1999 Lower Goose Lake Warmwater Survey Grant County, Washington

by

Marc R. Petersen, Randall S. Osborne, and Chad S. Jackson
Warmwater Fish Enhancement Program
Washington Department of Fish and Wildlife
1550 Alder Street NW
Ephrata, Washington 98823

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Abstract

Lower Goose Lake, Grant County, Washington, was surveyed between October 6 - 20, 1999 using a boat electrofisher, gill nets, and fyke nets. Lower Goose Lake was rehabilitated April 1, 1997, and since was planted with largemouth bass (*Micropterus salmoides),* bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), channel catfish (*Ictalurus punctatus*), rainbow trout (*Oncorhynchus mykiss*), and Lahontan cutthroat trout (*O. clarki henshawi*). Seven additional fish species were found in our survey that had either survived the 1997 rehabilitation, or entered the lake via inflow from Upper Goose Lake or the West Canal. Largemouth bass growth and condition was above average with a proportional stock density (PSD) value of 66. Overall, largemouth bass appear to have plenty of forage and are in condition above the national average. Bluegill growth and condition were found to be at or above average. Age 1 bluegill were the only age represented in our samples. Stock length bluegill (age 1) exhibited faster growth than expected. Black crappie density was low (n = 11); however, 238 young-of-the-year black crappie were collected, indicating successful reproduction had occurred. Yellow perch were found in high numbers. PSD for yellow perch was high (59), growth was above average, while condition was slightly below the national average. Yellow perch were found to age two and natural reproduction is occurring in Lower Goose Lake. We recommend a follow-up warmwater fish survey in two to three years, monitoring the yellow perch population, and periodic carp removal by electrofishing.

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Introduction and Background

Lower Goose Lake lies among the seep lakes in Grant County approximately 14.5 kilometers (9 miles) northwest of the City of Othello, Washington, and approximately 5.6 kilometers (3.5 miles) south of Potholes Reservoir (Figure 1). Water is supplied to Lower Goose Lake from two sources; intermittent discharge from Upper Goose Lake and irrigation return water via the West Canal. Water flows southerly from Lower Goose Lake into Black Lake and eventually into Crab Creek. Land surrounding the lake is owned exclusively by the Washington Department of Fish and Wildlife (WDFW) and is characterized by steep rolling hills with deeply eroded basaltic scablands and cliffs. Lower Goose Lake has a surface area of 20.2 hectares (50 acres), mean depth of 7.7 meters (25.1 ft.), and volume of 1,885 acre ft.

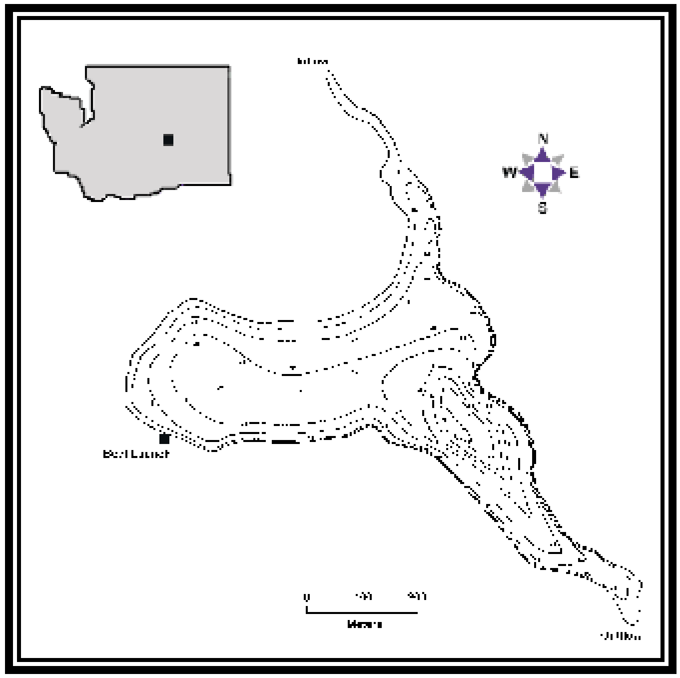

Figure 1. Map of Lower Goose Lake (Grant County).

Historically, Lower Goose Lake has been primarily managed for warmwater species. However, WDFW stocked the lake with coho salmon (*Oncorhynchus kisutch*) and rainbow trout (*O. mykiss*) in the late 1960's and early 1970's to provide additional angling opportunity. Alternative management projects were identified in 1976 to eliminate undesirable fish species, severe water level fluctuations, and turbidity caused by irrigation runoff (WDFW 1976). The first alternative was to re-route surface irrigation flows from the West Canal to Royal Lake, approximately 6 miles away, at a cost of $695,000. Alternative 2 identified modifying existing Columbia Basin Project structures and adding additional right-of-ways through irrigated lands at a cost of $2,155,000. Alternative 3 identified improving the existing wasteway and Crab Creek Lateral Canal to intercept the West Canal. Cost of this alternative was not identified, but was expected to be greater than alternative 2. Because of the inability to isolate the lake's waters from the irrigation system, WDFW management efforts have been hindered and proposed projects to accomplish this isolation have failed because of the high cost involved.

Rehabilitation efforts by WDFW in 1954 and 1970 were only marginally successful, and the lake became infested with common carp (*Cyprinus carpio*) and pumpkinseed (*Lepomis gibbosus*) following each attempt. Lower Goose Lake was last rehabilitated on April 1, 1997 in another attempt to control carp and pumpkinseed (WDFW 1997). Personnel from WDFW observed yellow perch

(*Perca flavescens*), common carp, sculpin (*Cottus spp*.), brown bullhead (*Ictalurus nebulosus*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), walleye (*Stizostedion vitreum*), pumpkinseed sunfish, and rainbow trout during that treatment. Several largemouth bass and walleye were salvaged and transported to other area waters. Since the 1997 rehabilitation, WDFW stocked Lower Goose Lake with black crappie, largemouth bass, channel catfish (*I. Punctatus*), bluegill (*L. macrochirus*), Lahontan cutthroat trout (*O. clarki henshawi*), and rainbow trout (Table 1). Although previous rehabilitations reduced numbers of carp and pumpkinseed, replacement fish were not acquired in sufficient numbers and/or sizes to replace the biomass previously occupied by those undesirable species. Gamefish populations, such as largemouth bass and bluegill, did not become established prior to the re-infestation of carp and pumpkinseed through the irrigation system and the fish communities in the lake became out of balance within several years. Currently, all fish species are managed under general statewide fishing regulations and anglers are allowed to fish the lake throughout the entire year.

Table 1. Fish stocked in Lower Goose Lake between spring 1997 and fall 1999 (prior to warmwater fish survey, October 6-20).

Year	Species	Size	Number
1997	largemouth bass	fry	12,173
	black crappie	adults	200
		fry	3,168
	bluegill	fry	3,040
	channel catfish	fingerlings	2,508
1998	largemouth bass	sub-adults	278
	channel catfish	fingerlings	2,002
	rainbow trout	catchables	287
		advanced fingerlings	2,502
	Lahontan cutthroat	fingerlings	2,016
1999	black crappie	fry	2,453
	bluegill	adults	500
		fry	37,562

In addition to fish species, Lower Goose Lake and drainage hosts various birds, such as great blue heron (*Ardea herodias*), gulls (*Larus spp.*), terns (*Sterna spp.*), Canada geese (*Branta cacadensis*), mallard (*Anas platyrhynchos*), blue winged teal (*Anas discors*), cinnamon teal (*Anas cyanoptera*), pheasant (*Phasianus colchicus*), California quail (*Lophortyx californicus*), chukar (*Alectoris graeca*), and small mammals including beaver (*Castor canadensis*) and raccoon (*Procyon lotor*) (WDFW 1976). Various aquatic (water milfoil *Myriophyllum spp.*), sub-aquatic (cattail *Typha latifolia* and bulrush *Scirpus spp.*), and terrestrial (Russian olive *Elaeagnus angustifolia*, sagebrush *Artemisia tridentata*, bluebunch wheatgrass *Agropyron spicatum*, cheatgrass *Bromus tectorum*, Sandberg's bluegrass *Poa sandbergii*, sand dock *Rumex spp*., and rabbitbrush *Chrysothamnus nauseosus*) vegetation are common in the area.

