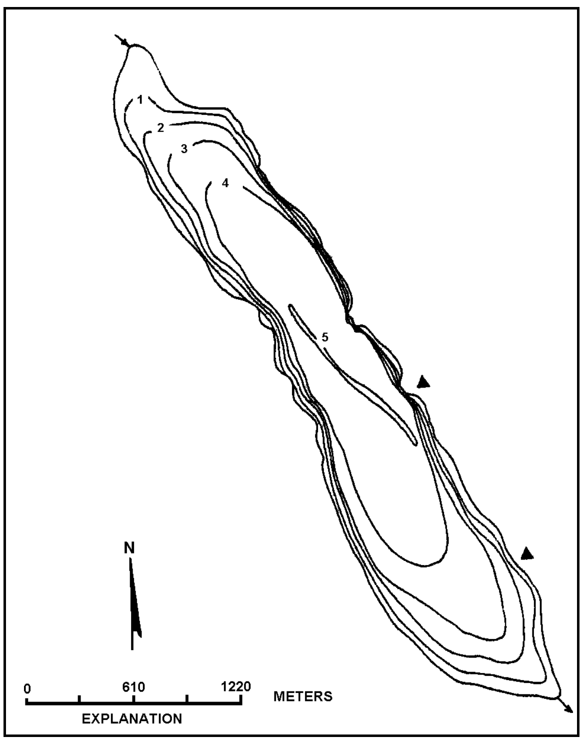

Figure 1. Bathymetric map of Eloika Lake (Spokane County).

Recreational access to Eloika Lake is available to the public at a WDFW owned and operated boat launch located on the southeast side of the lake. There is also a resort on the east shore allowing additional lake access, as well as RV camping and cabin rentals. A few residential homes are located around the lake perimeter, although some are only seasonally occupied. Eloika Lake is open year-round with ice fishing in the winter.

Documentation from the 1950s until the present shows that Eloika Lake has experienced extreme aquatic vegetation invasion, often making boating and angling difficult in summer months. To date, this condition has not been addressed as it is difficult and costly to remove the extensive amount of vegetation in the lake. A 1996 Washington Department of Ecology aquatic plant survey identified 16 species of aquatic plants in Eloika Lake (Table 2). A review of this list shows that the majority of aquatic plants are native species. One invasive nonnative species, Eurasion water-milfoil (*Myriophyllum spicatum*), was observed at the state boat ramp. Although extensive aquatic vegetation has at times posed problems for boaters, considering the historic quality of the warmwater fishery, it apparently has not been a detrimental to Eloika Lake fish populations.

Table 2. Aquatic vegetation data collected at Eloika Lake (Spokane County) by the Washington Department of Ecology on August 3, 1994 (Parsons 1995).

Species	Common Name	Distribution Value	Comments
Brasenia schreberi	watershield	2	
Ceratophyllum demersum	coontail; hornwort	3	
Elodea canadensis	common elodea	4	same with long thin leaves
Myriophyllum sibiricum	northern watermilfoil	2	
Myriophyllum spicatum	Eurasion water-milfoil	2	dense near boat launch
Nuphar polysepalsa	spatter-dock, yellow	2	
Potamogeton pusillus	slender pondweed	2	
Potamogeton richardsonii	Richardson's pondweed	3	may be a hybrid with *P. praelongus*
Potamogeton robbinsii	fern leaf pondweed	2	
Potamogeton zosteriformis	eel-grass pondweed	2	
Spirodela polyrhiza	great duckweed	2	

Distribution Value Definitions:
0 the value was not recorded
1 few plants in only 1 or a few locations
2 few plants, but with a wid patchy distribution
3 plants growing in large patches, co-dominant with other plants
4 plants in nearly monospecific patches, dominant
5 thick growth covering the substrate at the exclusion of other species

Historically, Eloika Lake has been one of Washington state's better warmwater fisheries, particularly for largemouth bass (*Micropterus salmoides*). Yet despite the lure of catching a big bass, yellow perch (*Perca flavescens*) have consistently dominated this fishery. In the 1950s, yellow perch and sunfish were the most plentiful species sampled. A creel survey conducted between April and October 1974 shows yellow perch were the species most often harvested, comprising 87% of the creel. Largemouth bass comprised 4.7%. Simons et al. (1974) estimated that a small number of bass (40-50) in Eloika Lake were in excess of 1.81 kg (four pounds). In 1975, anglers caught 50-60 as large as 1.36 kg (three pounds) (Nielsen 1975), however most largemouth bass averaged about .454 kg (one pound) (Duff et al. 1977). Currently, Eloika Lake offers anglers the opportunity to catch largemouth bass, yellow perch, black crappie (*Pomoxis nigromaculatus*), pumpkinseed sunfish (*Lepomis gibbosus*), bullhead catfish (*Ameiurus spp.*), as well as brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Brown trout yearlings are stocked in the spring with 5,000 being stocked in 1999, 4,000 in 2000, and 3,000 in 2001 (WDFW unpublished data). Trout are not thought to reproduce in the lake.

Under current statewide WDFW angling regulations, the following rules apply on Eloika Lake: a slot-limit on largemouth bass allows anglers to retain five largemouth bass less than 305 mm (12 inches) or greater than 432 mm (17 inches), and no more than one over 432 mm; a combination of five rainbow trout (no minimum length) and/or brown trout (no minimum length) may also be retained in the daily creel. There is no minimum length or bag limit on black crappie, green sunfish (*Lepomis cyanellus*), pumpkinseed sunfish, yellow perch, bullhead catfish, grass pickerel (*Esox americanus*), or tench (*Tinca tinca*).

Due to its habitat characteristics and history as a warmwater fishery, Eloika Lake was identified by regional fisheries biologists as a body of water to be surveyed under the Warmwater Fish Enhancement Program. To evaluate warmwater fish populations, and to identify ways to improve the quality of fishing, personnel from the WDFW Warmwater Enhancement Program conducted a fisheries survey on Eloika Lake during May, 2000. This report is intended to assist regional fisheries biologists in identifying management options which could improve the quality of warmwater fish angling in Eloika Lake.

Methods

Eloika Lake was surveyed by a three person investigation team May 15 - 18, 2000. Fish were captured using boat electrofishing, gill netting, and fyke netting. The electrofishing unit consisted of a 5.5 m Smith-Root 5.0 GPP "shock boat" using a DC current of 120 cycles / sec $^{-1}$ at 5 to 6 amps power. Experimental gill nets (45.7 m long x 2.4 m deep) were constructed of four sinking panels (two each at 7.6 m and 15.2 m long) of variable size (1.3, 1.9, 2.5, and 5.1 cm stretched mesh) monofilament. Fyke nets were constructed of a main trap (4.7 m long and 1.2 m in diameter), a lead net (30.5 m long x 1.2 m), and two wings (7.6 m long x 1.2 m deep).

Sampling locations were selected by dividing the shoreline into 27 sections of approximately 400 meters each. Fifteen sections were randomly selected for sampling by boat electrofishing, eight by gill netting, and eight by fyke netting. While electrofishing, the boat was maneuvered through the shallows (depth range = 0.2 - 2 m), adjacent to the shoreline (Bonar et al. 2000). This sampling was conducted during evening hours to maximize the size and number of fish captured. Electrofishing is more effective at night because some fish species seek shelter during the day and move freely at night (Reynolds 1996; Dumont and Dennis 1997). The total electrofishing time during the survey was 9000 seconds ("pedal-down" time). Gill nets were set perpendicular to the shoreline with the small mesh end attached onshore and the large mesh end anchored offshore. Fyke nets were set perpendicular to the shore with the lead net anchored onshore and the wing nets set at 45 degree angles to the trap. Fyke nets were set so that the trap was no deeper than three meters (Bonar et al. 2000).

Each fish captured was identified to species, measured to total length (mm TL) and weighed (g). Scales were collected for age and growth analysis from largemouth bass, black crappie, yellow perch, pumpkinseed sunfish, green sunfish, and grass pickerel. Scale samples (up to five per 10 mm length class for each species) were mounted, pressed, and aged according to Jearld (1983) and Fletcher et al. (1993). Brown trout, rainbow trout, brown bullhead (*Ameiurus nebulosus*), yellow bullhead (*Ameiurus natalis*), black bullhead (*Ameiurus melas)*, and tench were not aged.

Water quality data was collected from the deepest location in the lake on 4 separate occasions; the first on May 18, 2000 at 7:06 PM, the second on June 23, 2000 at 1:30 PM, the third on August 3, 2000 at 1:50 PM, and the fourth on August 24, 2000 at 2:49 PM. Information was gathered on dissolved oxygen, temperature, specific conductance, total dissolved solids, and pH using a Hydrolab® probe and digital recorder. Water clarity was measured using a Secchi disc.

