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A Standardized Warmwater Fish Survey and Roving Creel Survey of Lake Cassidy Snohomish County, Washington May-August 2011

Warmwater Fish Enhancement

by Daniel L. Garrett and Justin Spinelli

Washington Department of Fish and Wildlife
Fish Program
Fish Management

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Introduction

Lake Cassidy is a small (48 surface hectares; 125 acres), shallow (≤7 meters), seasonally eutrophic body of water located north of Lake Stevens and three miles east of Marysville in Snohomish County (Figure 1). The lake is fed by Little Martha Lake and forms the headwater of Catherine Creek which drains into the Pilchuck River.

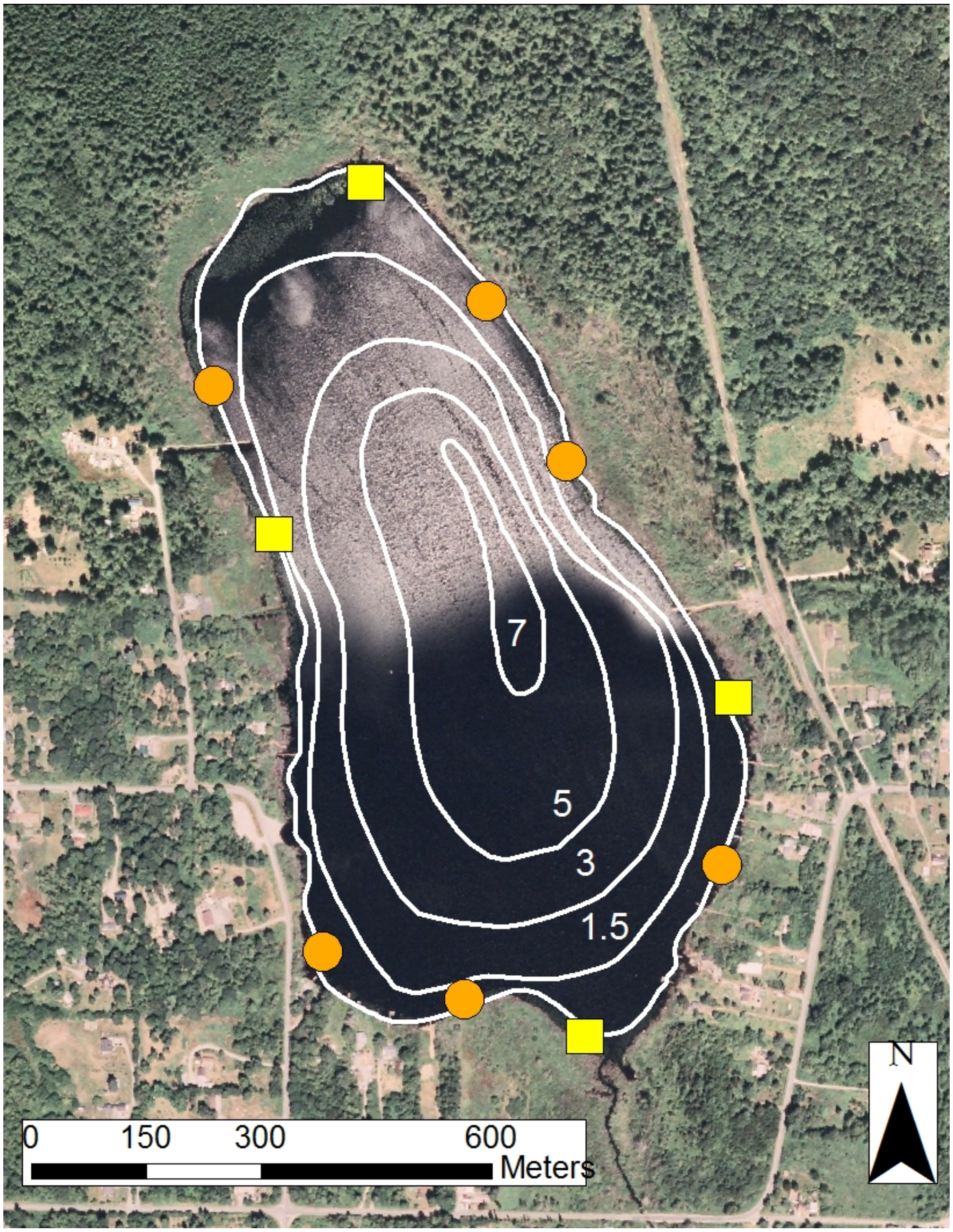

Figure 1. Lake Cassidy bathymetry (meters) and sampling locations. Circles denote gill net locations; squares denote fyke net locations. Electrofishing was conducted along the entire shoreline

Water quality in Lake Cassidy is characterized by thermal stratification and hypoxia in the hypolimnion during the late summer (Figures 2 and 3). Although algal production appears to contribute significantly to microbial respiration and subsequent hypoxia in the hypolimnion, much of the productivity of Lake Cassidy probably results from littoral macrophyte growth and decomposition (Downen et al. 1999). Over 65 percent of the shoreline to the two-meter bathymetric contour is densely vegetated with yellow water lily (*Nuphar polysepalum*), coontail (*Ceratophyllum demersum*), and bulrush (*Scirpus sp.*; Downen et al. 1999). The remaining shoreline is moderately vegetated with these and other aquatic plant species.