Methods and Materials

Lower Goose Lake was surveyed by a three-person team October 6 - 20, 1999. All fish were collected using a boat electrofisher, gill nets, and fyke nets. The electrofisher unit consisted of a 5.5 m (18 ft.) Smith-Root GPP electrofisher boat with a DC current of 120 cycles/sec at 3 to 4 amps power (Bonar et al. 2000). Experimental gill nets (45.7 m x 2.4 m) of variable size (13, 19, 25, and 51 mm stretched) monofilament mesh. Fyke nets were constructed of a main trap (four 1.2 m aluminum rings), a single 30.3 m lead, and two 15.2 m wings. All netting material was constructed of 13 mm nylon mesh.

Sampling locations were selected by dividing the shoreline into 400 m sections determined from a map. The number of randomly selected sections surveyed are as follows: electrofishing - 8, gill netting - 4, and fyke netting - 4. Electrofishing occurred in shallow water (depth range: 0.2 - 1.5 m), adjacent to the shoreline at a rate of approximately 18.3 m/minute for 600 second intervals (Bonar et al. 2000). Gill nets were set perpendicular to the shoreline with the small-mesh end attached on or near the shore and the large-mesh end anchored offshore. Fyke nets were set perpendicular to the shoreline with the wings extended at 70° angles from the lead. Gill nets and fyke nets were set overnight prior to electrofishing and were pulled the following morning (1 net night each). All sampling was conducted during night-time hours when fish are most numerous along the shoreline thus maximizing the efficiency of each gear type.

All fish were identified to species, measured in millimeters (mm) to total length (TL) from the anterior most part of head to the tip of the compressed caudal fin, and weighed to the nearest gram (g). Total length data was used to construct length-frequency histograms and to evaluate the size structure of the warmwater species in the lake. Warmwater fish species were assigned to a 10 mm size group based on total length, and scale samples were collected from the first five fish in each size group (Bonar et al. 2000). Scale samples were mounted on adhesive data cards and pressed onto acetate slides using a Carver® laboratory press (Fletcher et al. 1993).

Water quality data was collected at 1 meter (m) increments from the area of greatest depth. A Hydrolab® was used to collect information on dissolved oxygen (milligrams per liter)(mg/l), temperature (degrees Celsius)(EC), pH, conductivity (micro siemens per centimeter)(FS/cm), and turbidity (nephelometric turbidity units)(NTU).

Species composition, by weight in kilograms (kg) and number, was determined from fish captured. Fish less than one year old, i.e., young-of-the-year (YOY), were excluded from all analyses. Eliminating YOY fish prevents distortions in analyses that may occur due to sampling location, method, and specific timing of hatches (Fletcher et al. 1993).

Catch per unit effort (CPUE) of each sampling gear was determined for each warmwater fish species collected. The CPUE of electrofishing was determined by dividing the number of fish captured by the total amount of time electrofished. Similarly, CPUE of gill nets and fyke nets was determined by dividing the number of fish captured by the total time that the nets were deployed. Since CPUE is standardized, it can be useful in comparing catch rates between lakes or between sampling dates on the same water.

A relative weight (W_r) index was used to evaluate the condition of fish in Lower Goose Lake. As presented by Anderson and Neumann (1996), a W_r of 100 generally indicates that the fish is in a condition similar to the national average for that species and length. The index is defined 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 was derived from a standard weight-length ($\log_{10}$) relationship which was defined for each species of interest in Anderson and Neumann (1996). Minimum lengths were used for each species as the variability can be significant for small fish (YOY). Relative weights less than 50 were also excluded from our analyses as we suspected unreliable weight measurements.

Age and growth of warmwater species in Lower Goose Lake were evaluated using procedures described by Fletcher et al. (1993). All samples were evaluated using both the direct proportion method (Fletcher et al. 1993) and Lee's modification of the direct proportion method (Carlander 1982). Mean back-calculated lengths-at-age for all warmwater species were then compared to those of Eastern Washington and/or statewide averages (Fletcher et al. 1993), and Minnesota averages (walleye only) (Carlander 1997).

The proportional stock density (PSD) of each warmwater fish species was determined following procedures outlined in Anderson and Neumann (1996). PSD uses two measurements, stock length and quality length, to provide information about the proportion of various size fish in a population. Stock length is defined as the minimum size of a fish which provides recreational value or approximate length when fish reach maturity (Table 2). Quality length is the minimum size of a fish that most anglers like to catch or begin keeping (Table 2). PSD is calculated using the number of quality sized fish, divided by the number of stock sized fish, multiplied by 100. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths (Anderson and Weithman 1978). Stock length is 20-26 percent of the world record length, whereas quality length is 36-41 percent of the world record length.

Relative stock density (RSD) of each warmwater fish species was examined using the five-cell model proposed by Gabelhouse (1984). In addition to stock and quality lengths, the Gabelhouse model adds preferred, memorable, and trophy categories (Table 2). Preferred length (RSD-P) is defined as the minimum size of fish anglers would prefer to catch. Memorable (RSD-M) length refers to the minimum size fish anglers remember catching, and trophy length (RSD-T) refers to the minimum size fish worthy of acknowledgment. Preferred, memorable, and trophy length fish were also based on percentages of world record lengths (Anderson and Weithman 1978).

Table 2. Minimum total length (mm) categories of warmwater fish used to calculate PSD and RSD values (Willis et al. 1993).

	Length Category				
Species	**Stock**	**Quality**	**Preferred**	**Memorable**	**Trophy**
black crappie	130	200	250	300	380
white crappie	130	200	250	300	380
bluegill	80	150	200	250	300
yellow perch	130	200	250	300	380
largemouth bass	200	300	380	510	630
smallmouth bass	180	280	350	430	510
walleye	250	380	510	630	760
channel catfish	280	410	610	710	910
brown bullhead	150	230	300	390	460
yellow bullhead	150	230	300	390	460

Preferred length was 45-55 percent of world record length, memorable length is 59-64 percent of world record length, and trophy length is 74-80 percent of world record length. RSD differs from PSD in that it is more sensitive to changes in year class strength. RSD is calculated as the number of fish within the specified length category, divided by the total number of stock length fish, multiplied by 100. Eighty percent confidence intervals for PSD and RSD were selected from tables in Gustafson (1988).

Results/Discussion

Species Composition

We found 13 different species in our samples, of which only six have been intentionally planted since Lower Goose was rehabilitated in 1997. Yellow perch were the most abundant species (n = 279) and accounted for the second highest percent biomass (26.48) in our samples (Table 3). Largemouth bass accounted for the highest percent biomass (26.90) and were the fifth most abundant species collected (n = 783). A few species (i.e., Lahontan cutthroat, channel catfish, longnose sucker (*Catostomus catostomus*), walleye) were represented in low numbers in our samples. Yellow perch YOY accounted for the highest percent biomass (59.22) and number (n = 1,831) of all YOY fish observed (Table 4). Largemouth bass accounted for the second highest number (n = 873) and second highest percent biomass (42.74) among YOY fish.

