1999 Warmwater Survey of Duck Lake, Grays Harbor County

by

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Abstract

The warmwater fish population in Duck Lake, Grays Harbor County, was sampled on May 4-5, and 10-11, 1999. A modified Petersen mark and recapture population estimate was completed for the gamefish, as well as a standard warmwater fish survey. The 95% confidence intervals for largemouth bass population estimates range from 11,236 - 14,853 fish over 100 mm, 844 - 3,188 black crappie greater than 100 mm, and 11,305 - 16,009 bluegill over 100 mm. Our recommendation for protecting the bass population and positively altering its size structure is to implement a slot length regulation. Additionally, an angler creel survey should be planned to monitor angler pressure, preference, and harvest.

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Introduction and Background

Duck Lake is a shallow, eutrophic lake located on the Point Brown peninsula, Ocean Shores, Washington. The main body of the lake is approximately 280 surface acres, with a maximum depth of 9.1 m (Bortelson et al. 1976). In the 1960s, the peninsula was being converted to a resort/retirement community, and the natural Duck Lake was being dredged and filled to create a series of lakes and canals, creating what is known as Duck Lake today. There is a total of six main sections that together comprise Duck Lake, they are: North Duck Lake; Duck Lake; Bass Canal; the Grand Canal; the Bell Canals; and Lake Minard. With the numerous canals and coves, the total surface acreage of Duck Lake is approximately 450 acres.

Duck Lake is fed mainly by shallow groundwater; it is also the main stormflow detention basin for the peninsula. As such, it has experienced water quality problems associated with high nutrient loads from runoff and through poorly designed septic systems in the area. The poor water quality, dense algal blooms, and thick aquatic vegetation spurred the city of Ocean Shores to contract KCM, Inc. to develop a lake restoration plan (KCM, Inc. 1994a).

In April 1995, the city of Ocean Shores planted 2,400 11–inch grass carp (*Ctenopharyngodon idella*) into Duck Lake for vegetation control. Some baseline fish population data was collected during May 1995, for future comparisons as to the affect grass carp had on the fish community. Much of this data is limited in use due to differences in sampling techniques, but will still be presented.

Materials and Methods

Standardized Data Collection

Duck Lake was surveyed by three, three–person teams during the weeks of May 4-5, and May 10-11, 1999. Fish were captured using two sampling techniques: electrofishing and fyke netting. The electrofishing unit consisted of a Smith-Root SR-16s electrofishing boat, with a 5.0GPP pulsator unit. The boat was fished using a pulsed DC current of 120 cycles/second at 3-4 amps power. Fyke (modified hoop) nets were constructed of five 4–foot diameter hoops with two funnels, and an 8–foot cod end (¼ inch nylon delta mesh). Attached to the mouth of the net were two 25–foot wings, and a 100–foot lead.

In order to reduce the gear induced bias in the data, the sampling time for each gear was standardized so that the ratio of electrofishing to fyke netting was 1:1. Our standardized sample is 1800 seconds of electrofishing (3 sections), two gill net nights, and two fyke net nights, but we omitted the gill netting to help meet the assumptions of no mortality for the Petersen estimate. Sampling occurred during the evening hours to maximize the type and number of fish captured. Sampling locations were selected from a map (Figure 1) by dividing the entire shoreline into 400–m sections, and numbering them consecutively. Nightly sampling locations were randomly chosen (without replication) utilizing a random numbers table (Zar 1984). While electrofishing, the boat was maneuvered through the shallows at a slow rate of speed (~18 m/minute, linear distance covered over time) for a total of 600 seconds of “pedal–down” time or until the end of the section was reached, whichever came first. Nighttime electrofishing occurred along nearly 100% of the available shoreline in the main lake, and around 25% of the shoreline in the canals. Fyke nets were fished perpendicular to the shoreline; the lead was tied off to shore, and the cod end was anchored off shore, with the wings anchored at approximately a 45° angle from the net lead. We tried to set fyke nets so that the hoops were 1-2 feet below the water surface, this sometimes would require shortening the lead. No gill nets were used at Duck Lake, whereas fyke nets were set overnight at four locations.

With the exception of sculpin (*Cottidae*), all fish captured were identified to the species level. Each fish was measured to the nearest millimeter (mm) and assigned to a 10 mm size class based on total length (TL). For example, a fish measuring 156 mm TL was assigned to the 150 mm size class for that species, and a fish measuring 113 mm TL was assigned to the 110 mm size class, and so on. However, if a sample included several hundred young–of–year (YOY) or small juveniles (<100 mm TL) of a given species, then a subsample (N ~100 fish) were measured, and the remainder were just counted. The frequency distribution of the subsample was then applied to the total number collected. At least ten fish from each size class were weighed to the nearest gram (g); in some instances, multiple small fish were weighed together to get an average weight. Scales were taken from five individuals per size class, mounted, pressed, and aged using the