Data Analysis

Percentages of the total biomass and number of fish collected for each species provides useful information regarding the balance and productivity of the community (Swingle 1950; Fletcher et al. 1993). Species composition by weight (kg) and number was calculated using the first twelve boat electrofishing sections, all eight gill netting sections, and all eight fyke netting sections to calculate the species composition of the lake. This methodology was utilized to maintain a standardized 1:1:1 ratio of electrofishing to gill netting to fyke netting (1:1:1 -1800 seconds of boat electrofishing:24 hours of gill netting:24 hours of fyke netting) to compare the species composition in other lakes to the species composition in Eloika Lake. This technique is employed to reduce bias between gear types (Fletcher et al. 1993). Fish determined to be less than one year old were excluded from the calculations for species composition. Fry numbers can fluctuate dramatically according to sampling location, sampling methodology, and time of hatches (Fletcher et al. 1993). Including young-of-the-year fish in the calculation of species composition can give a false impression of year class strength due to the abundance of small fish which can suffer extensive mortality during the first winter (Chew 1974).

Catch per unit of effort (CPUE), by gear type, was determined for each fish species collected (number of fish/hour electrofishing, number of fish/gill net night, and number of fish/fyke net night). The CPUE for each fish species was calculated using all fish excluding young-of-the-year and also using only stock length fish and longer. Stock length fish, which varies by species, is the length of fish that offers a threshold recreational value to an angler (Anderson 1976). Randomly chosen sample sections can contribute to high variability among samples, therefore, 80 percent confidence intervals (CI) were calculated for each mean CPUE by species and gear type. Each CI was calculated as the mean ±t(%,N-1)×SE, where *t*=Student's *t* for % confidence level with N-1 degrees of freedom (two tailed) and SE=standard error of the mean. When standardized sampling is used, CPUE is a useful index to compare lakes within the state of Washington and to monitor changes in relative abundance over time.

Length frequency histograms (percent frequency captured by each gear type) were developed to evaluate the length structure of largemouth bass, black crappie, yellow perch, pumpkinseed sunfish, yellow bullhead, grass pickerel, and tench. These were made using only fish greater than one year old and also using stock-length fish and longer for species with established stock-lengths.

Proportional stock density (PSD), calculated as the number of fish$quality length/number of fish$stock length×100, was determined for each warmwater fish species collected that have established stock lengths (Anderson and Neuman 1996). PSD can provide information about the proportion of various length fish in a population and can be a useful tool when sample size is adequate (Willis et al. 1993; Divens et al. 1998). Stock and quality lengths are based on percentages of world record catch length and vary depending on fish species (Table 3). Stock length (20-26 percent of the world record) refers to the minimum length fish of recreational value, and quality length (36-41 percent of the world record) refers to the minimum length fish anglers would like to catch. In addition to stock and quality length, Gabelhouse (1984b) introduced relative stock density (RSD) which includes preferred, memorable, and trophy lengths. Preferred length (45-55 percent of world record length) refers to the length fish anglers would prefer to catch. Memorable length (59-64 percent of the world record length) refers to the minimum length fish most anglers remember catching, whereas trophy length (74-80 percent of world record length) refers to the minimum length fish worthy of acknowledgment. RSD, calculated as the number of fish$specific length/number of fish$stock length×100, was also calculated for each warmwater fish species. Like PSD, RSD can also provide useful information regarding population dynamics and is more sensitive to changes in year class strength. For example, relative stock density preferred (RSD-P) is the percentage of stock length fish preferred length and longer, RSD-M is the percentage of stock length fish memorable length and longer, and RSD-T is the percentage of stock length fish trophy size and longer. Eighty-percent confidence intervals for PSDs and RSDs are provided as an estimate of statistical precision and were calculated using normal approximation (Conover 1980; Gustafson 1988). Bister et al. (2000) developed additional PSD and RSD length categories for 83 additional species, including brown bullhead, which were previously uncategorized.

Table 3. PSD/RSD length categories for fish species collected from Eloika Lake (Spokane County) in May 2000. Measurements are total length (mm) for each category (Anderson and Neumann 1996; Bister et al. 2000). Numbers in parenthesis represent percentages of world record lengths (Gabelhouse 1984b).

	Standard Length Categories				
Species	**Stock (20-26%)**	**Quality (36-41%)**	**Preferred (45-55%)**	**Memorable (59-64%)**	**Trophy (74-80%)**
Black Crappie	130	200	250	300	380
Brown Bullhead	130	200	280	360	430
Green Sunfish	80	150	200	250	300
Largemouth Bass	200	300	380	510	630
Pumpkinseed	80	150	200	250	300
Sunfish	100	180	230	280	360
Yellow Bullhead	130	200	250	300	380
Yellow Perch					

Age and growth of warmwater fishes sampled were evaluated using the direct proportion method (Fletcher et al. 1993) and Lee's modification of the direct proportional method (Carlander 1982). Using the direct proportional 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 the lake average and what has been found in other areas around the state of Washington (Fletcher et al. 1993) for the same species. Fletcher et al. (1993) calculated state averages using data collected from select warmwater fish populations throughout the state. These growth rates are referred to as the state average in the results section. Although not a true state average, this is likely representative of fish growth for lakes sampled within the state.

The relative weight (W_r) index was calculated to evaluate the condition of fish collected. Relative weight is calculated as the actual weight of a fish divided by the standard weight (W_s) for the same species at the same length times 100 ($W_r = W/W_s \times 100$, where W is the weight (g) of an individual fish and W_s is the standard weight of a fish of the same length). The standard weight (W_s) is calculated from the standard log 10 weight-log10 length relationship defined for the species of interest. Standard weight equations have been established for many freshwater game and non-game fish species (Anderson and Neumann 1996; Bister et al. 2000). Relative weights are useful for comparing the condition of different size groups within a single population to determine if all sizes are getting adequate nutrition (ODFW 1997). A W_r value of 100 generally indicates that a fish is in average condition when compared to the national average for that species (Anderson and Gutreuter 1983). Fish collected with relative weights below 85 are underweight and may be an indication of extensive competition for available food resources (Flickinger and Bulow 1993). Anderson and Neumann (1996) list the parameters for the W_r equations of many warmwater fish species, including the minimum length recommendations for their application. Relative weight values from this survey were compared to the national average (W_r=100) for each species.

Results

Water Quality

Eloika Lake is mostly shallow with a maximum depth of five meters (Table 1). Measured water temperatures ranged from 11.7 in May, 2000, to 25.9 in August, 2000, and were within the acceptable range of warmwater fish species (Boyd 1990) (Table 4). Temperatures were within the range for optimal warmwater fish growth (20EC - 28EC) only during the warmest months. Measured pH values ranged from 8 to 10.2. The preferred range for warmwater fish species is pH 6.5 to 9 (Swingle 1969). In general, dissolved oxygen levels were adequate in the majority of the lake throughout the summer. However, dissolved oxygen levels were below the desired range for warmwater fish species in a portion of the lake on August 3, 2000, suggesting that at least part of the lake is not available to fish at certain times of the year. Additional water quality monitoring should be conducted to better quantify water quality limitations at Eloika Lake.

Table 4. Water quality data collected from May through August 2000 at Eloika Lake (Spokane County).

Date	Depth (m)	Temp (EC)	pH	DO (mg/l)	TDS	Conductivity	Secchi (m)
5/18/00	0	17.9	8.0	3.6	0.050	77.9	2.5
	1	16.9	8.2	3.6			
	2	14.3	8.4	4.0			
	3	14.4	8.4	4.0			
	4	11.7	8.2	4.4	0.057	90.0	
6/23/00	0	21.0	9.9	2.9	0.050	82.0	
	2	18.7	10.0	3.0			
	4	16.3	9.1	3.0	0.060	100.0	
8/3/00	0	25.9	9.7	7.6	0.058	90.6	4.0
	2	24.1	9.9	8.4			
	4	21.1	8.7	0.7	0.127	197.7	
8/24/00	0	19.0	10.2	9.3	0.060	95.2	2.5
	2	20.3	10.2	9.1			
	4	19.8	9.3	5.5	0.061	95.5	

Species Composition

Twelve fish species were collected from Eloika Lake. Tench was the most abundant species comprising 70 percent of the sample by weight (Table 5). Largemouth bass, pumpkinseed sunfish, and black crappie were the most abundant game fish species and together comprised 22 percent of the catch by weight. Yellow perch, bullhead catfish, brown trout, rainbow trout and green sunfish together comprised less than 10 percent of the catch by weight.

Table 5. Species composition (excluding young-of-the-year) by weight (kg) and number for fish collected at Eloika Lake (Spokane County) in May 2000.