All fish species were sampled in proportions relative to which they were planted. The overall number sampled was low in comparison to the number stocked. Most notably, 41,102 bluegill and 12,451 largemouth bass were stocked prior to our survey of which 265 and 66 were found in our samples, respectively (Table 1 and 3). Largemouth bass and bluegill were predominantly stocked as fry, which exhibit high mortality, and may explain the low numbers found in our samples. Given the fact that Lower Goose Lake was recently rehabilitated, and 100% of the shoreline was sampled by electrofishing, we would have expected to find higher numbers of stocked fish. Angler exploitation is not likely a factor in the low numbers of stocked fish observed, as few of the fry stocked in 1997, 1998, or 1999 would be expected to reach quality size until age 2 or 3.

Table 3. Species composition by weight, number, and size range of fish captured at Lower Goose Lake during a warmwater fish survey in October 1999.

	Species Composition					
	Weight		Number		Size Range (mm TL)	
Type of Fish	kg	%	No.	%	Min	Max
black crappie	2.14	1.89	11	1.22	211	265
bluegill	5.94	5.24	265	29.48	56	157
pumpkinseed sunfish	2.17	1.91	129	14.35	45	153
largemouth bass	30.48	26.90	66	7.34	222	353
walleye	11.31	9.99	11	1.22	205	592
yellow perch	30.00	26.48	279	31.03	160	282
channel catfish	2.79	2.46	4	0.44	194	515
brown bullhead	7.80	6.88	67	7.45	140	255
rainbow trout	5.02	4.43	6	0.67	369	449
Lahontan cutthroat	1.19	1.05	1	0.11	512	512
longnose sucker	0.86	0.75	1	0.11	414	414
carp	12.67	11.18	7	0.78	200	610
sculpin (*Cottus spp.*)	0.94	0.83	52	5.78	17	172

Table 4. Species composition by weight, number, and size range of YOY fish captured at Lower Goose Lake during a warmwater fish survey in October 1999.						
	Species Composition					
	Weight		Number		Size Range (mm TL)	
Type of Fish	kg	%	No.	%	Min	Max
black crappie	1.22	5.13	238	8.26	35	92
bluegill	0.02	0.08	15	0.52	30	46
largemouth bass	8.47	35.57	798	27.69	48	162
yellow perch)	14.11	59.22	1831	63.53	59	127

Catch per unit Effort (CPUE)

Catch rates by electrofishing were much higher for all species, except yellow perch and walleye, for which gill nets were most effective (Table 5). This was expected as electrofishing is more effective at sampling fish species which inhabit the litoral zone. Conversely, larger sized yellow perch and walleye are more commonly found in the pelagic zone which is more effectively sampled by gill nets. Fyke nets were more effective capturing small fish found along the shoreline, and did not aide in collecting larger sized fish than electrofishing or gill nets in the Lower Goose Lake survey. We collected approximately 1,700 fish using fyke nets; however, the majority were young-of-the-year (YOY) and were not included in most analyses. Overall, confidence intervals were high on many fish species indicating a high degree of variability exists in CPUE. This may be explained in part by the low number of fish sampled in Lower Goose Lake. Electrofishing captured similar sized fish as gill nets or fyke nets for most species; however, gill nets captured yellow perch more effectively than electrofishing.

Table 5. Mean catch per unit effort by sampling method (excluding YOY), including 80% confidence intervals, for fish collected from Lower Goose Lake in October 1999.									
	Gear Type								
	Electrofishing			Gill Netting			Fyke Netting		
Species	No. Hour	CI (+/-)	No. Sites	No. Night	CI (+/-)	Net Nights	No. Night	CI (+/-)	Net Nights
black crappie	5.24	2.69	8	0.00	—	4	1.00	0.52	4
bluegill	136.13	56.02	8	0.50	0.37	4	5.50	5.79	4
pumpkinseed sunfish	50.86	13.95	8	1.00	0.74	4	4.25	5.45	4
largemouth bass	39.68	29.28	8	4.25	2.42	4	0.00	—	4
walleye	0.00	—	8	2.00	2.16	4	0.00	—	4
yellow perch	26.84	19.61	8	61.25	30.67	4	0.00	—	4
channel catfish	0.00	—	8	0.25	0.32	4	0.00	—	4
brown bullhead catfish	25.37	13.45	8	7.50	7.18	4	0.25	0.32	4
rainbow trout	2.24	1.40	8	0.75	0.32	4	0.00	—	4
Lahontan cutthroat	0.00	—	8	0.25	0.32	4	0.00	—	4
longnose sucker	0.00	—	8	0.25	0.32	4	0.00	—	4
carp	2.25	2.02	8	0.25	0.32	4	0.00	—	4
sculpin	32.16	6.83	8	0.00	—	4	2.25	2.88	4

Stock Density Indices

Proportional Stock density (PSD) values were high (100%) for black crappie, rainbow trout, and walleye; however, the number of stock length fish is too low for an accurate analysis (Table 6). Stock length bluegill were found in high numbers but the PSD value was low. Since many of the bluegill stocked following the 1997 rehabilitation were stocked as fry, high numbers of stock length fish and low PSD values were expected at the time of our survey (Table 1). Stock length largemouth bass were found in moderate to low numbers with a high PSD (Table 6). The stock length largemouth bass and high PSD value was likely a result of the 278 sub-adult bass stocked in 1998. While the number of age 2 largemouth bass (n = 3) evaluated for age and growth was low, available data suggests that largemouth bass fry stocked in 1997 would not have recruited to stock size at the time of our survey. Stock length yellow perch were found in high numbers with high PSD values. Yellow perch were not stocked in Lower Goose following the 1997 rehabilitation and were not expected in high numbers. The presence of age 2 and 3 yellow perch in our samples indicate these fish survived the 1997 rehabilitation and/or entered the lake following the rehabilitation (Table 10). We did not find any fish with RSD-M (memorable) or RSD-T (trophy) values in our samples, which was expected based on stocking records and rehabilitation efforts (Table 1 and 6).

Table 6. Stock density indices, including 80% confidence interval, for warmwater fishes collected by electrofishing, gill netting, fyke netting, and combined gear types from Lower Goose Lake (Grant County) during October 1999. PSD = proportional stock density, RSD = relative stock density, RSD-P = relative stock density of preferred fish, RSD-M = relative stock density of memorable fish, and RSD-T = relative stock density of trophy fish.

Species	# Stock Length	PSD	RSD-P	RSD-M	RSD-T
		Electrofishing			
black crappie	7	100	14 ± 17	0	0
bluegill	182	1 ± 1	0	0	0
pumpkinseed sunfish	68	3 ± 3	0	0	0
largemouth bass	53	66 ± 8	0	0	0
yellow perch	36	44 ± 11	8 ± 6	0	0
		Gill Netting			
bluegill	2	0	0	0	0
pumpkinseed sunfish	4	0	0	0	0
largemouth bass	17	71 ± 14	0	0	0
walleye	8	100	50 ± 23	0	0
yellow perch	245	29 ± 4	0	0	0
		Fyke Netting			
black crappie	4	100	0	0	0
bluegill	22	0	0	0	0
pumpkinseed sunfish	17	0	0	0	0

Water Chemistry

As with many lakes throughout the Columbia Basin, dissolved oxygen levels in Lower Goose Lake varied greatly and were only in the acceptable range for good health and vigorous growth of warmwater species in the top 10 m of the water column (Table 7). Most fish species require 5 ppm oxygen, but can tolerate levels as low as 1 or 2 ppm for short periods before becoming stressed and cease feeding (Willis et al. 1990). Slightly lower than desirable pH levels were found in the first 11 m of the water column with more desirable levels below 12 m. Desirable pH levels for warmwater fish are between 6.5 and 9 (Swingle 1969). Low dissolved oxygen levels below 11 m would likely prevent fish from inhabiting depths, for prolonged periods of time, where more desirable pH levels were observed.

Table 7. Water quality data from Lower Goose Lake collected during a warmwater fish survey in October 1999.