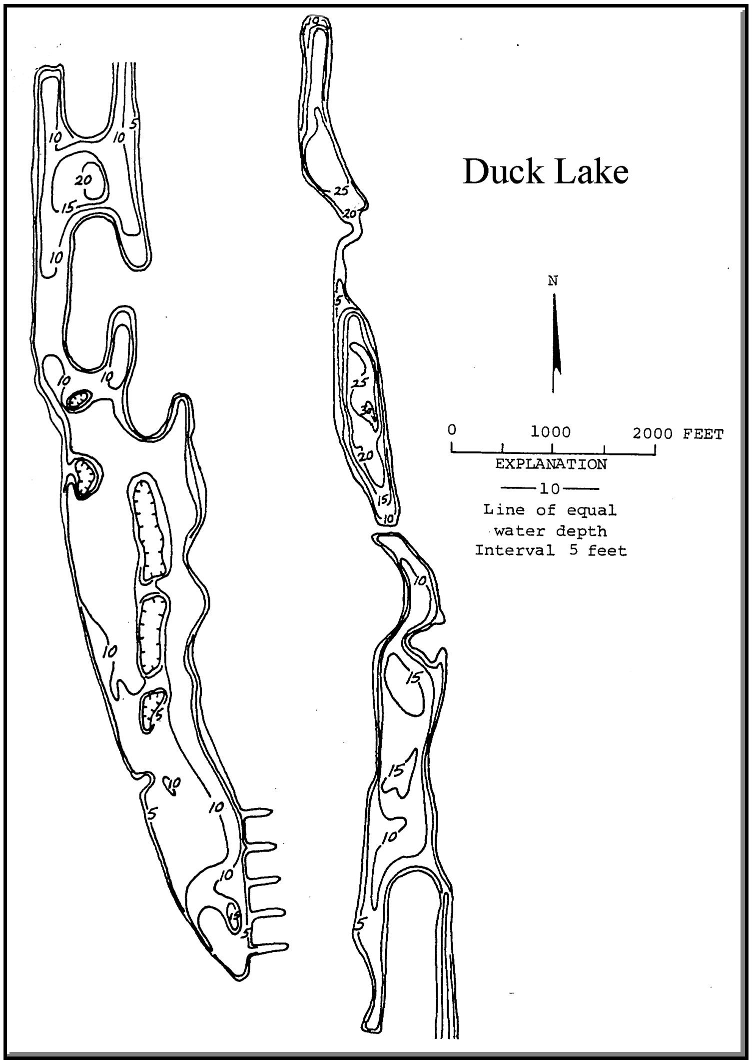

Figure 1. Bathymetric map of Duck Lake, Grays Harbor County, taken from Bortelson et al. (1976). This map represents the main lake, not the associated canals.

Fraser-Lee method. However, members of the bullhead family (*Ictaluridae*), and non–game fish like carp (*Cyprinidae*), were not aged.

Water quality data (Table 1) was collected during mid–day from two locations on May 3, 1999. Using a Hydrolab® probe and digital recorder, dissolved oxygen, temperature, pH, and conductivity data was gathered in the littoral zone and in the deepest section of the lake at 1 m intervals through the water column. Secchi disk readings, used to measure transparency, were taken by the methods outlined by Wetzel (1983).

Table 1. Water quality parameters collected from Duck Lake, Grays Harbor County. Water quality data was collected mid–day May 3, 1999.

	Depth (m)	Temp (C)	pH	D.O. mg/l	Conductivity µs/cm^2
Location 1	1	15.3	8.25	8.03	76.5
	2	14.9	8.27	8.13	76.4
	3	14.5	8.27	8.17	76.3
Location 2	0	15.25	8.71	8.92	77
	1	14.86	8.64	8.27	76.9
	2	14.51	8.6	8.03	76.8
	3	13.71	8.46	7.2	77.1

Secchi depth, 0.75m.

Mark–Recapture Data Collection

In addition to the normal, standardized data collection techniques, we also utilized a mark–recapture technique to estimate total population size of game fish. A nearly complete circuit of the lake was made by the three boats within two nights; bluegill, black crappie and largemouth bass of at least 100 mm total length were weighed, measured, and received an upper caudal fin clip.

The standardized survey was accomplished during our marking session on May 3-4, 1999. Buoys were placed around the lake denoting the beginning of a randomly chosen section. When a buoy was reached, all species were captured as in a normal survey, and all centrarchids of at least 100 mm total length received a fin clip. Standardized survey techniques were completed by two of the boats.

Released fish were given a week to redistribute themselves around the lake before the recapture session on May 10-11, 1999. Again, a nearly complete circuit of the lake was made by the three boats, all captured fish were weighed, measured, and examined for marks.

Data Analysis

All of the collected data was used for the Petersen recapture estimate, but only the data collected from the standardized surveys were used for calculating all of the following indices.

Species Composition

The species composition by number of fish captured, was determined using procedures outlined by Fletcher et al. (1993). Species composition by weight (kg) of fish captured, was determined using procedures adapted from Swingle (1950). Percentage of the aggregate biomass for each species provided useful information regarding the balance and productivity of the community

(Swingle 1950, Bennett 1962). Only fish estimated to be at least one year old were used to determine species composition. These were inferred from the length frequency distributions described below, in conjunction with the results of the aging process. YOY or small juveniles were not considered because large fluctuations in their numbers may cause distorted results (Fletcher et al. 1993). For example, the length frequency distribution of yellow perch (*Perca flavescens*) may suggest successful spawning during a given year, as indicated by a abundance of fish in the smallest size classes. However, most of these fish would be subject to natural attrition during their first winter, resulting in a different size distribution by the following year.

Catch Per Unit of Effort

The catch per unit of effort (CPUE) of electrofishing for each species was determined by dividing the total number in all size classes equal to or greater than stock size (Appendix A), by the total electrofishing time (seconds). The CPUE for gill nets and fyke nets was determined similarly, except the number equal to or greater than stock size was divided by the number of net nights for each net (usually one). An average CPUE (across sample sections) with 80% confidence interval was calculated for each species and gear type, and is shown in Table 4.

For fishes in which there is no published stock size (i.e., sculpins, suckers, etc.), CPUE is calculated using all individuals captured. Furthermore, since it is standardized, the CPUE is useful for comparing stocks between lakes.

Length Frequency

A length frequency histogram was calculated for each species and gear type in the sample (Figures 2, 4 and 6). Length frequency histograms are constructed using individuals that are age one and older (determined by the aging process, age one - 1 standard deviation), and calculated as the number of individuals of a species in a given size class, divided by the total individuals of that species sampled. Plotting the histogram this way tends to flatten out large peaks created by an abundant size class, and makes the graph a little easier to read. These length frequency histograms are helpful when trying to evaluate the size and age structure of the fish community, and their relative abundance in the lake.