	Species Composition					
	by Weight		by Number		Size Range (mm TL)	
Species	(kg)	(%w)	(#)	(%n)	Min	Max
Tench	238.64	69.76	277	30.21	107	470
Largemouth Bass	35.70	10.44	122	13.30	143	566
Pumpkinseed Sunfish	23.58	6.89	265	28.90	70	190
Black Crappie	15.14	4.43	60	6.54	121	303
Yellow Perch	12.53	3.66	119	12.98	125	266
Brown Bullhead	7.38	2.16	16	1.74	241	350
Yellow Bullhead	5.82	1.70	32	3.49	186	326
Brown Trout	1.12	0.33	3	0.33	185	465
Grass Pickerel	0.99	0.29	16	1.74	109	275
Rainbow Trout	0.58	0.17	4	0.44	240	273
Green Sunfish	0.20	0.06	2	0.22	138	183

CPUE

Pumpkinseed sunfish were sampled at the highest rate by boat electrofishing followed by largemouth bass, tench, and yellow perch (Table 6). Tench were sampled at the highest rate by gillnetting followed by yellow perch. Tench, pumpkinseed sunfish, and black crappie were sampled at the highest rate by fyke netting. The majority of fish sampled were of stock length (Table 7). Two exceptions were largemouth bass and yellow perch captured by electrofishing, of which a substantial number were between age one and stock length.

Table 6. Mean catch-per-unit-effort by sampling method, including 80% confidence intervals, for all fish, excluding young-of-the-year, collected at Eloika Lake (Spokane County) in May 2000.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
	(#/hour)	Sites	#/Net Night	Net Nights	#/Net Night	Net Nights
Brown Bullhead	3.6 ± 1.8	15	0.6 ± 0.4	8	0.5 ± 0.3	8
Black Crappie	5.6 ± 4.8	15	3.1 ± 2.5	8	2.6 ± 2.2	8
Brown Trout	0.4 ± 0.5	15	0.3 ± 0.2	8	0.0	8
Green Sunfish	0.4 ± 0.5	15	0.0	8	0.1 ± 0.2	8
Largemouth Bass	60.4 ± 6.8	15	0.9 ± 0.4	8	0.0	8
Grass Pickerel	5.6 ± 2.1	15	0.5 ± 0.2	8	0.0	8
Pumpkinseed	110.4 ± 21.7	15	2.0 ± 0.9	8	2.1 ± 0.9	8
Sunfish	0.0	15	0.3 ± 0.2	8	0.0	8
Rainbow Trout	34.8 ± 6.5	15	17.5 ± 4.2	8	8.4 ± 2.7	8
Tench	5.6 ± 1.9	15	2.5 ± 1.2	8	0.3 ± 0.2	8
Yellow Bullhead	28.4 ± 8.0	15	8.0 ± 4.4	8	0.0	8
Yellow Perch						

Table 7. Mean catch-per-unit-effort by sampling method, including 80% confidence intervals, for stock length fish collected at Eloika Lake (Spokane County) in May 2000.

	Gear Type					
	Electrofishing		Gill Netting		Fyke Netting	
	(#/hour)	Sites	#/Net Night	Net Nights	#/Net Night	Net Nights
Brown Bullhead	3.6 ± 1.8	15	0.6 ± 0.4	8	0.5 ± 0.3	8
Black Crappie	5.6 ± 4.8	15	3.1 ± 2.5	8	2.5 ± 2.1	8
Brown Trout	0.4 ± 0.5	15	0.3 ± 0.2	8	0.0	8
Green Sunfish	0.4 ± 0.5	15	0.0	8	0.1 ± 0.2	8
Largemouth Bass	38.0 ± 6.0	15	0.9 ± 0.4	8	0.0	8
Grass Pickerel	5.6 ± 2.1	15	0.5 ± 0.2	8	0.0	8
Pumpkinseed	109.6 ± 21.8	15	2.0 ± 0.9	8	2.1 ± 0.9	8
Sunfish	0.0	15	0.3 ± 0.2	8	0.0	8
Rainbow Trout	34.8 ± 6.5	15	17.5 ± 4.2	8	8.4 ± 2.7	8
Tench	5.6 ± 1.9	15	2.5 ± 1.2	8	0.3 ± 0.2	8
Yellow Bullhead	27.6 ± 7.8	15	8.0 ± 4.4	8	0.0	8
Yellow Perch						

Stock Density Indices

Electrofishing sample sizes for evaluating stock density indices were adequate for largemouth bass, pumpkinseed sunfish, and yellow perch; however, sample sizes of stock-length fish of other warmwater game fish species were low (Table 8). Largemouth bass proportional stock density (PSD) and relative stock density (RSD) values were high compared to other lakes surveyed within the drainage (e.g., Diamond Lake and Sacheen Lake). Values for largemouth bass are within the desired range for populations managed for quality panfish (Anderson and Neumann 1996). Similarly, PSD values for Eloika Lake panfish species including pumpkinseed sunfish, yellow perch, and black crappie were within the desired range for communities managed for quality panfish.

Table 8. Traditional stock density indices, including 80% confidence intervals, for fish collected from Eloika Lake (Spokane County) in May 2000 by sampling method.

Species	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
Black Crappie	14	100 ± 0	43 ± 17	7 ± 9	0
Brown Bullhead	9	100 ± 0	100 ± 0	0	0
Largemouth Bass	95	29 ± 6	11 ± 4	6 ± 3	0
Pumpkinseed Sunfish	274	62 ± 4	0	0	0
Yellow Bullhead	14	100 ± 0	57 ± 17	7 ± 9	0
Yellow Perch	69	42 ±8	6 ± 4	0	0
		Gill Netting			
Black Crappie	25	100 ± 0	96 ± 5	0	0
Pumpkinseed Sunfish	16	50 ± 16	0	0	0
Yellow Bullhead	20	100 ± 0	45 ± 14	10 ± 9	0
Yellow Perch	64	73 ± 7	5 ± 3	0	0
		Fyke Netting			
Black Crappie	20	100 ± 0	45 ± 14	0	0
Pumpkinseed Sunfish	17	76 ± 13	0	0	0

Largemouth Bass

Eloika Lake largemouth bass sampled ranged in size from 107 to 470 mm TL (Table 5; Figure 2). The age of largemouth bass sampled ranged from one to ten years (Table 9). Largemouth bass growth rates were higher than the known Washington state average at all age classes (Fletcher et al. 1993). Length frequency distributions indicate stable year-class strength (Figures 2 and 3). Few fish were sampled between 340 and 440 mm total length. This may indicate extensive harvest of fish over 340 mm prior to the implementation of a 305 to 432 mm (12 to 17 inch) restrictive slot-limit regulation in 1999. The condition of largemouth bass less than 350 mm was below the national average (Figure 4). This may be an indication of extensive inter- and/or intra-specific competition for available food resources with young bass, abundant panfish, and possibly grass pickerel. Largemouth bass condition for fish greater than 350 mm was above the national average. This may indicate a reduction in interspecific competition as bass become increasingly piscivorus with size.

Table 9. Age and growth of largemouth bass sampled from Eloika Lake (Spokane County) in May 2000. Unshaded values are mean back-calculated lengths at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification method (Carlander 1982).

		Mean Total Length (mm) at Age									
Year Class	**# of Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1999	1	77									
		77									
1998	44	98	201								
		108	202								
1997	8	76	204	261							
		90	208	261							
1996	16	89	185	249	301						
		103	193	252	301						
1995	6	85	184	245	285	322					
		100	193	250	288	322					
1994	1	97	181	245	287	312	338				
		111	190	250	290	314	338				
1993	1	94	161	218	265	315	342	372			
		109	172	226	271	318	343	372			
1992	2	86	171	243	308	355	405	437	458		
		103	183	252	315	359	407	438	458		
1991	5	85	208	298	373	418	455	483	502	517	
		101	220	306	378	422	457	484	502	517	
1990	3	98	225	318	385	438	469	489	509	526	539
		115	237	326	391	441	472	491	510	526	539
Overall Mean		88	191	259	315	360	402	445	489	522	539
Lee's Weighted Mean		104	202	265	318	373	433	467	496	521	539
State Average		60	146	222	261	289	319	368	396	440	485

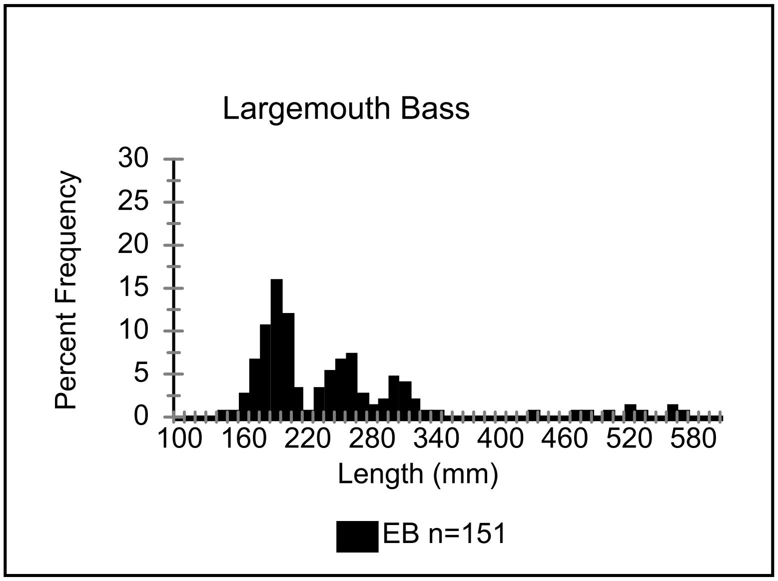

Figure 2. Length frequency distribution of largemouth bass, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing.