Location	Depth (m)	Temp (EC)	pH	Dissolved O2	Conductivity
Center Lake	Surface	13.1	4.36	11.19	251
	1	13.0	4.36	10.91	253
	2	13.0	4.34	10.76	253
	3	12.9	4.34	10.64	257
	4	12.9	4.33	10.52	254
	5	13.1	4.34	10.47	255
	6	12.9	4.34	10.44	258
	7	12.8	4.34	10.35	252
	8	12.8	4.34	9.83	261
	9	12.7	4.36	9.47	255
	10	12.5	4.37	9.36	255
	11	11.2	4.50	0.55	486
	12	9.2	6.47	0.40	518
	13	8.6	6.80	0.36	526
	14	8.4	6.85	0.31	532
	15	8.2	7.01	0.29	536
	16	8.2	6.81	0.26	539
	17	8.1	6.87	0.25	547
	18	8.0	6.79	0.24	555
	19	7.9	6.91	0.22	572
	20	7.9	6.90	0.22	582
	21	7.8	6.98	0.21	621
	22	7.8	6.9	0.21	622
	23	7.7	7.2	0.20	9,300
	24	7.5	7.47	0.20	15,300
	25	7.6	7.71	0.20	25,300
	26	7.7	7.93	0.22	33,500
	27	7.9	8.04	0.20	38,600
	27.5	8.1	8.63	0.15	41,600

A thermocline was identified between 10 and 13 m of depth and was indicated by a change in temperature of 1°C per meter of depth (Goldman and Horne 1983). The presence of a thermocline is an indication of resistance to vertical mixing within the water column, and most likely explains why dissolved oxygen levels below 10 m were low. Additionally, a chemocline likely exists between 22 and 23 m of depth. Chemoclines occur after the onset of thermal stratification when nutrients accumulate and become trapped in denser water below the thermal barrier. The increase in pH and conductivity observed at 23 m and below suggest a chemocline existed in Lower Goose Lake during the time of our survey. The thermocline and chemocline observed in Lower Goose Lake is unlikely to effect good health and growth of warmwater fish populations as most inhabit the litoral zone where chemicals are well mixed by wind action and convection.

Largemouth Bass

Ages of largemouth bass ranged from 1 to 4, with age 3 being the most abundant of those fish analyzed for age and growth (Table 8). Assessment of age 2 and 4 largemouth bass was difficult given the low number found in our survey. With the exception of age 1 and 2 fish, overall mean growth of largemouth bass was above average when compared to the Eastern Washington average. However, growth of age 1 largemouth bass from the 1998 year class (98.5mm) and age 2 fish from the 1997 year class (166.3), those fish stocked as fry (Table 1) or naturally reproduced, were above the Eastern Washington average and only reflected growth achieved in Lower Goose Lake. Overall means included 1995 and 1996 year class back-calculations, which represented growth achieved in waters from which they were collected prior to stocking in Lower Goose lake. This explains the below average mean growth for all back-calculated age 1 and 2 largemouth bass. Largemouth bass fry were not stocked in Lower Goose Lake in 1998, indicating age 1 bass observed in our samples were from natural reproduction. We observed 3 age 2 largemouth bass in our samples, which was considered low given 12,173 fry were stocked in Lower Goose Lake in 1997.

Lengths (TL) of largemouth bass collected from Lower Goose Lake ranged from 222 mm to 350 mm (Figure 2). Relative weights for largemouth bass were above average and remained above average as the fish grew (Figure 3). Largemouth bass PSD was high (66%). A high PSD value combined with above average growth and condition may be due to the population being below it's carrying capacity suggesting recruitment of largemouth bass was low. Where recruitment is low enough that populations remain below their carrying capacity, PSD values can be high (Willis et al. 1993). Additionally, the stocking of 278 sub-adult largemouth bass (primarily age 3) in 1998 likely inflated the PSD value. As the number of largemouth bass recruiting to stock size increases through natural reproduction or stocking, PSD values would be expected to decrease. However, Lower Goose lake is currently managed with a slot limit for largemouth bass (5 bass, less than 12", no more than 1 over 17" retained), and if angler exploitation of stock length bass is high, PSD values may remain high. We collected many young-of-the-year largemouth bass (n = 798) in our samples indicating that reproduction of largemouth bass was successful in 1999. The number of YOY largemouth bass observed in 1999 would be expected given spawning occurred from stocked bass just reaching maturity.

Table 8. Age and growth of largemouth bass captured at Lower Goose Lake during October 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded 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**
1998	12	98.5			
		109.8			
1997	3	56.2	166.3		
		72.1	174.2		
1996	34	31.1	97.6	239.4	
		49.2	111.5	244.7	
1995	1	66.6	181.2	233.6	274.7
		82.6	190.5	239.8	278.4
Overall mean		49.5	105.2	239.2	274.7
		65.8	118.5	244.6	278.4
E. Washington Average		68.8	135.6	189.2	248.9

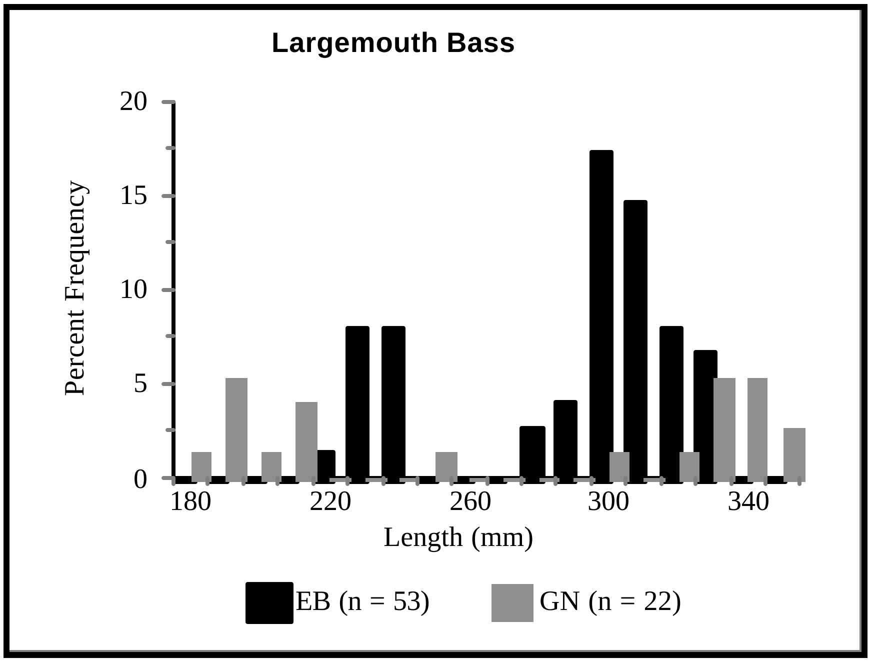

Figure 2. Length frequency of largemouth bass captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999.