Stock Density Indices

Stock density indices are used to assess the size structure of fish populations. Proportional stock density (PSD and relative stock density RSD) are calculated as proportions of various size classes of fish in a sample. The size classes are referred to as minimum stock (S), quality (Q), preferred (P), memorable (M), and trophy (T). Lengths have been published to represent these size classes for each species, and were developed to represent a percentage of world–record lengths as listed by the International Game Fish Association (Gablehouse 1984). These lengths are presented in Appendix A.

The indices calculated here are described by Gablehouse (1984) as the traditional approach. The indices are accompanied by a 80% confidence interval (Gustafson 1988) to provide an estimate of statistical precision.

Relative Weight

A relative weight index (W_r) was used to evaluate the condition (plumpness or robustness) of fish in the lake. A W_r value of 1.0 generally indicates a fish in good condition when compared to the national average for that species and size. Furthermore, relative weights are useful for comparing the condition of different size groups within a single population to determine if all sizes are finding adequate forage or food (ODFW 1997). Following Murphy and Willis (1991), the index was calculated as $W_r = W/W_s$ x 100, where W is the weight (g) for an individual fish from the sample and W_s is the standard weight of a fish of the same total length (mm). W_s is calculated from a standard log weight - log length relationship defined for the species of interest. The parameters for the W_s equations of many fish species, including the minimum length recommendations for their application, are listed in Anderson and Neumann (1996). For the species where data are available, the W_r values from this study are compared to the national standard (W_r=100).

Age and Growth

Age and growth of warmwater fishes were evaluated according to Fletcher et al. (1993). Total length at annulus formation, L_n, was back–calculated using the Fraser-Lee method. Intercepts for the *y* axis for each species were taken from Carlander (1982). Mean back–calculated lengths at each age for each species were presented in tabular form for easy comparison between year classes. Mean back–calculated lengths at each age for each species were compared to averages calculated from scale samples gathered at lakes sampled by the warmwater enhancement teams.

Population Estimate

The total estimated population size of largemouth bass, bluegill, and black crappie was calculated by using the adjusted Petersen method (Ricker 1975). The 95% confidence limits were approximated by a Poisson distribution, using the number of recaptures as the variable, and then the new approximated number of recaptures was re-entered into the Petersen equation to obtain a new population estimate. A total estimate of population size was made for each species, as well as an estimate for each length class represented in Appendix A.

Results and Discussion

Water Quality and Habitat

Water quality information was collected from two locations in Duck Lake on May 5, 1999. Spring water temperatures and dissolved oxygen levels (Table 1) are well within the levels required by most fish. During the summer months, however, oxygen levels drop sharply in many of the canals due to poor water mixing and high temperatures. Habitat is not a limiting factor at Duck Lake; the numerous canals and islands provide plenty of shoreline habitat, and the visible submersed vegetation provides plenty of refuge for young fish. Bulkhead construction on the main lake has been pretty minimal, being less than 5% of the main lake shoreline.

Our population sampling was early in the spring, before the growth of many of the aquatic plant species. It is unclear as to what effect the grass carp have had on the aquatic vegetation community in Duck Lake.

For a very in–depth report on the water quality, groundwater, aquatic invertebrates, and aquatic macrophytes, review the technical appendices published by KCM, Inc. (1994b). A summary of aquatic plant surveys performed by Washington Department of Ecology is provided in Appendix B (Jenifer Parsons, Washington Department of Ecology, personal communication).

Species Composition and Relative Abundance

A total of seven species of fish were captured at Duck Lake; largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), sculpin (*Cottidae*), coho (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), and grass carp (*Ctenopharyngodon idella*).

Largemouth bass and bluegill were the two most abundant species captured at the time of our sampling (Table 2). Though grass carp rank near the top in total biomass, our sampling efforts were not directed towards them, hence they are under–represented by our sampling.

Table 2. Species composition by weight (kg), and number of fish captured at Duck Lake (Grays Harbor County) during the spring 1999 warmwater fish survey.						
	Species Composition					
	by Weight		**by Number**		**Size Range (mm TL)**	
Species	**(kg)**	**(%w)**	**(#)**	**(%n)**	**Min**	**Max**
Black crappie	5.2	4.1	63	4.6	118	253
Bluegill	17.9	14.1	634	46.3	53	203
Coho	1.0	0.8	2	0.1	175	456
Sculpin	0.3	0.2	15	1.1	75	163
Grass carp	11.2	8.9	2	0.1	695	726
Largemouth bass	91.0	71.8	653	47.7	52	477
Rainbow trout	0.1	0.1	1	0.1	245	245

Stock density indices (Table 3) showed that there are few preferred, memorable, or trophy sized fish in Duck Lake. Criteria presented by Gablehouse (1984), suggest that the Duck Lake largemouth bass population is in balance. As well, the black crappie population appears to be nearly in balance. Manipulation of populations from where they are currently will usually happen at the expense of one of the other species within the population. New regulations or management decisions should be considered carefully as to their full consequences before being implemented.

Table 3. Stock density indices by gear type and length categories for the fish population at Duck Lake during the spring 1999 warmwater fish survey.									
		Quality		**Preferred**		**Memorable**		**Trophy**	
Species	**# Stock Length**	**PSD**	**80% CI**	**RSD-P**	**80% CI**	**RSD-M**	**80% CI**	**RSD-T**	**80% CI**
Electrofishing									
Black crappie	36	31	10	3	4	0	--	0	--
Bluegill	485	12	2	0	--	0	--	0	--
Largemouth bass	195	35	4	12	3	0	--	0	--
Fyke Netting									
Black crappie	21	33	13	0	--	0	--	0	--

Catch per unit of effort for each species is shown in Table 4 broken out by gear type. Electrofishing proved to be the most effective method of capture for all species, and the highest catch rates were for bluegill, largemouth bass, and black crappie, respectively.

Table 4. Average catch per unit of effort (number of fish caught/hour of electrofishing and number of fish caught/net night) for stock sized and larger fish sampled in Duck Lake during the spring 1999 warmwater fish survey.