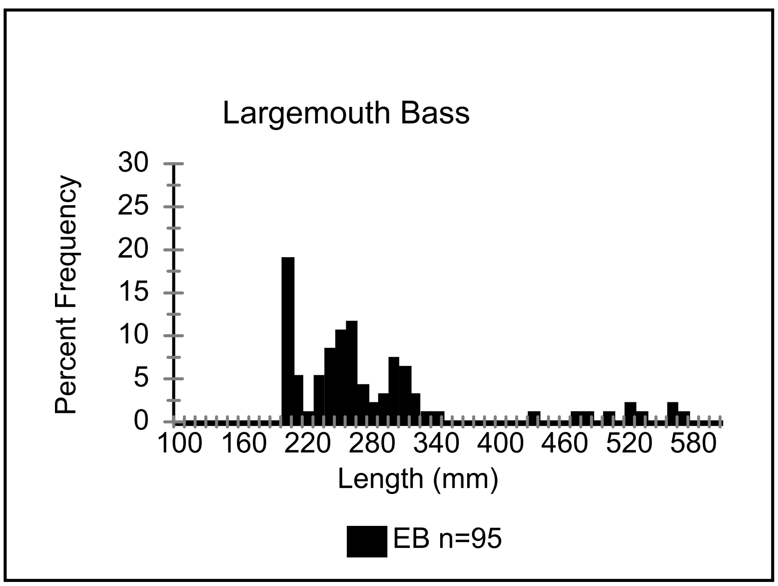

Figure 3. Length frequency distribution of stock-length largemouth bass sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing.

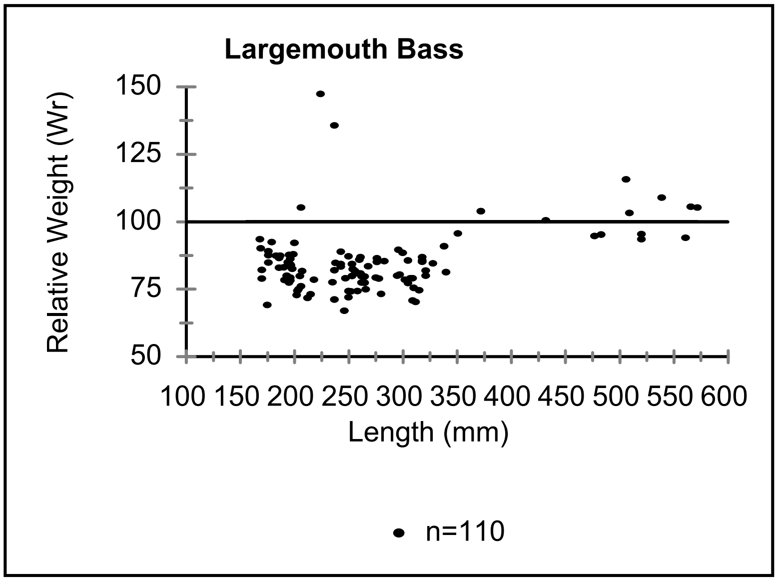

Figure 4. Relative weight (Wr) of largemouth bass, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Pumpkinseed Sunfish

Eloika Lake pumpkinseed sunfish sampled ranged in size from 70 to 190 mm (Table 5; Figure 5). The age of pumpkinseed sunfish ranged from one to four years (Table 10). Pumpkinseed growth rates were higher than the known Washington state average at all age classes. A high proportion of pumpkinseed sunfish sampled were greater than quality-length (150 mm) (Figures 5 and 6). Pumpkinseed sunfish condition was at or above the national average (Figure 7).

Table 10. Age and growth of pumpkinseed sunfish sampled from Eloika Lake (Spokane County) in May 2000. Unshaded values are mean back-calculated lengths at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification method (Carlander 1982).

		Mean Total Length (mm) at Age				
Year Class	**# of Fish**	**1**	**2**	**3**	**4**	**5**
1999	0					
1998	9	34	87			
		49	87			
1997	28	23	78	139		
		44	89	139		
1996	5	28	76	128	166	
		49	90	134	167	
1995	8	25	73	120	154	172
		46	88	128	157	172
Direct Proportion Overall Mean		28	78	129	160	172
Lee's Weighted Mean		46	89	136	161	172
Direct Proportion State Average		24	72	102	123	139

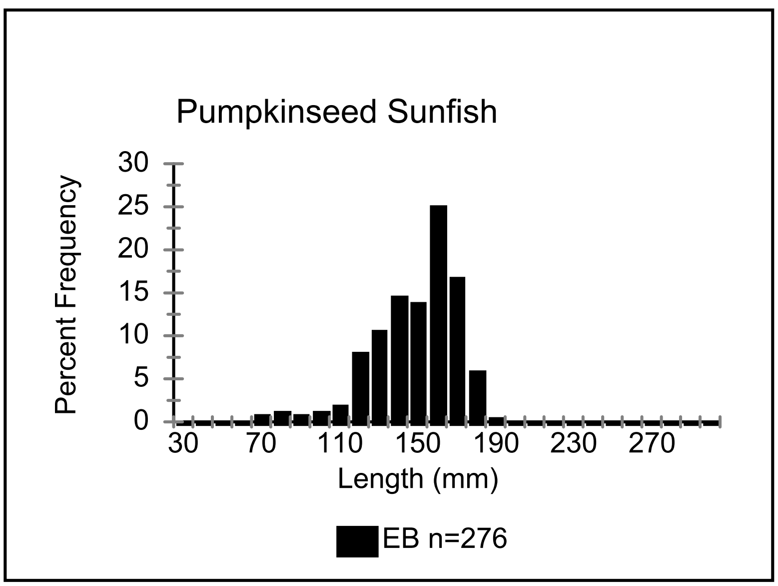

Figure 5. Length frequency distribution of pumpkinseed sunfish, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing.

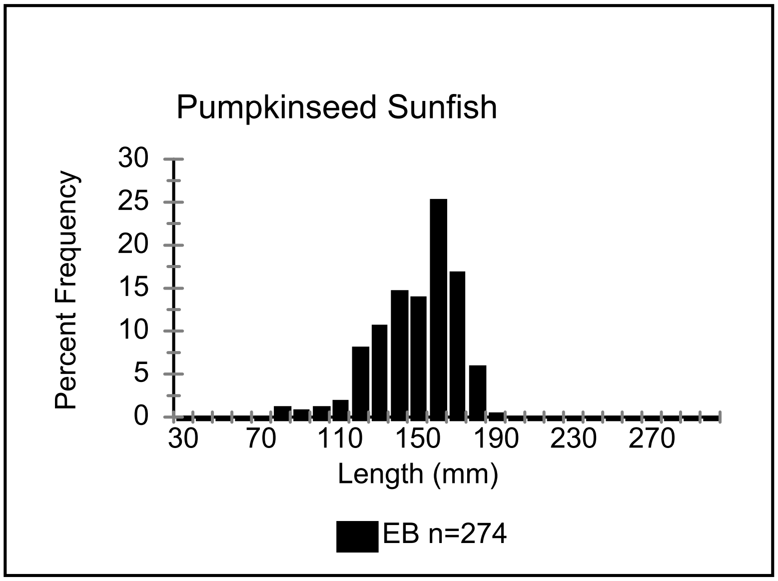

Figure 6. Length frequency distribution of stock-length pumpkinseed sunfish sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing.

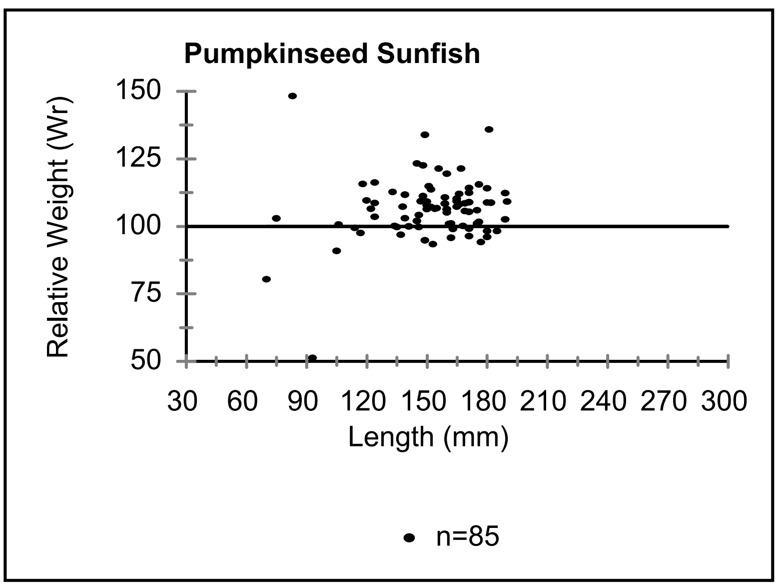

Figure 7. Relative weight (Wr) of pumpkinseed sunfish, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Yellow Perch

Eloika Lake yellow perch sampled ranged from 75 to 266 mm (Table 5 and Figure 8). Length frequency distribution analysis indicates stable year-class strength (Figures 8 and 9). A higher proportion of larger yellow perch sampled by gill netting is common and attributed to gear-type bias. The age of most yellow perch sampled ranged from one to five years; however, one individual was aged at eight (Table 11). Yellow perch growth rates were higher than the known Washington average for all age classes. Yellow perch condition was at or below the national average (Figure 10). Larger yellow perch exhibited the lowest condition.