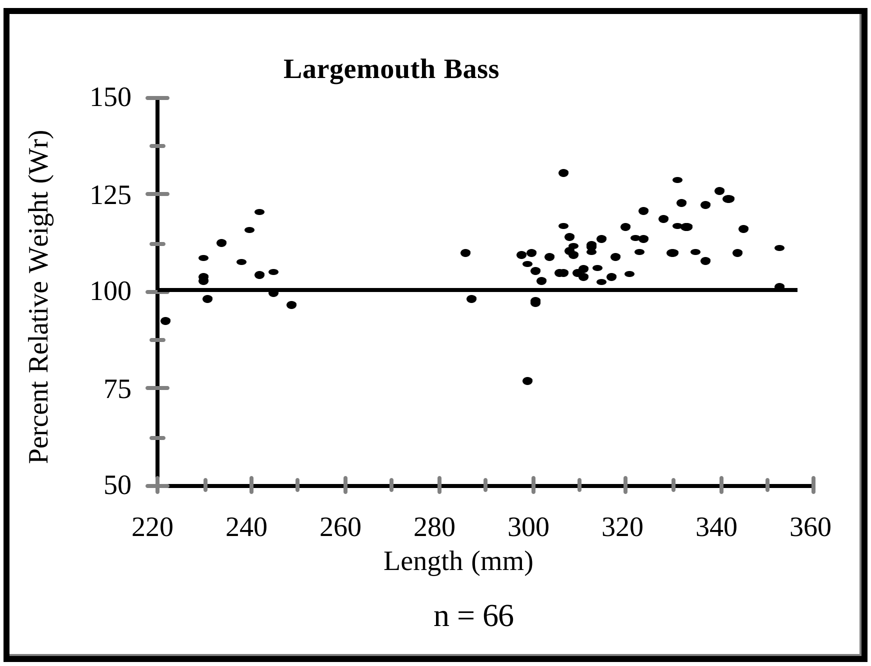

Figure 3. Relative weights of largemouth bass captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Bluegill

Growth of bluegill was below average when compared to the statewide average (Table 9). We evaluated 56 bluegill for age and growth; all were identified as age 1. While our sample size was sufficient for age 1 bluegill, a greater sampling effort may have been needed to detect the presence of age 2 fish. Age 2 bluegill were expected in our samples; 3,040 fry were stocked in 1997 following the rehabilitation, but were not observed. Stocking of bluegill did not occur during 1998, suggesting that age 2 fish were naturally reproduced, or errors occurred in age estimation. A re-evaluation of age and growth data confirmed the presence of only age 1 bluegill. Based on growth observed for age 1 bluegill, age 2 fish stocked as fry in 1997 may have reached the size of maturity during 1998. While we did not observe age 2 bluegill in our samples, stocking records suggest they may have been present.

Lengths (TL) of bluegill in Lower Goose Lake ranged from 56 mm to 157 mm (Figure 4). Age 1 bluegill were observed throughout the entire length frequency which was larger than expected for a single age class. This size differential may be explained in part by the stocking of fry from different spawn timing hatches. Relative weights of bluegill were slightly below average for fish smaller than 110 mm in length, and above average for those larger than 110 mm (Figure 5). Lower Goose Lake received bluegill plants in August 1997 (3,040 fry) and October 1999 (500 adults and 37,562 fry) (Table 1). Since Lower Goose Lake was rehabilitated in 1997, we would expect relative weights to be above average. The presence of yellow perch and pumpkinseed sunfish likely reduced forage biomass and led to below average relative weights of bluegill.

Bluegill PSD (1) was very low while the number of stock length fish was much higher (182) (Table 6). The low PSD/high stock length values were likely caused by stocked bluegill just reaching stock length size. We observed 15 young-of-the-year bluegill in our samples, but are unsure whether they are from successful spawning, or from fry plants prior to our survey.

Table 9. Age and growth of bluegill captured at Lower Goose Lake during October 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded 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**
1998	56	27.2
		42.0
Overall mean		27.2
		42.0
Statewide Average		37.3

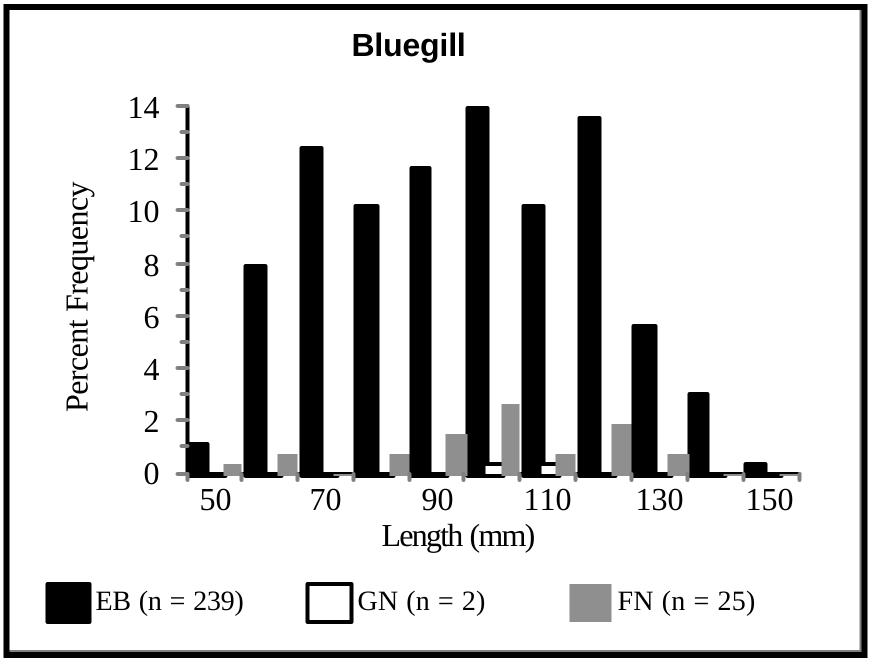

Figure 4. Length frequency of bluegill captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999.

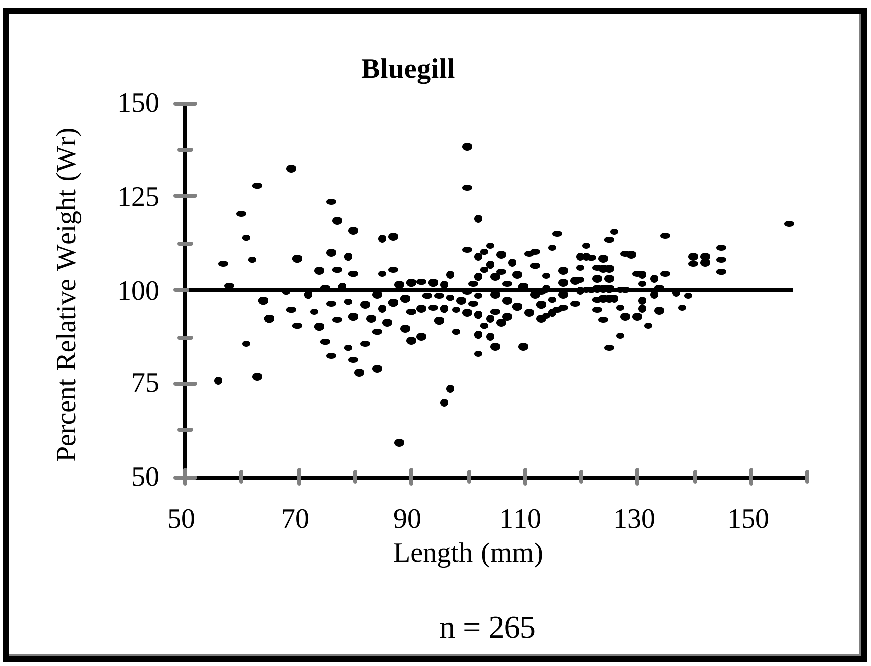

Figure 5. Relative weights of bluegill captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Yellow Perch

Ages of yellow perch ranged from 1 to 2, with age 1 being the most abundant of those fish analyzed for age and growth (Table 10). Growth of yellow perch was much better than the Eastern Washington average. Yellow perch were not stocked in Lower Goose Lake following it's rehabilitation in 1997, and most likely entered the lake from the inlet via Upper Goose Lake, or survived the rehabilitation. The presence of age 1 and 2 fish and high numbers of young-of-the-year fish (1,831) would indicate yellow perch found in Lower Goose Lake were from post-rehabilitation spawns and survival of the rehabilitation.

Lengths (TL) of yellow perch from Lower Goose Lake ranged from 150 mm to 280 mm (Figure 6). Above average growth of yellow perch may indicate these fish reared in Lower Goose Lake and are taking advantage of the plentiful food supplies and the available niche provided by the rehabilitation. Relative weights of yellow perch were below the national average and declined as the fish grow larger (Figure 7). This pattern has been observed in other lakes in the Columbia Basin (Osborne and Petersen in prep., Osborne et al. in prep.) and may be an indication that a limited food source exists for larger fish in this fast growing population. Yellow perch PSD (59) and number of stock length fish (281) were high, indicating there are plenty of desirable sized yellow perch available for angler harvest. A fast growing population with a high PSD can indicate anglers are not harvesting the available fish (Willis et al. 1993).