	Electrofishing			Gill Netting			Fyke Netting		
Species	**(#/hour)**	**80% CI**	**Sample Sites**	**#/net night**	**80% CI**	**# net nights**	**#/net night**	**80% CI**	**# net nights**
Black crappie	16.9	9.3	12	--	--	--	5.3	1.7	4
Bluegill	193.7	38.7	12	--	--	--	2.5	2.8	4
Coho	0.5	0.6	12	--	--	--	0.3	0.3	4
Sculpin, Unknown	6.5	3.2	12	--	--	--	0.0	--	4
Grass carp	1.0	1.3	12	--	--	--	0.0	--	4
Largemouth bass	81.0	13.1	12	--	--	--	0.0	--	4

Summary by Species

Largemouth Bass (*Micropterus salmoides*)

Relative weights of largemouth bass (Figure 2) shows an increasing trend as fish length increases. The smaller size classes are exhibiting a relatively poorer condition than the larger size classes, which are closer to the national standard W_r of 100. For early spring, this makes sense, as the smaller size classes would use more of their stored energy reserves through the winter. This being the part of the reason that the smaller size classes exhibit high over–winter mortalities. There is also a seasonal related difference in W_r for all species. Bass tend to have higher relative weights in the late spring (prior to spawning), declining through the summer and increasing again in the early fall (Pope and Willis, 1996).

Length at age of largemouth bass in Duck Lake (Table 6) is slightly higher than the average for western Washington. Duck Lake is a productive lake, and it is assumed that there is plenty of prey species available for all life stages; whether it be young of year fish, small shellfish, or zooplankton.

The size range of largemouth bass captured was 52 - 477 mm total length, and the capture frequency of each size class is shown in Figure 3.

Table 5 shows the total estimated population size of largemouth bass, greater than 100mm total length and equal and greater than each length category. The 95% confidence interval was calculated based on a Poisson distribution, and shows a range in which the population size will fall. Based on a lake area of 280 acres, there is an estimated five (5) fish greater than 300mm per acre.

Table 5. Back–calculated length at age (Fraser-Lee) for largemouth bass in Duck Lake, Grays Harbor County, during the spring 1999 warmwater fish survey. Direct proportion values are provided for comparison to historical data.

		Mean Length at Age (mm)										
Year Class	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1998	0	--										
1997	46	85	154									
1996	34	72	141	210								
1995	24	76	142	206	255							
1994	29	86	156	221	277	311						
1993	19	86	172	241	294	334	365					
1992	17	87	178	254	310	345	372	392				
1991	5	80	170	271	323	352	378	395	416			
1990	0	--	--	--	--	--	--	--	--	--		
1989	2	63	128	204	270	329	389	417	432	443	454	
1987	1	155	245	283	310	358	382	424	438	451	461	472
Fraser-Lee		82	155	225	283	329	371	396	422	445	456	472
Direct Proportion		68	148	220	280	327	370	395	422	445	456	472
State Average (d.p.)		60	146	222	261	289	319	368	396	440	485	472

Table 6. Modified Petersen mark–recapture estimates for largemouth bass in Duck Lake, spring 1999, by length category.

	>100	**>200**	**>300**	**>380**	**>510**	**>630**
Number Marked	1,356	446	166	51	0	0
Number Recaptured	195	73	27	6	0	0
Total Captured	1,865	613	220	60	0	0
Pop. Estimate	12,919	3,709	1,318	453	1	1
+ 95% CI	11,236	2,958	916	225	0	0
- 95% CI	14,853	4,647	1,888	849	1	1
Recapture + 95% CI	224	92	39	13	4	4
Recapture - 95% CI	169	58	19	3	(0)	(0)

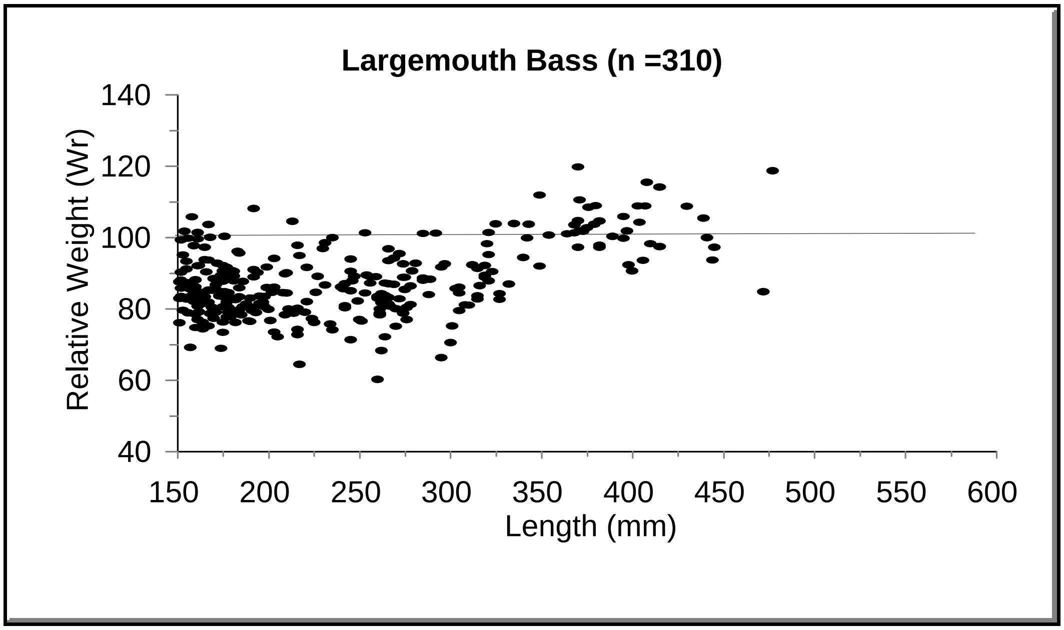

Figure 2. Relationship between total length and relative weight (W_r) for largemouth bass sampled at Duck Lake, Grays Harbor County, during the spring 1999 warmwater fish survey; as compared to the national standard (horizontal line at 100).