Table 11. Age and growth of yellow perch sampled from Eloika Lake (Spokane County) in May 2000. Unshaded values are mean back-calculated lengths at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification method (Carlander 1982).

		Mean Total Length (mm) at Age							
Year Class	# of Fish	1	2	3	4	5	6	7	8
1999	3	72							
		75							
1998	18	69	153						
		86	154						
1997	25	57	139	205					
		79	149	205					
1996	13	62	142	204	236				
		84	154	209	236				
1995	3	59	135	197	231	248			
		82	149	203	233	248			
1994	0								
1993	0								
1992	1	60	98	158	192	214	239	257	276
		83	118	171	201	221	243	259	276
Direct Proportion Overall Mean		63	134	191	219	231	239	257	276
Lee's Weighted Mean		82	151	205	234	242	243	259	276
Direct Proportion State Average		60	120	152	193	206			

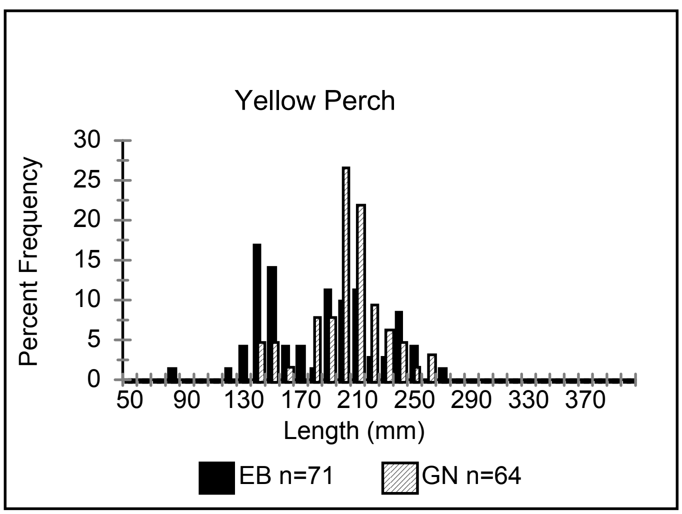

Figure 8. Length frequency distribution of yellow perch, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing (EB) and gill netting (GN).

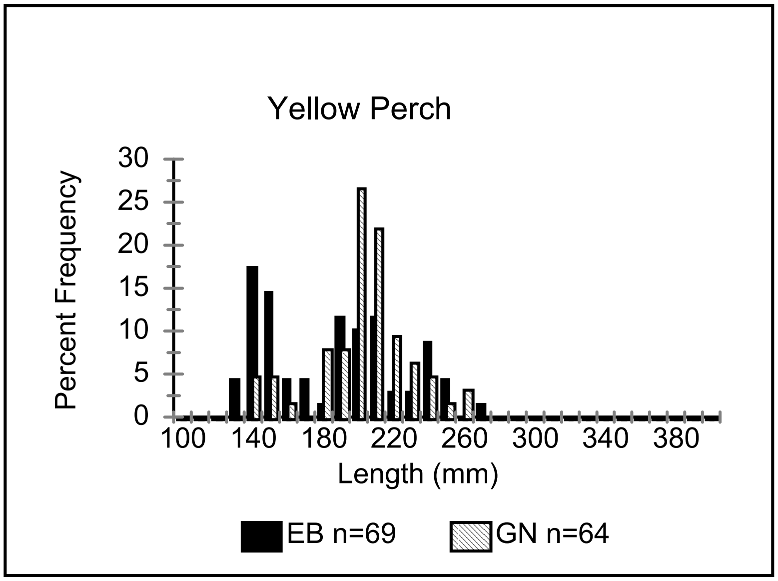

Figure 9. Length frequency distribution of stock-length yellow perch sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing (EB) and gill netting (GN).

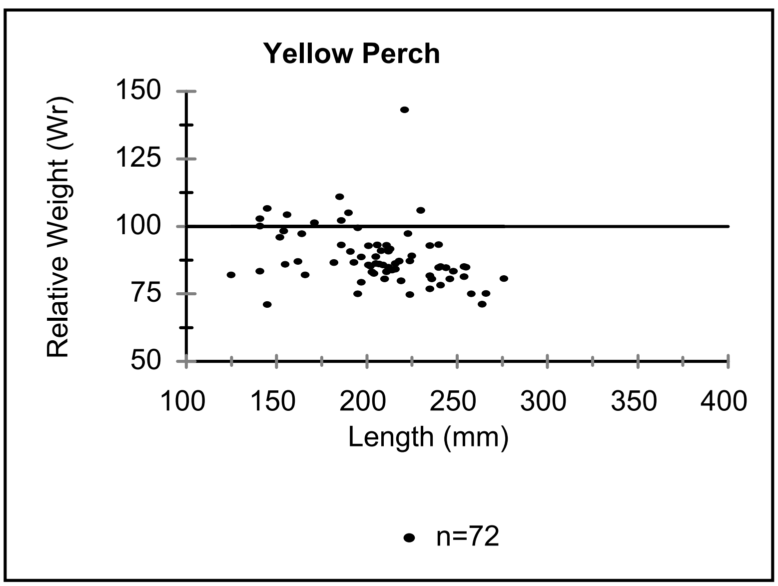

Figure 10. Relative weight (Wr) of yellow perch, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Black Crappie

Eloika Lake black crappie sampled ranged in length from 121 to 303 mm total length (Table 5; Figure 11). The age of black crappie sampled ranged from one to nine years (Table 12). Black crappie growth rates were higher than the known Washington state average with the exception of age one fish. Black crappie condition was below the national average and appeared to decrease with total length and age (Figure 13).

Table 12. Age and growth of black crappie sampled from Eloika Lake (Spokane County) in May 2000. Unshaded values are mean back-calculated lengths at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification method (Carlander 1982).

		Mean Total Length (mm) at Age								
Year Class	**# of Fish**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1999	0									
1998	0									
1997	8	37	146	212						
		66	157	212						
1996	6	40	117	188	234					
		69	136	196	236					
1995	4	43	139	201	239	261				
		72	156	210	243	262				
1994	0									
1993	2	35	104	161	190	218	242	267		
		65	125	175	200	224	246	267		
1992	10	33	94	152	192	220	244	266	283	
		64	117	168	203	228	249	268	283	
1991	4	34	101	158	180	203	227	251	272	288
		65	124	174	193	213	234	256	274	288
Direct Proportion Overall Mean		37	179	179	207	225	238	261	277	288
Lee's Weighted Mean		67	189	189	215	231	245	265	280	288
Direct Proportion State Average		46	157	157	183	220				

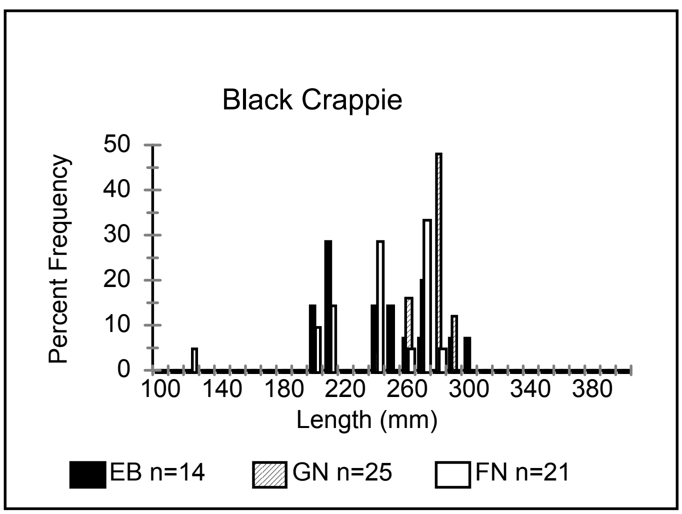

Figure 11. Length frequency distribution of black crappie, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing (EB), gill netting (GN) and fyke netting (FN).