Table 10. Age and growth of yellow perch captured at Lower Goose Lake during October 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded 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**
1998	56	89.5	
		106.2	
1997	3	92.9	209.7
		112.2	215.6
Overall mean		89.7	209.7
		106.5	215.6
E. Washington Average		59.7	119.9

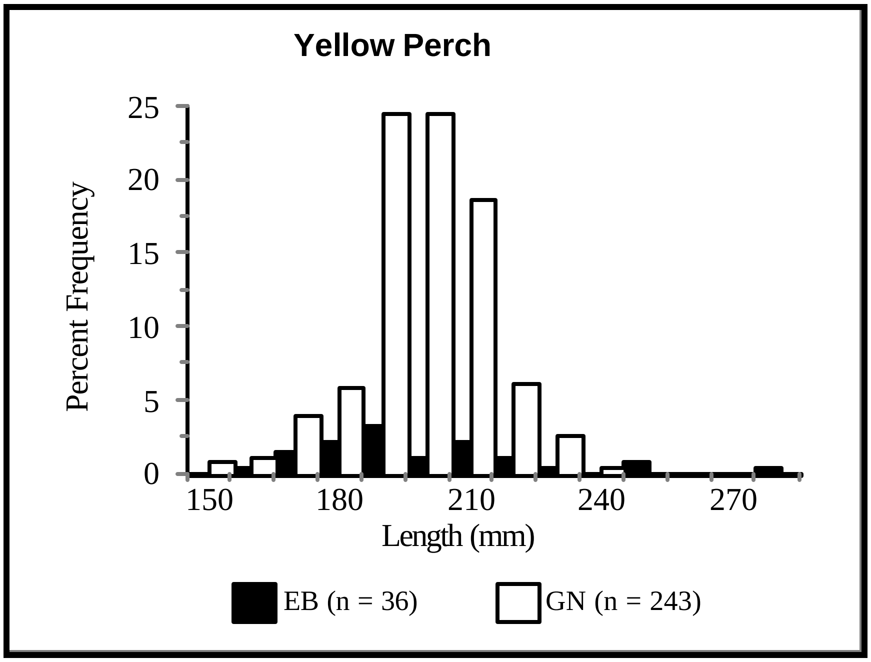

Figure 6. Length frequency of yellow perch captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999.

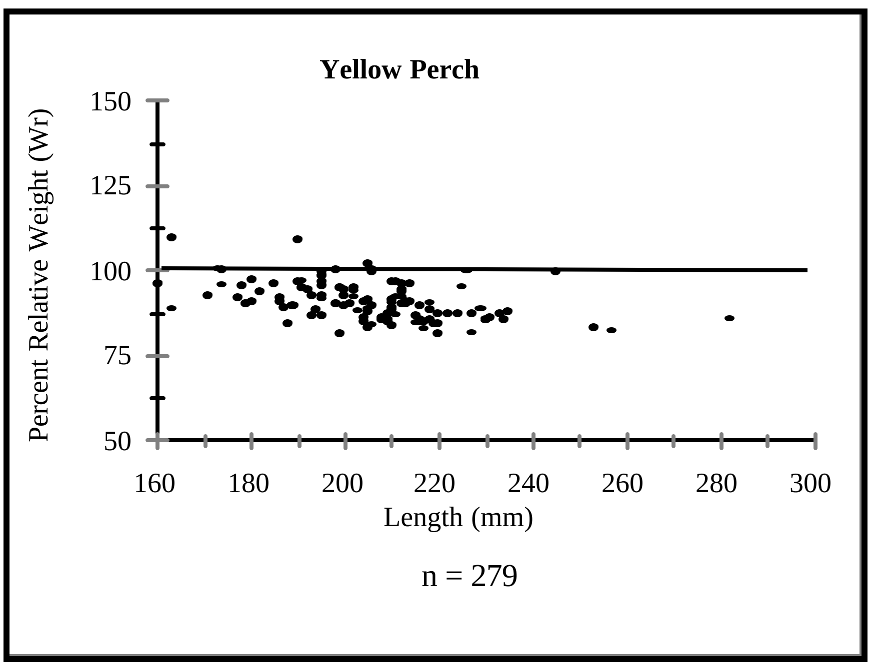

Figure 7. Relative weights of yellow perch captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Black Crappie

Black crappie were found in low abundance (n = 11) in our samples (Table 3). We evaluated 9 black crappie for age and growth; all were found to be age 2 (Table 11). While the sample size was low, growth was above the Eastern Washington average for these fish. Lengths (TL) of black crappie ranged from 210 mm to 260 mm (Figure 8) and relative weights were above the national average for most fish (Figure 9).

Black crappie were stocked in Lower Goose Lake in 1997 (200 adults and 3,168 fry) and 1999 (2,453 fry) (Table 1). Black crappie observed in our samples were likely from the fry stocking in 1997. Age 1 black crappie were not observed in our samples even though reproduction in 1998 was expected from the stocking of 200 adult fish in 1997. We observed 238 young-of-the-year fish providing evidence that successful spawning occurred in 1999.

Table 11. Age and growth of black crappie captured at Lower Goose Lake during October 1999. Shaded values are mean back-calculated lengths using the direct proportion method (Fletcher et al. 1993), and unshaded 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**
1998	0	0	0
		0	0
1997	9	56.9	176.2
		83.0	183.7
Overall mean		56.9	176.2
		83.0	183.7
E. Washington average		46.0	111.2

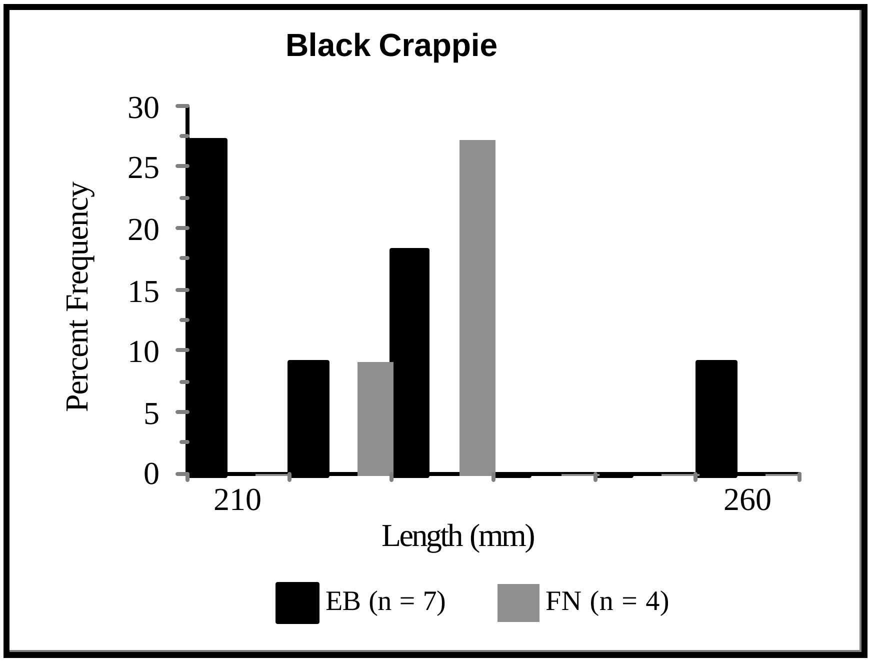

Figure 8. Length frequency of black crappie captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999.