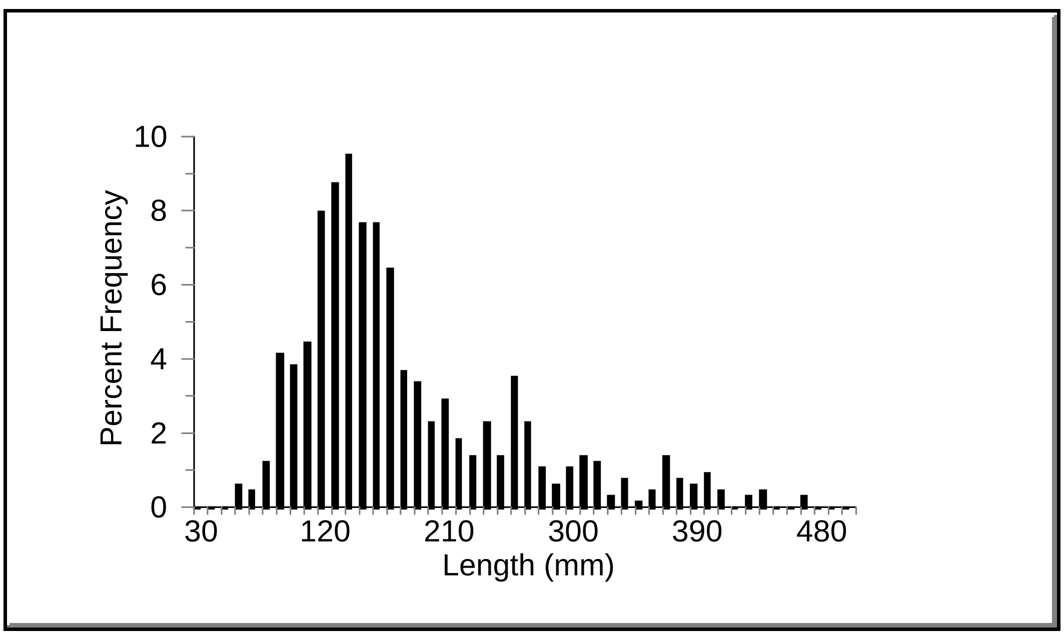

Figure 3. Length frequency distribution of largemouth bass from electrofishing from the spring 1999 survey of Duck Lake, Grays Harbor County.

Bluegill (*Lepomis macrochirus*)

Bluegill were the second most abundant species sampled in Duck Lake, by number and by total biomass (Table 2). The relative weights of bluegill (Figure 4) at the time of our sampling average just slightly below the national standard of 100. Relative weights will probably increase through the late spring and into the summer. The high variability of relative weights for the smaller size classes is most likely due to the low accuracy of weighing small fish in the field. Length at age (Table 7) shows that growth is slower than the western Washington average, this can be backed up by the slightly low relative weights as well. This suggests that, overall, prey may be a limiting factor on the growth of bluegill.

The highest density of bluegill is in the 80-120 mm size classes (Figure 5). The population estimate for bluegill shows that there are approximately 10,000 bluegill between 80 and 150 mm, which translates to approximately 35 fish/acre. The low PSD and RSD's (Table 3) show that the population is out of balance, weighted towards smaller fish.

Table 7. Back–calculated length at age (Fraser-Lee) for bluegill sampled from Duck Lake, Grays Harbor County, during the spring 1999 warmwater fish survey. Direct proportion values are provided for comparison to historical data.

		Mean Length at Age (mm)						
Year Class	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1998	0	–						
1997	31	48	104					
1996	16	34	87	146				
1995	14	43	97	143	175			
1994	10	36	80	134	159	179		
1993	2	38	77	115	161	172	186	
1992	1	31	79	118	150	168	181	188
Fraser-Lee	74	42	95	140	167	177	184	188
Direct Proportion		26	88	137	165	177	184	188
State Average (d.p.)		37	97	132	148	170	201	196

Table 8. Modified Petersen mark–recapture estimates for bluegill in Duck Lake, spring 1999, by length category.

	>100	**>80**	**>150**	**>200**	**>250**	**>300**
Number Marked	546	580	120	4	0	0
Number Recaptured	29	32	5	0	0	0
Total Captured	619	696	136	4	0	0
Pop. Estimate	11,305	12,271	2,763	25	1	1
+ 95% CI	7,951	8,769	1,303	5	0	0
- 95% CI	16,009	17,115	5,315	26	1	1
# Recapture + 95% CI	41.66	45.18	11.72	3.88	3.88	3.88
# Recapture - 95% CI	20.18	22.66	2.12	(0)	(0)	(0)