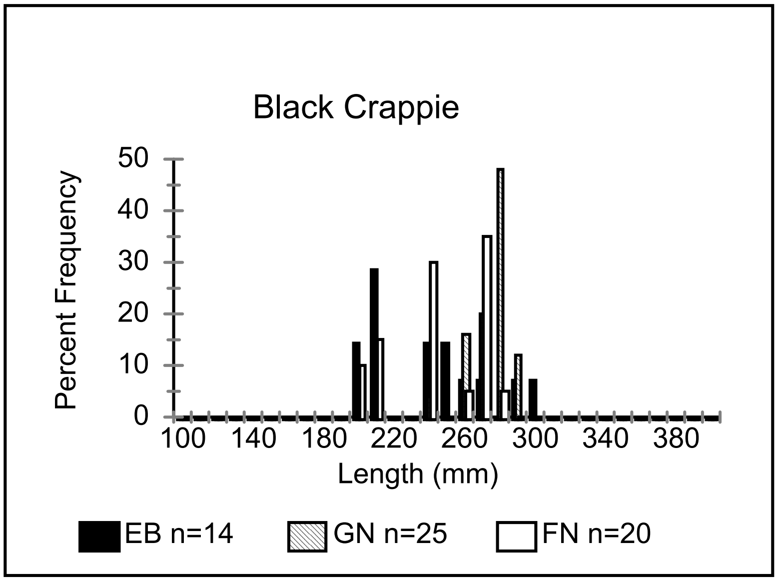

Figure 12. Length frequency distribution of stock-length black crappie sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing (EB), gill netting (GN), and fyke netting (FN).

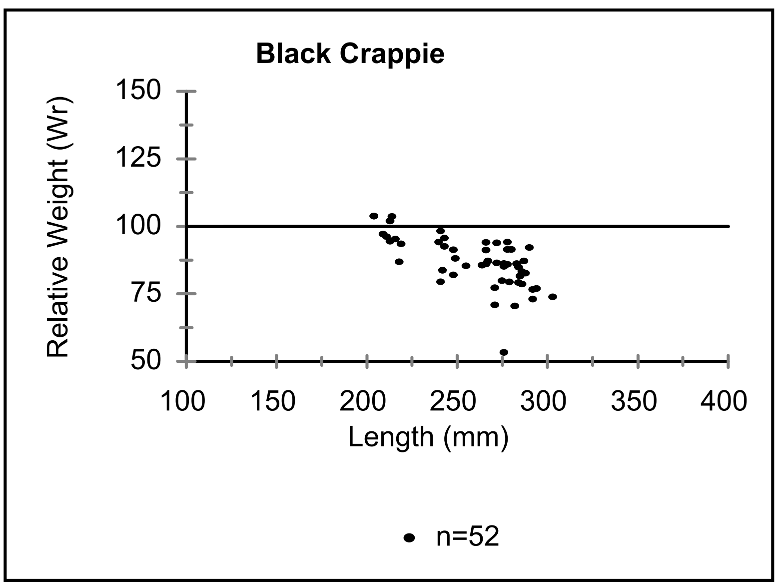

Figure 13. Relative weight (Wr) of black crappie, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Green Sunfish

The two green sunfish sampled at Eloika Lake were 138 and 183 mm total length (Table 5). As only two green sunfish were collected, no length frequency distribution was completed. Green sunfish growth rates were higher than those reported by Wydoski and Whitney (1979) for populations in other states including Montana, Ohio, Oklahoma, and Iowa (Table 13). Condition for the two green sunfish collected was slightly above the national average (Figure 14). As only two specimens were collected in sampling at Eloika Lake, green sunfish may be immigrants to the lake from populations known to exist upstream in Sacheen and Diamond Lakes.

Table 13. Age and growth of green sunfish sampled from Eloika Lake (Spokane County) in May 2000. Unshaded values are mean back-calculated lengths at annulus using the direct proportion method (Fletcher et al. 1993). Shaded values are mean back-calculated lengths using the Lee's modification method (Carlander 1982).

		Mean Total Length (mm) at Age			
Year Class	**# of Fish**	**1**	**2**	**3**	**4**
1999	0				
1998	1	48	129		
		54	129		
1997	0				
1996	1	25	90	152	183
		34	95	154	183
Direct Proportion Overall Mean		36	109	152	183
Lee's Weighted Mean		44	112	154	183
Direct Proportion State Average	n/a				

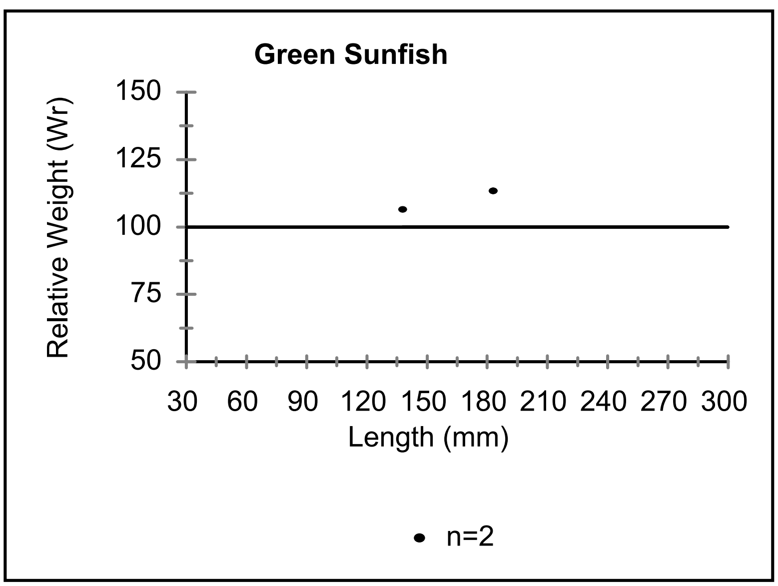

Figure 14. Relative weight (Wr) of green sunfish sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Grass Pickerel

Eloika Lake grass pickerel sampled ranged in length from 109 to 275 mm total length (Table 5; Figure 15). The age of grass pickerel sampled ranged from one to five years (Table 14). Growth rates were lower than those reported for grass pickerel populations in Wisconsin and higher than those reported for populations in Ontario by Wydoski and Whitney (1979).

Table 14. Age and growth of green pickerel sampled from Eloika Lake (Spokane County) in May 2000. Unshaded values are mean back-calculated lengths at annulus using the direct proportion method (Fletcher et al.)

		Mean Total Length (mm) at Age				
Year Class	**# of Fish**	**1**	**2**	**3**	**4**	**5**
1999	1	99				
1998	1	69	136			
1997	10	74	149	221		
1996	2	96	174	213	242	
1995	2	56	107	165	229	225
Direct Proportion Overall Mean		79	141	199	235	255
Lee's Weighted Mean		n/a				
Direct Proportion State Average		n/a				

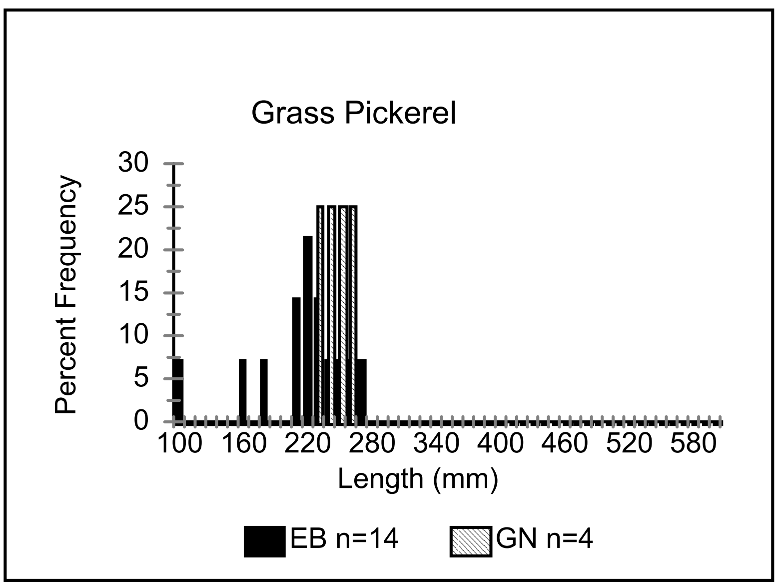

Figure 15. Length frequency distribution of grass pickerel, excluding young-of-the-year, sampled at Eloika Lake (Spokane County) in May 2000 by boat electrofishing (EB) and gill netting (GN).

Yellow Bullhead

Eloika Lake yellow bullhead sampled ranged in length from 186 to 326 mm total length (Table 5; Figure 16). Condition of yellow bullhead sampled was equally above and below the national average (Figure 17). No age analysis was completed for this species.