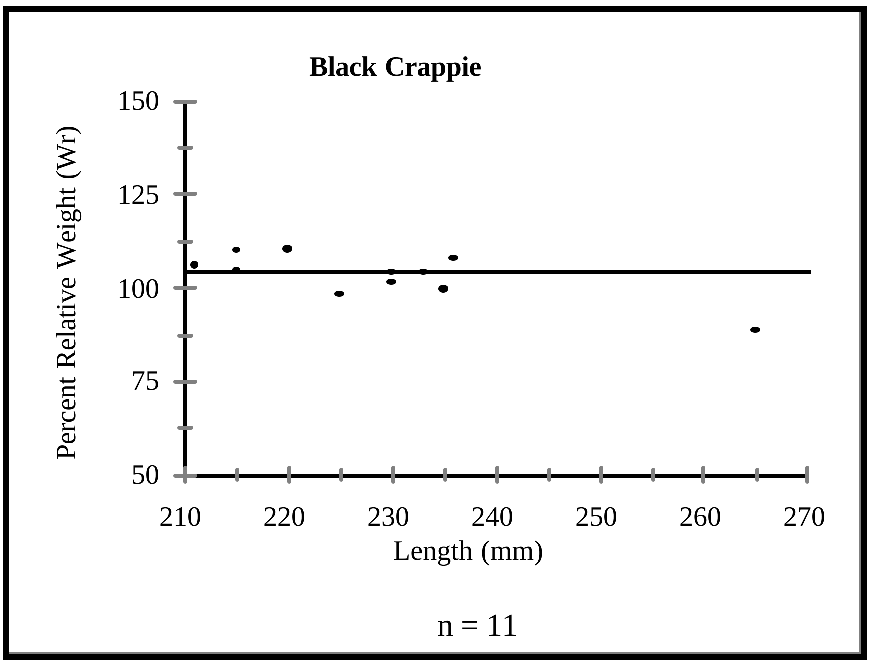

Figure 9. Relative weights of black crappie captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Pumpkinseed Sunfish

Pumpkinseed were found in third highest abundance (n = 129, 14.4%) in our samples (Table 3). Age and growth were not evaluated for pumpkinseed. Lengths (TL) ranged from 45 mm to 153 mm (Figure 10). Pumpkinseed were not stocked in Lower Goose Lake following the rehabilitation in 1997, and most likely entered the lake from the inlet via Upper Goose Lake, or survived the rehabilitation. Relative weights for pumpkinseed were average and improved as the fish grew larger (Figure 11). While pumpkinseed were not found as abundant as bluegill (n = 265, 29.5%), abundance is high enough to provide competition with bluegill for the available food source.

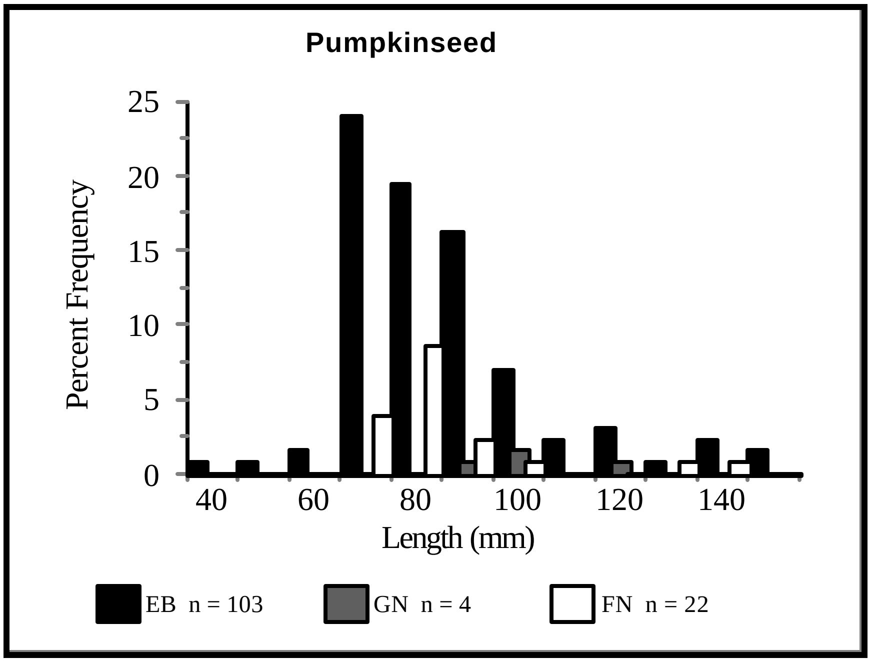

Figure 10. Length frequency of pumpkinseed captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999.

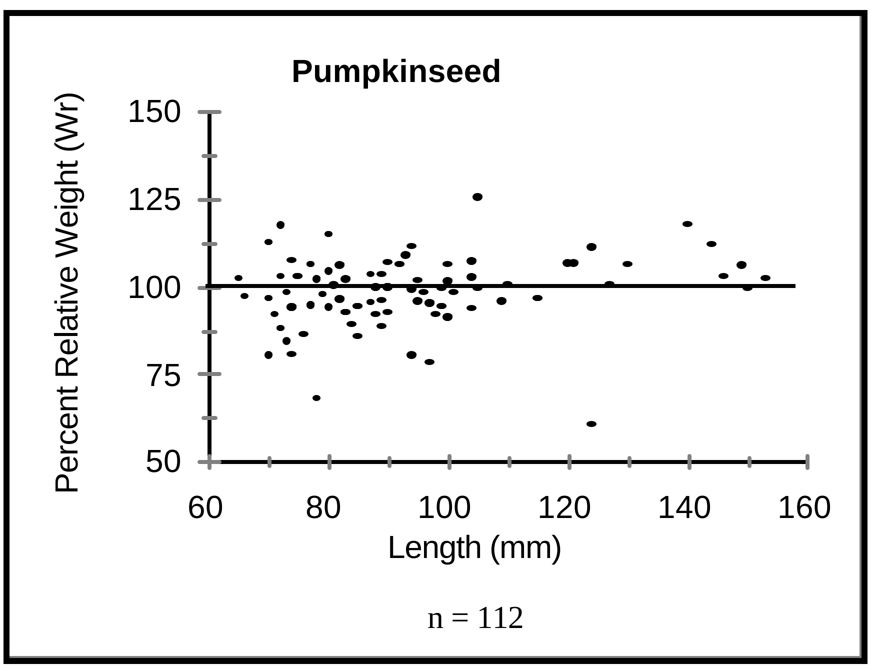

Figure 11. Relative weights of pumpkinseed captured by a boat electrofisher (EB), gill nets (GN), and fyke nets (FN) in Lower Goose Lake during October 1999, as compared to the national average, W_r = 100 (Anderson and Neumann 1996).

Channel Catfish

Lengths (TL) were collected from 4 channel catfish ranging from 194 mm to 515 mm (Table 3). Channel catfish fry were stocked in 1997 (2,508 fingerlings), however; it's unlikely the largest catfish we found in our samples came from that stocking (Table 1). Three channel catfish ranged in size from 190 mm to 230 mm and were likely those stocked in 1997. The adult channel catfish (515 mm) likely survived the rehabilitation. Relative weights of these fish were above average.

Brown Bullhead Catfish

Lengths (TL) of brown bullhead collected from Lower Goose Lake ranged from 194 mm to 255 mm (Table 3). We collected 67 brown bullhead in our samples. Brown bullhead were not planted in Lower Goose Lake and likely entered the lake by the same methods as other non-planted species, or survived the rehabilitation.

Walleye

We collected 11 walleye in our samples with lengths (TL) ranging from 205 mm to 592 mm (Table 3). Ages ranged from 2 to 4 with age 2 being the most abundant age evaluated (n = 6). Walleye growth was below average when compared to a Minnesota Lakes average (Wydoski and Whitney 1979). Walleye relative weights were found below the national average. Walleye were not stocked in Lower Goose Lake and likely entered the lake via Upper Goose Lake or survived the rehabilitation. We observed 1 YOY walleye in our samples which may indicate successful spawning occurred in Lower Goose Lake following the rehabilitation.