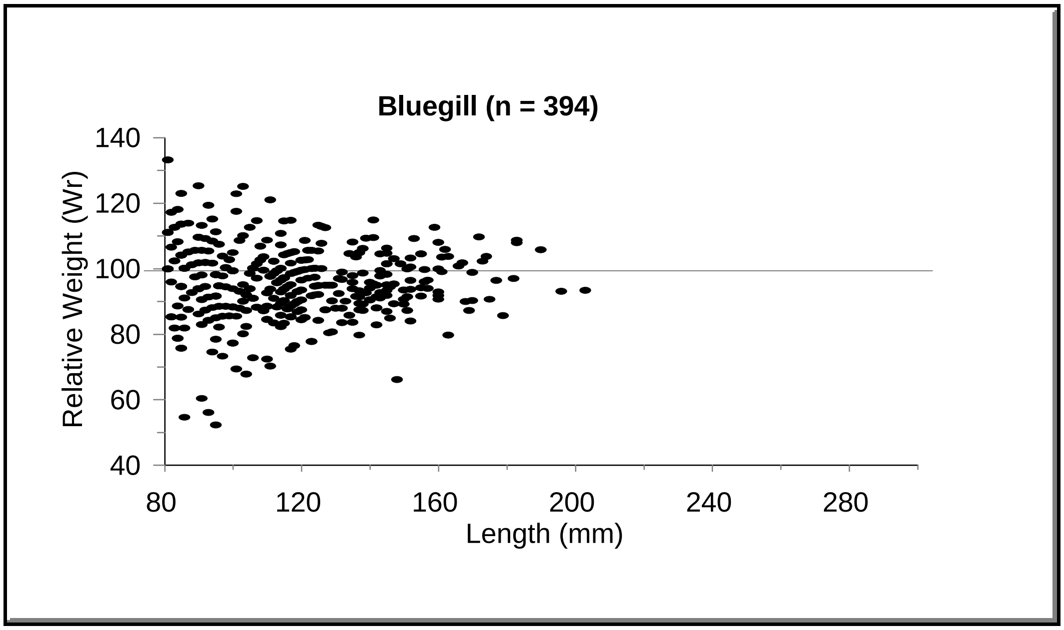

Figure 4. Relationship between total length and relative weight (W_r) for bluegill sampled at Duck Lake, Grays Harbor County, during the spring 1999 warmwater fish survey; as compared to the national standard (horizontal line at 100).

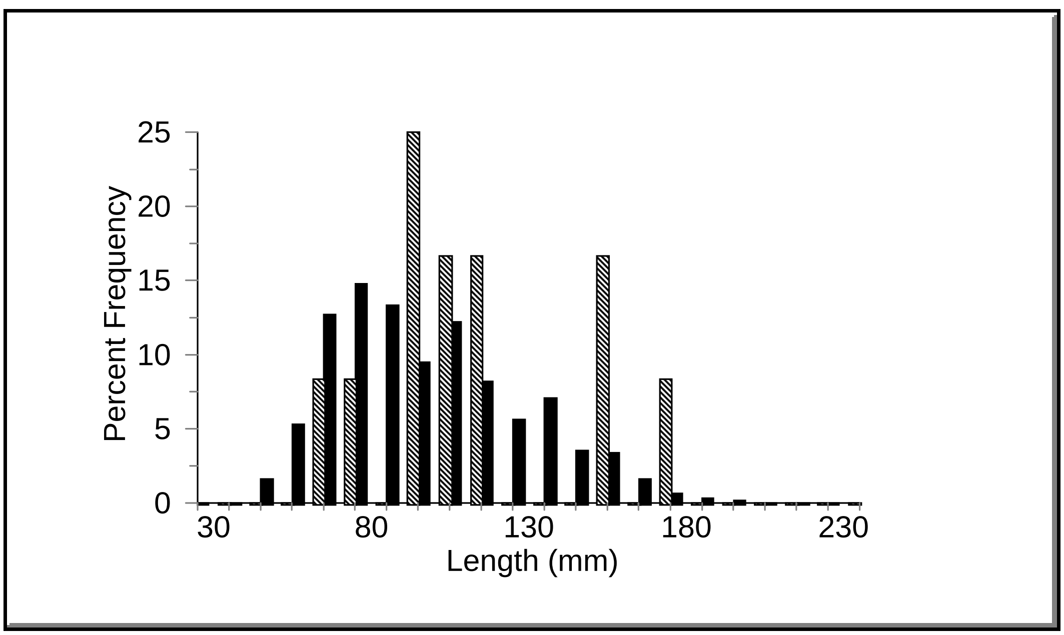

Figure 5. Length frequency distribution of bluegill from electrofishing (dark bars) and fyke netting (hatched bars) during the spring 1999 survey of Duck Lake, Grays Harbor County.

Black Crappie (*Pomoxis nigromaculatus*)

Black crappie were the least abundant warm water gamefish in our sample. This is probably due more to our sampling locations than our sampling techniques. The spatial and temporal distribution of fishes vary by season, so it is probable that the majority of the crappie population was farther offshore during our sampling.

Back–calculated length at age for black crappie (Table 9) is slightly faster than average for western Washington lakes, at least during the early life stages. This can also be confirmed by viewing the relative weights (Figure 6). The younger age classes have a higher relative weight that drops off as length increases, indicating that there is a bottleneck limiting growth of the older fish. The bottleneck is most likely related to a lack of available prey items for the larger fish.

Table 9. Back–calculated length at age (Fraser-Lee) for black crappie sampled from Duck Lake, Grays Harbor County, during the spring 1999 warmwater fish survey. Direct proportion values are provided for comparison to historical data.

		Mean Length at Age (mm)						
Year Class	**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1998	0	–						
1997	25	81	150					
1996	8	79	134	190				
1995	4	77	127	174	214			
1994	8	79	125	156	192	221		
1993	2	79	122	166	224	249	270	
1992	1	61	83	113	132	143	151	155
Fraser-Lee		79	139	170	198	219	230	155
Direct Proportion		56	131	162	194	218	230	155
State Average (d.p.)		46	111	157	183	220	224	261

The length frequency distribution of black crappie (Figure 7) shows peaks that correspond to the age classes sampled. There is a noticeable lack of one year old fish in the sample. This could be due to low recruitment over the winter, or these fish were just offshore at the time of sampling.

The total estimate of population size for black crappie (Table 10) is estimated at 1,700 fish greater than 100 mm total length. That translates to only six (6) fish per acre. A previous study in 1995 reported an estimate of 7,440 black crappie. Our sampling, though intensive, was possibly insufficient to capture crappie. A more probable explanation is that crappie reside away from the shoreline, closer to the center of the lake, during the time of year we were sampling.

Table 10. Modified Peterson mark–recapture estimates for black crappie in Duck Lake, spring 1999, for each length category.