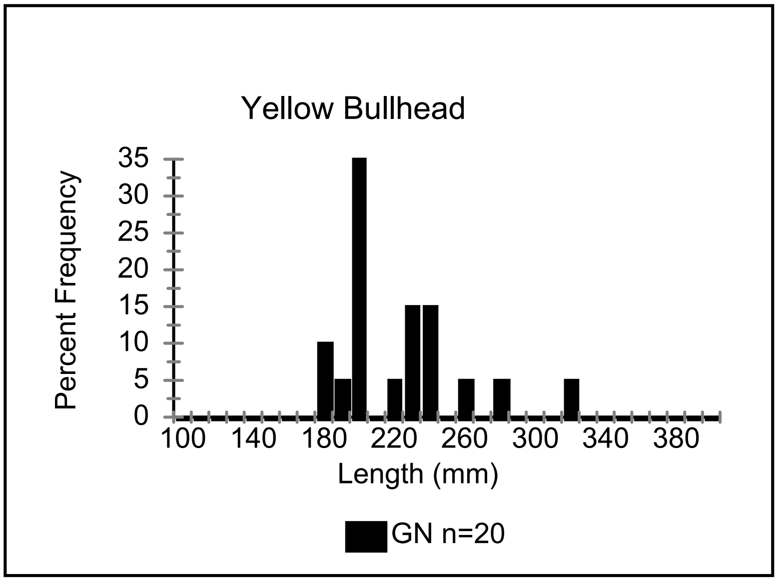

Figure 16. Length frequency distribution of yellow bullhead sampled at Eloika Lake (Spokane County) in May 2000 by gill netting.

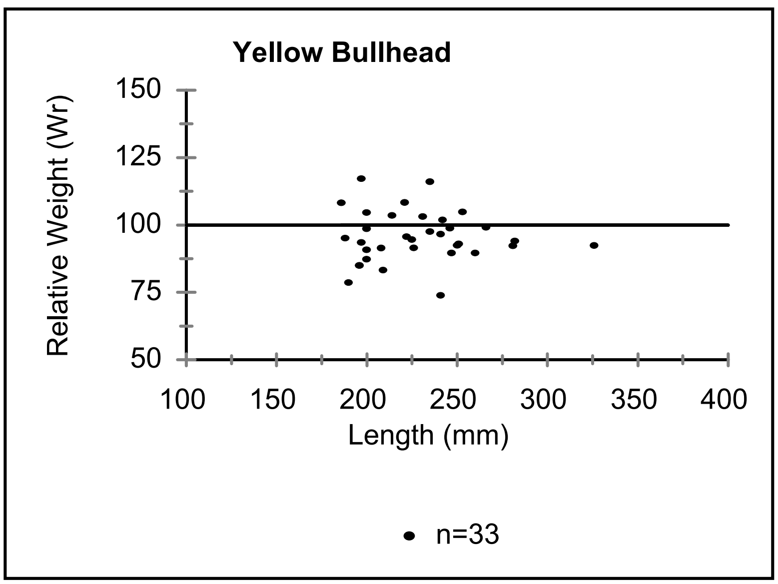

Figure 17. Relative weight (Wr) of yellow bullhead sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Brown Bullhead

Eloika Lake brown bullhead sampled ranged in length from 241 to 350 mm total length (Table 5). Condition of brown bullhead sampled was both above and below the national average (Figure 18). No age analysis was completed for this species.

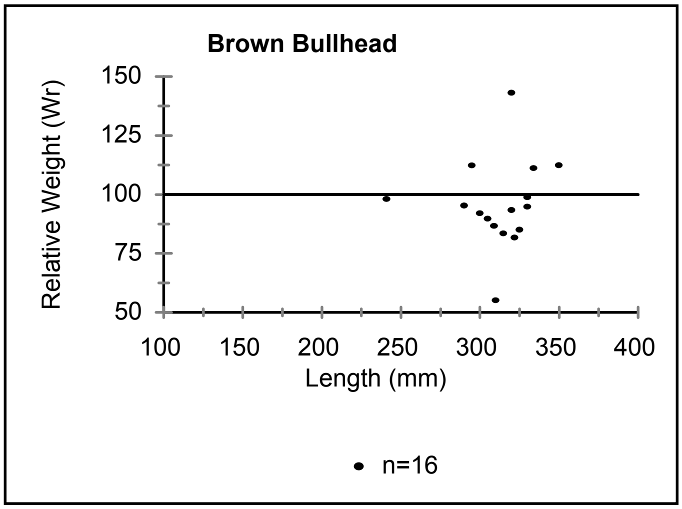

Figure 18. Relative weight (Wr) of brown bullhead sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Rainbow Trout

Eloika Lake rainbow trout sampled ranged in length from 240 to 273 mm total length (Table 5). The condition of the rainbow trout sampled was below the national average (Figure 19). No age analysis was completed for this species.

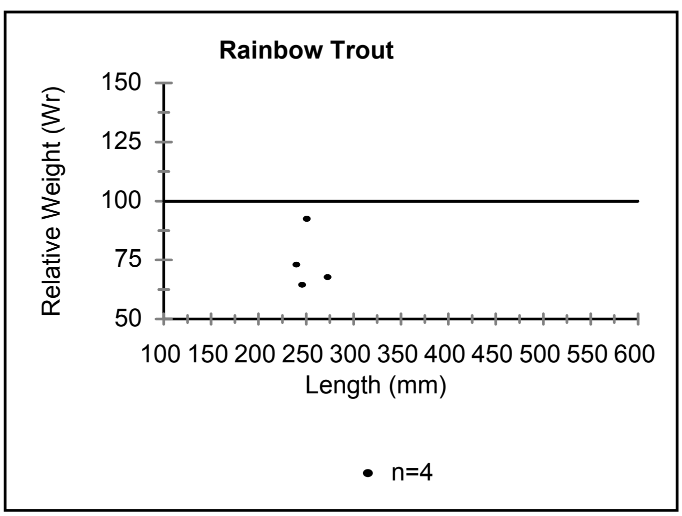

Figure 19. Relative weight (Wr) of rainbow trout sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Brown Trout

Eloika Lake brown trout sampled ranged in length from 185 to 465 mm total length (Table 5). The condition of the brown trout sampled was below the national average (Figure 20). No age analysis was completed for this species.

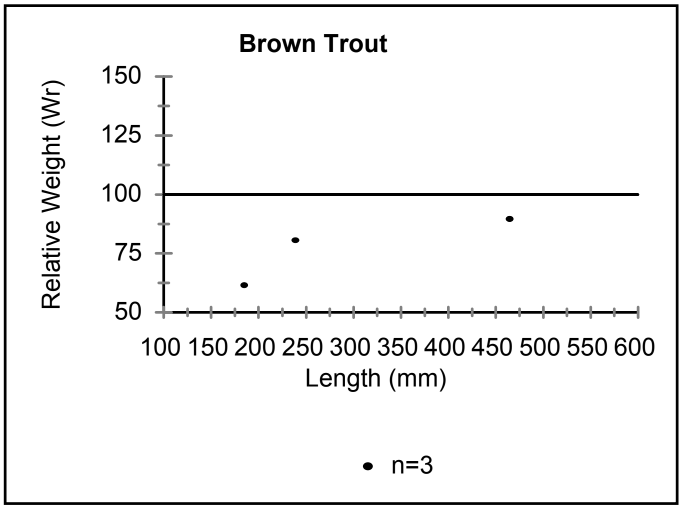

Figure 20. Relative weight (Wr) of brown trout sampled at Eloika Lake (Spokane County) in May 2000 compared to the national 75th percentile.

Tench

Eloika Lake tench sampled ranged in length from 107 to 470 mm total length (Table 5). The tench population is apparently reproducing in the lake as evidenced by multiple year-classes sampled (Figure 21). No condition or age analysis was completed for this species.

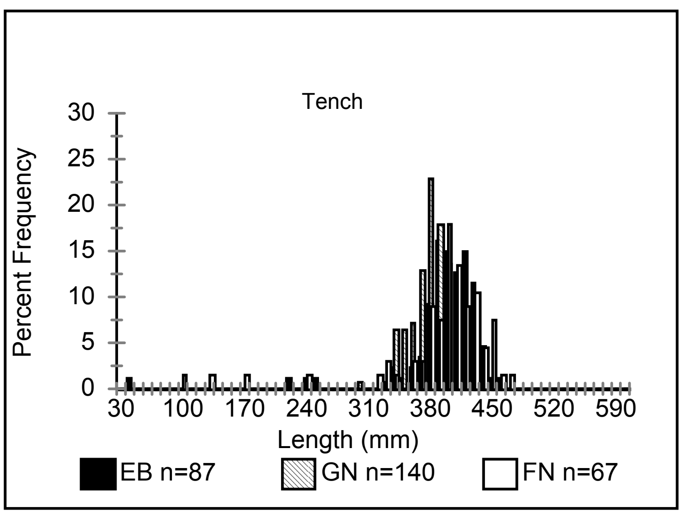

Figure 21. Length frequency distribution of tench sampled at Eloika Lake (Spokane County) in May 2000 by boat elecrofishing (EB), gill netting (GN), and fyke netting (FN).

Discussion

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

At the time of this survey, Eloika Lake largemouth bass population indices exhibited characteristics of a predator crowded community. Densities of young bass were high and their relative weight was low indicating intense intra- and/or inter-specific competition for available food resources. Stock density index values of PSD and RSD were within or near textbook objective ranges for a panfish management option which calls for a dense predator population to control stunting of panfish species (Anderson and Neuman 1996). However, considering that actual objective ranges for lakes in Washington may be somewhat lower than those recommended for southern and midwestern lakes, Eloika Lake's largemouth bass population should likely be considered quality compared to most Washington lakes.