Conclusions and Management Options

Because of the inability to isolate its water from the irrigation system, Lower Goose Lake is difficult to manage. Although previous rehabilitation efforts focused on controlling populations of carp and pumpkinseed, recontamination of these species through the upstream wasteways was inevitable. WDFW's management goal for Lower Goose Lake was to suppress carp and pumpkinseed populations through rehabilitation and restock the lake with desirable species such as largemouth bass and bluegill (WDFW 1997). If bass and bluegill populations were established and became the dominant species in the lake, survival of carp and pumpkinseed might be depressed.

Lower Goose Lake was rehabilitated in April, 1997, and subsequently stocked with largemouth bass, bluegill, black crappie, channel catfish, rainbow trout, and Lahontan cutthroat trout. Pumpkinseed sunfish, walleye, yellow perch, brown bullhead, sculpin, longnose sucker, and carp were found during our warmwater fish survey in October, 1999. These undesirable species either entered the lake via Upper Goose lake, or survived the rehabilitation. Yellow perch were found in highest number (n = 279) and second highest biomass (26.5%). Undesirable fish species found in Lower Goose Lake accounted for 58% of the total biomass sampled. This high biomass of undesirable fish species found less than 2 years following a rehabilitation indicates efforts to control undesirable fish species and restock with desired species has not yet been successful.

Following the rehabilitation in 1997, largemouth bass were stocked (278 sub-adults in 1998, and 12,173 fry in 1997) in Lower Goose Lake. Ages 1 to 4 were observed in our samples. Growth and relative weights of largemouth bass in our samples were above average. Young-of-the-year production for largemouth bass was second highest (n = 798) observed by any species reproducing at the time of our survey. Bluegill were stocked as fry (3,168) in 1997, and as adults (500) and fry (37,562) in 1999. Age 1 bluegill were the only age class represented in our samples. Growth was slightly below average and relative weights were average. Young-of-the-year production was observed at 15 fish. Black crappie were stocked as adults (200) and fry (3,168) in 1997, and as fry (2,453) in 1999. Age 2 black crappie were the only age class represented in our samples. While black crappie were found in low abundance (n = 11), growth and relative weights were above average. Young-of-the-year production was observed at 238 fish. Channel catfish were stocked as fingerlings (2,002) in 1998. We observed low numbers (n = 4) of channel catfish in our samples. Relative weights of these fish were found above average.

Yellow perch (n = 279) and pumpkinseed sunfish (129) were found in high abundance when compared to stocked species. While age and growth data was not collected on pumpkinseed, yellow perch were found above average in growth and slightly below average in condition. Age 1 and 2 yellow perch were represented in our age and growth analysis. Young-of-the-year production was high (n = 1,831) at the time of our survey. Yellow perch PSD value was high (59) which indicated angler exploitation was relatively low. It is expected that many more yellow perch are on the verge of reaching maturity and will soon contribute to reproduction. Yellow perch are prolific and become overabundant and stunted unless predators, angling, or rehabilitations keep populations under control (Wydoski and Whitney 1979). Additionally, this fast growing population of yellow perch eventually may cause interspecific and intraspecific food competition.

Current management objectives for Lower Goose Lake include attempting to manage the lake for desirable species, such as largemouth bass and bluegill. However, the ongoing task of controlling species such as carp and pumpkinseed make it difficult. The following are options developed in response to the Warmwater Gamefish Enhancement Program's goal of increasing opportunities to fish for and to catch warmwater gamefish in Lower Goose Lake. It is likely that these options will need to be exercised in combination in order to control undesirable fish populations in the lake and establish populations of management preferred fish species.

Option 1: Warmwater Fish Survey

Periodic warmwater surveys should be conducted to monitor abundance and recruitment of fish species in Lower Goose Lake. Adjustments to the warmwater fish community in Lower Goose Lake may be made through stocking or fish removal, pending the findings of future warmwater fish surveys. A warmwater fish survey is recommended in two to three years to re-evaluate the status of the Lower Goose Lake fish community.

Option 2: Yellow perch control

While rehabilitative attempts were made in 1997 to control yellow perch and other fish species, an above average yellow perch fishery may exist. Predation on yellow perch will likely be needed to prevent this prolific species from becoming over-populated and stunted in this small lake. In addition to other fish species in Lower Goose Lake, larger-sized yellow perch will likely be useful in providing predation on YOY yellow perch. Although yellow perch in Lower Goose Lake may sustain some level of angler exploitation, the number of larger yellow perch should be monitored to detect over-harvest. Periodic warmwater fish surveys would be valuable in monitoring yellow perch size structure, abundance, and condition. Should stunting of yellow perch occur, regulation changes or additional stocking of predators may need to be considered.

Option 3: Carp control

An attempt to control common carp and other undesirable fish species from Lower Goose Lake in 1997 was moderately successful. Low numbers of carp were observed in our survey (n = 7);

however, most were adults which accounted for 11.2 percent of the total fish biomass. Removal of adult carp by periodic electrofishing and/or gill netting is recommended to reduce the expansion rate of this population. Although most of the shoreline on Lower Goose Lake consists of steep talus slopes and/or cliffs, carp could be electrofished in several shallow vegetated areas. Large mesh (4 inch) gill nets could be deployed in those same areas to target carp with minimal by-catch. Like rehabilitations, removing carp with a boat electrofisher or gill nets would not totally eliminate this species from the lake. However, carp were found in low numbers in 1999 and early removal would be expected to have a significant impact in preventing the growth of this population.

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Glossary

Catch Per Unit Effort (CPUE): Is defined as the number of fish captured by a sampling method (i.e., electrofishing, gill netting, or fyke netting) divided by the amount of time sampled.

Confidence Interval (CI): Is defined as an estimated range of values which is likely to include an unknown population parameter with a percentage or degree of confidence.

Memorable Size: Is defined as fish anglers remember catching, and also identified as 59-64 percent of the world record length. Memorable length varies by species.

Preferred Size: Is defined as the size fish anglers preferred to catch when given a choice, and also identified as 45-55 percent of world record length. Preferred length varies by species.

Proportional Stock Density (PSD): Is defined as the number of quality length fish and larger, divided by the number of stock sized fish and larger, multiplied by 100.

Quality Length: Is defined as the length at which anglers begin keeping fish. Also identified as 36-41 percent of world record length. Quality length varies by species.

Relative Stock Density (RSD): Is defined as the number of fish of a specified length category (preferred, memorable, or trophy) and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Stock Density of Preferred Fish (RSD-P): Is defined as the number of fish in the preferred size category and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Stock Density of Memorable Fish (RSD-M): Is defined as the number of fish in the memorable size category and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Stock Density of Trophy Fish (RSD-T): Is defined as the number of fish in the trophy size category and larger, divided by the number of stock length fish and larger, multiplied by 100.

Relative Weight (W_r): The comparison of the weight of a fish at a given size to the national average weight (W_r = 100) of fish of the same species and size.

Standard Weight (W_s): Is defined as a standard or average weight of a fish species at a given length determined by a national length-weight regression.

Stock Length: Is defined by the following: 1) approximate length of fish species at maturity, 2) the minimum length effectively sampled by traditional sampling gears, 3) minimum length of fish that provide recreational value, and 4) 20-26 percent of world record length. Stock length varies by species.

Total Length (TL): Is defined as the length measurement from the anterior most part of the fish to the tip of the longest caudal (tail) fin ray (compressed).

Trophy Size: Is defined as the minimum size fish worthy of acknowledgment. Is also identified as 74-80 percent of world record length. Trophy length varies by species.