	>100	**>130**	**>200**	**>250**	**>300**	**>380**
Number Marked	95	90	25	1	0	0
Number Recaptured	6	6	0	0	0	0
Total Captured	123	112	20	2	0	0
Pop. Estimate	1,701	1,469	546	6	1	1
+ 95% CI	844	729	112	1	0	0
- 95% CI	3,188	2,754	569	6	1	1
Recapture + 95% CI	13	13	4	4	4	4
Recapture - 95% CI	3	3	(0)	(0)	(0)	(0)

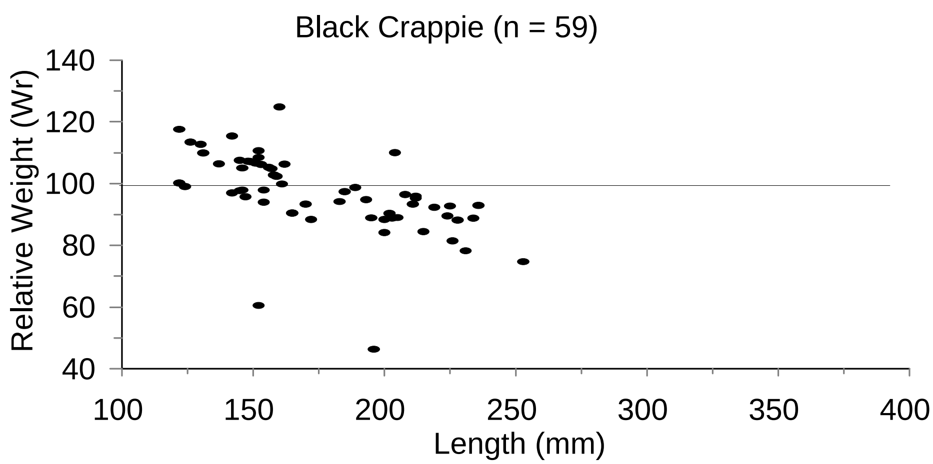

Figure 6. Relationship between total length and relative weight (W_r) for black crappie sampled at Duck Lake, Grays Harbor County, during the spring 1999 warmwater fish survey; as compared to the national standard (horizontal line at 100).

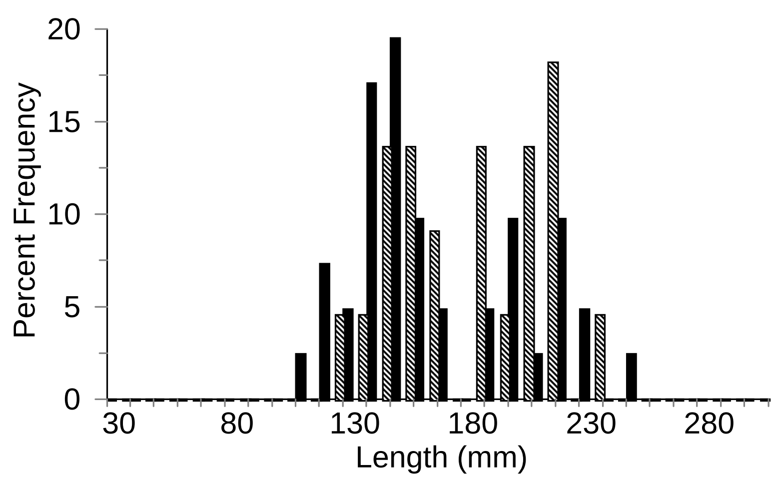

Figure 7. Length frequency distribution of black crappie from electrofishing (dark bars) and fyke netting (hatched bars) during the spring 1999 survey of Duck Lake, Grays Harbor County.

Grass Carp (*Ctenopharyngodon idella*)

A total of 2,400 grass carp (approximately 280 mm total length) were planted by the city of Ocean Shores in April of 1995. Few grass carp were encountered by the survey crews. The two individuals that were captured were 695 to 726 mm total length (Table 2), showing consistent growth between individuals. Our main sampling methods are not very effective at capturing grass carp. We know the size at which individuals were stocked, and have a general idea of their size range now. If we assuming there is 10% total mortality per year, there should be approximately 1,500 grass carp still inhabiting Duck Lake.

Sculpin (*Cottidae*)

Sculpin are not an important sport or food fish. They are, however, possibly an important prey species for largemouth bass; the smaller size classes may be important for crappie or larger bluegill as well.

Due to their morphological variation, we only identify these fish to the family level, *Cottidae*. But, the most commonly found sculpin in western Washington lakes will be the prickly sculpin (*Cottus asper*) (Paul Mongillo, WDFW, personal communication). Other possibilities may include the reticulate sculpin (*Cottus perplexus*), and the torrent sculpin (*Cottus rhotheus*).

Rainbow Trout (*Oncorhynchus mykiss*)

Duck Lake is managed as a mixed species lake, it receives occasional trout plants to support a put–and–take fishery. We caught only one rainbow trout in our sample.

Coho (*Oncorhynchus kisutch*)

There is no coho run through Duck Lake. Excess hatchery fish are sometimes planted by the regional biologists to create a small sport fishery from excess hatchery production. We caught two coho in our sample.

Management Options

Duck Lake is managed as a mixed–species lake, it receives trout plants yearly, and sometimes excess hatchery coho (fry/fingerling). The many canals and fingers of this lake make ideal fishing conditions for warm water anglers; there are plenty of overhanging trees, brush, and shoreline structure to attract fish. Access to the lake is through two public launches owned and maintained by the city of Ocean Shores.

Creel Survey

Duck Lake is a popular fishing destination for many warmwater fish anglers. Though growth and population size appear to be healthy, angler exploitation should be assessed to determine impacts by the users to ensure a lasting, quality fishery. Compared to lakes in more southern areas of the country, our lower water temperatures and shorter growing seasons contribute to slow growth, even if relative weights are high. Because of this, it is easy to overharvest many of our fish populations.

A well designed angler creel survey can help determine angler pressure, harvest, and species preference. All of this information is essential when making management decisions, as it will allow us to know how our fish populations are harvested, so we better know what we may do to manage them more effectively.

Slot Limit for Bass

One way of protecting a stock, especially one that has few larger individuals, is with a length limit or a slot limit. Current harvest regulations for bass allow for harvest of five fish, with no more than three over 15 inches. This does not allow much protection for our populations.