Panfish species, including black crappie, yellow perch, and pumpkinseed sunfish, were all characterized by high growth rates and stock density indices characteristic of populations in a community managed for quality panfish. The high proportion of pumpkinseed sunfish sampled greater than quality-length, as indicated by length frequency distribution and PSD, may be an indication of variable year-class strength or high predation of young fish by largemouth bass and possibly grass pickerel. If predation is controlling the numbers in the population, it may facilitate the excellent growth of individuals that avoid predation by reducing intraspecific competition. Overall, Eloika Lake has one of the highest quality pumpkinseed sunfish populations observed to date in Washington. During our survey, anglers were observed readily harvesting pumpkinseed sunfish in the 170 to 190 mm (6.5 to 7.5 inches) size range. The presence of grass pickerel, a member of the pike family, in the fish community may contribute to the quality of panfish populations by contributing to the overall predation on young fish; thereby minimizing the potential for reduced panfish growth rates and condition.

Brown trout sampled were of varying size classes and apparently offer some opportunity for quality trout angling. Brown trout appear to be more desirable in warmwater fisheries management schemes than rainbow trout due to their piscivorus nature and their ability to survive in warmer water. Brown trout more readily prey on panfish species which may contribute to the quality of panfish in the lake. Additionally, brown trout are more likely to grow to large size by utilizing panfish as prey. The extent of competition between stocked brown trout and naturally reproducing predator populations in the lake is unknown. Under the current management program, brown trout offer anglers a unique opportunity to catch fish of quality length. However, it is unlikely that anglers will harvest limits of these fish considering the low stocking rate.

Rainbow trout were sampled at low levels. The condition of rainbow trout sampled was poor. No fish of larger size were sampled indicating low carryover to larger size fish in the lake. No record of recent rainbow trout stocking in Eloika Lake by WDFW exists; however, they are stocked in lakes upstream including Fan, Sacheen, and Diamond. It is most likely that the rainbow trout we sampled were immigrants from other populations. Eloika Lake rainbow trout are likely to offer only limited angling opportunity. Considering the low condition of rainbow trout observed, high summer water temperatures, shallow mean depth, and the presence of numerous panfish, it is unlikely that rainbow trout would offer much additional recreational opportunity.

Tench comprised the largest proportion of the sample by weight and should be considered an important player in the Eloika Lake fish community. This introduced minnow likely competes with warmwater fish game fish species for food resources, but may be preyed upon by largemouth bass (Wydoski and Whitney 1979). The actual effect of tench introductions in Washington has not been measured. Tench were originally imported from Europe, where it is highly regarded as a sport fish, and introduced in many states, including Washington, during the late 1800's by the U.S. Fish Commission for food and as a sport fish (Baughman 1947). Records show that tench were stocked into several Spokane area lakes, including Diamond Lake upstream of Eloika, at that time. The species now inhabits the Columbia River and the Spokane River as well (Wydoski and Whitney 1979). Today this species is typically considered undesirable by fisheries managers in the United States who now favor other species. The removal of tench from some local lakes using rotenone has been used to reduce interspecific competition with more desirable game fish species. Considering the connectivity of Eloika Lake to other waters, removing tench from the fish community using chemical or biological controls is likely unfeasible.

Management Considerations

Slot-limit Regulation Monitoring

As the 12-17 inch slot-limit on largemouth bass was implemented in May 1999, the indices of population structure from this spring 2000 survey are likely representative of the population under the previous regulation. Therefore, this survey may serve as a baseline for documenting changes in the Eloika Lake fish community under the new, more restrictive regulation. Considering this, management biologists should consider developing a long-term monitoring plan to document any changes in the fish community over time. Objectives of such a program should focus on documenting changes in largemouth bass population density, changes in largemouth bass population structure with a particular interest in the number of fish greater than quality-length (300 mm), and changes in panfish population structures possibly due to increased predation by largemouth bass. Additionally, creel survey data should be collected regularly to evaluate angler compliance.

Creel Survey

Warmwater fisheries surveys can provide management biologists useful information on the state of a fish community; however, they provide only circumstantial evidence as to the effects of angler harvest. Detailed and well planned creel surveys can provide more conclusive information. Creel surveys can provide information on fishing effort, angler catch per unit effort (e.g., # fish/hour fishing), and numbers of fish caught or harvested. Creel surveys can also be used to determine angler preferences with regard to management actions, regulations, as well as species and sizes of fish desired (Hahn et al. 1993).

Biological information collected from the anglers creel can provide information not typically colleted during standard surveys. As it is the preference of WDFW biologists to return sampled fish back to the lake alive when conducting surveys, information collected from fish retained by anglers can be collected without killing fish. For example, otoliths collected from dead fish are very accurate when determining fish age.

Creel survey objectives for Eloika Lake should include documenting fishery utilization throughout the year, angler catch per unit effort, and angler preferences. Otoliths should be collected from dead fish retained by anglers for more definitive aging of warmwater populations in the lake. Over time, creel information should aid management biologists in evaluating whether or not current regulations are effectively working to achieve current fishery objectives.

Aquatic Vegetation

Aquatic vegetation offers important foraging, spawning, and refuge habitat for warmwater fish communities (Willis et al. 1997). Shifts in the composition and balance of the warmwater fish community are likely following the altering of aquatic vegetation levels (Bettoli et al. 1993). Studies have shown that intermediate levels of aquatic vegetation are desirable for thriving warmwater fish communities (Savino and Stein 1982; Durocher et al. 1984; Wiley et al. 1984; Dibble et al. 1996; Olson et al. 1998). Some species may benefit from the removal of aquatic plants in lakes with high plant densities. Crappie growth can be impaired in lakes densely populated with aquatic plants (Maceina and Shireman 1982). The condition of certain age classes of largemouth bass and bluegill has been reported to improve following the mechanical removal of aquatic plants in lakes with dense aquatic vegetaion (Colle and Shireman 1980; Olson et al. 1998). Too much aquatic vegetation reduces the forage efficiency of largemouth bass by forming a visual barrier between bass and forage fish (Savino and Stein 1982). Bettoli et al. (1992) reported that young bass especially benefitted by reductions in aquatic vegetation abundance as their diet became more piscivorus earlier at a smaller size. This allowed young bass to grow more in the first year of life, enabling them to better survive their first winter. On the other hand, too little aquatic vegetation is not optimal.

With regard to Eloika Lake's aquatic vegetation, it is interesting to note that lakes with dense aquatic vegetation often support stunted pumpkinseed sunfish populations as predation by largemouth bass is unable to adequately control their numbers. Wiley et al. (1984) suggested that bluegill sunfish production would increase with an increase in aquatic vegetation density. Although the total biomass of sunfish in lakes with dense aquatic vegetation was high, the quality of fish available to anglers was low due to high interspecific competition of available resources. Considering the dense vegetation found in Eloika Lake, it would not be surprising to find a stunted sunfish population; however, the results of this survey suggest that stunting is not a problem in the lake. One hypothesis that deserves investigation is that predation by grass pickerel, a predator not found in most Washington lakes, may be sufficient to control stunting in lakes with dense aquatic vegetation. Northern pike (*Esox lucius*), a larger related piscivorus species, has been reported to prey effectively regardless of plant density (Savino et al. 1985).

Residents and lake users of Eloika Lake have expressed concern about the high density of aquatic vegetation that develops during summer months. Best visual estimate data shows that submergent aquatic vegetation covers from 75 - 90% of the lake at peak times. The major complaint from lake residents and users has been the difficulty of boating on the lake in summer. However, some bass fishermen have expressed that they like the weeds as it keeps traffic down on the lake. These anglers have simply altered fishing techniques to be successful during periods of high weed density.

Removing vegetation from lakes for boating, water sports and aesthetics is often manageable; however, the effects on fish communities are complex and not always predictable. Although some species may benefit from reductions in plant abundance, other species may not (Bettoli et al. 1993). Aquatic vegetation control plans should include careful consideration of potential impacts to all fish and wildlife species.

A well planned and executed plant control program could improve the quality of boating, the warmwater fish community, and the overall sportfishing opportunity at Eloika Lake (Engel 1995). Many techniques are used to control aquatic weeds including chemical, mechanical, and biological controls (Summerfelt 1999). Considering that Eloika Lake is not a closed system, but connected directly to the Little Spokane River via its west branch, aquatic vegetation management options are limited to mechanical or possibly chemical methods. Biological aquatic weed controls, such as introducing grass carp (*Ctenopharyngodon idella*), are not feasible. Controlling plants in Eloika Lake may require a combination of mechanical and chemical methods. It is important to consider that the benefits of aquatic plant control measures can be short lived and annual treatment efforts are required (Pothoven et al. 1999). A comprehensive aquatic plant management plan with specific objectives should be developed in a cooperative effort by lakeside residents, lake users, and management agencies.

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