We are proposing a 12 - 17–inch slot length limit on the bass in Duck Lake. This would allow harvest of bass below 12 inches and above 17 inches, while protecting fish within that range. The overall effect on the population should be an increased number of fish within the slot range, while decreasing abundance of smaller size classes. The reduction of the smaller size classes sometimes translates into better growth rates for larger fish. This would result in a more balanced overall community.

Crappie Management

There are few lakes in western Washington that support a healthy black crappie population. Crappie were the least abundant warm water game species in our sample, but this does not mean that they are the least abundant species in the lake. We have struggled to find a good technique to get decent black crappie samples in our lakes. Before we make a major decision how to best manage crappie, we need to get a better handle on exactly how the crappie population is doing. This will probably mean trying different sampling techniques, and targeting parts of the lake other than the shoreline; this will probably require us to deviate greatly from our standardized sampling protocol.

There is currently a reduced creel limit of ten fish for crappie in Duck Lake. It is unclear how this has affected the crappie population, but it is advisable to continue this regulation until we have a better understanding of the crappie population dynamics.

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Appendix A

Table A1. Length categories that have been proposed for various fish species. Measurements are for total lengths (updated from Neumann and Anderson 1996).

	Category									
	Stock		Quality		Preferred		Memorable		Trophy	
Species	**(in)**	**(cm)**	**(in)**	**(cm)**	**(in)**	**(cm)**	**(in)**	**(cm)**	**(in)**	**(cm)**
Black bullhead[a]	6	15	9	23	12	30	15	38	18	46
Black crappie	5	13	8	20	10	25	12	30	15	38
Bluegill[a]	3	8	6	15	8	20	10	25	12	30
Brook trout	5	13	8	20						
Brown bullhead[a]	5	13	8	20	11	28	14	36	17	43
Brown trout	6	15	9	23	12	30	15	38	18	46
Burbot	8	20	15	38	21	53	26	67	32	82
Channel catfish	11	28	16	41	24	61	28	71	36	91
Common carp	11	28	16	41	21	53	26	66	33	84
Cutthroat trout	8	20	14	35	18	45	24	60	30	75
Flathead catfish	11	28	16	41	24	61	28	71	36	91
Green sunfish	3	8	6	15	8	20	10	25	12	30
Largemouth bass	8	20	12	30	15	38	20	51	25	63
Pumpkinseed	3	8	6	15	8	20	10	25	12	30
Rainbow trout	10	25	16	40	20	50	26	65	31	80
Rock bass	4	10	7	18	9	23	11	28	13	33
Smallmouth bass	7	18	11	28	14	35	17	43	20	51
Walleye	10	25	15	38	20	51	25	63	30	76
Warmouth	3	8	6	15	8	20	10	25	12	30
White catfish[a]	8	20	13	33	17	43	21	53	26	66
White crappie	5	13	8	20	10	25	12	30	15	38
Yellow bullhead	4	10	7	18	9	23	11	28	14	36
Yellow perch	5	13	8	20	10	25	12	30	15	38

[a] As of this writing, these new, or updated length classifications have yet to go through the peer review process, but a proposal for their use will soon be in press (Timothy J. Bister, South Dakota State University, personal communication).

Appendix B

This aquatic plant survey information was completed and provided by Jenifer Parsons, Washington Department of Ecology.

Species Summary

Duck Lake Grays Harbor County

Date: 18-Aug-98

Scientific name	Common name	Distribution Value	Comments
Carex sp.	sedge	1	
Cicuta douglasii	western water-hemlock	2	
Egeria densa	Brazilian elodea	4	very dense in north part of lake
Elodea canadensis	common elodea	2	few plants seen
Hydrocotyle ranunculoides	water-pennywort	2	in canal
Iris pseudacorus	yellow flag	2	
Juncus sp.	rush	1	
Lythrum salicaria	purple loosestrife	1	only saw one plant, pulled it
Myriophyllum spicatum	Eurasian water-milfoil	1	only saw one patch, not a thorough survey done
Nuphar polysepala water-lily	spatter-dock, yellow	2	
Potamogeton epihydrus	ribbonleaf pondweed	1	only seen 2 places
Potamogeton pectinatus	sago pondweed	1	only seen in 1 place
Potentilla palustris	purple (marsh) cinquefoil	2	
Solanum sp.	nightshade	1	
Sparganium eurycarpum	broadfruited bur-reed	4	dominant shoreline plant
Spirodela polyrhiza	great duckweed	2	

Date: 21-Sep-99

Scientific name	Common name	Distribution Value	Comments
Egeria densa	Brazilian elodea	5	blooming at south end
Elodea canadensis	common elodea	2	
Elodea nuttallii	Nuttall's waterweed	1	
Iris pseudacorus	yellow flag	1	
Juncus sp.	rush	1	

Myriophyllum spicatum	Eurasian water-milfoil	2	
Nitella sp.	stonewort	1	
Nuphar polysepala	spatter-dock, yellow water-lily	2	
Polygonum sp.	smartweed	2	not sure of species, may be hydropiper
Pontederia cordata	pickerel-weed	1	?? One large plant in front of a house
Potamogeton pectinatus	sago pondweed	1	
Potentilla palustris	purple (marsh) cinquefoil	2	
Sparganium eurycarpum	broadfruited bur-reed	4	along shore

Comments

Waterbody Name	***County***	***Date***	***Comments***
Duck Lake	*Grays*		
		8/18/1998	Cloudy, light breeze. Egeria densa north of area around Overlake Rd much more dense. South lake with more algae growing on plants, fewer plants and murkier seeming water. Only quickly motored shoreline in most of Duck Lake proper, skipped the canals. Stopped over canal at Overlake Rd and did not see submersed plants growing.
		9/21/1999	Sunny, breeze. Habitat survey, quickly motored along parts of shoreline to save time. Egeria dense, but ~1-2 feet below surface, maybe from harvester? Much algae growing on plants.