Lake Cassidy's shallow basin, low altitude, productivity and largely undeveloped shoreline provide adequate habitat for warmwater fish species, despite the poor water quality that occurs in late summer. The popularity of this warmwater fishery led to a 1982 survey of the warmwater community by the Washington Department of Game (WDG). Populations of largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and pumpkinseed sunfish (*Lepomis gibbosus*) demonstrated slow growth and poor condition.

In 1984, a slot limit was imposed on largemouth bass to increase recruitment to larger size classes. Downen et al. (1999) reports that growth rates for largemouth bass began improving throughout the 1980s. In 1998, the Washington Department of Fish and Wildlife (WDFW) Warmwater Enhancement Program conducted the first standardized warmwater survey (for methods, see Bonar et al. 2000) to detect changes in community structure, growth and condition of warmwater fish and form a basis for other management options that might increase warmwater fishing opportunities in the lake (Downen et al. 1999). Growth rates of largemouth bass, yellow perch, and black crappie improved from the 1982 survey, though proportional stock densities (PSDs) and numbers of stock size fish in the sample remained low. Based on these results, Downen et al. (1999) made the following management recommendations: destratify lake with aerator, control aquatic vegetation, and change the slot limit for largemouth bass to improve size structure. In 2000, WDFW adjusted the slot length for largemouth bass from 12-15 to 12-17 inches (5 fish limit; no more than one fish over 17 inches may be retained).

As early as the 1930s, there was considerable interest in the crappie fishery at Lake Cassidy. In 1938, 938 fishermen caught 2135 fish, of which 79% were black crappie (WDFW, unpublished data). Three major changes have occurred to the fish community since that time: (1) numbers of native cutthroat and coho have declined, (2) rainbow trout are planted annually to provide a trout fishery and (3) the yellow perch population has grown, and may have partially supplanted black crappie. A 1993 creel survey of 128 anglers on Lake Cassidy showed the catch of 128 fish was predominantly black crappie (39%) with the remainder split evenly between largemouth bass (21%), rainbow trout (20%), and yellow perch (18%; Curt Kraemer, WDFW, unpublished data). In 1999, black crappie comprised only 4% of the population by number; 5% by weight (Downen et al. 1999). From 2001-2003, the WDFW Warmwater Enhancement Program attempted to improve the crappie fishing on Lake Cassidy by stocking fry and adults.

Given the investment by the WDFW to enhance the crappie fishery at Lake Cassidy, we conducted a warmwater survey during spring 2011 to assess the relative abundance, growth, and condition of black crappie to inform future management decisions. Size structure, stock density indices, and relative weights of largemouth bass were used to evaluate whether changes to slot regulations have had any impact on the population. Second, we conducted a creel survey during the summer 2011 to characterize the largemouth bass, yellow perch, and crappie fisheries in terms of effort and catch rates and draw comparisons to a 1993 creel survey (Curt Kraemer, WDFW, unpublished data).

Materials and Methods

Standardized Warmwater Survey

Two WDFW biologists and one scientific technician surveyed Lake Cassidy on 9–11 May, 2011. Fish were captured using three sampling techniques: electrofishing, gill netting, and fyke netting. The electrofishing unit consisted of a 4.9-m Smith-Root 5.0 GPP electrofishing boat set to a DC current of 120 cycles/sec at three to six amps. Experimental gill nets (45.7 m long X 2.4 m deep) were constructed four sinking panels (two each at 7.6 m and 15.2 m long) of variable-mesh (13, 19, 25, and 51 mm stretched) monofilament mesh. Fyke nets were constructed of a single 30.4-m lead and two 15.2-m wings of 130 mm nylon mesh. The body of the nets stretched around four 1.2 m aluminum rings in each of two sections.

Sampling locations were selected by creating random numbers along the shoreline in ArcMap. Numbers were chosen at random to determine set points for gill and fyke nets. The entire shoreline was electrofished in eight 600-second increments, or sampling sections. While electrofishing, the boat was maneuvered through the shallows (depth range 0.2–1.5 m) adjacent to the shoreline at an average rate of 36.2 m/min. Six gill nets were set perpendicular to shore. The small-mesh end was attached onshore while the large-mesh end was anchored offshore. Four fyke nets were set in water less than three meters deep, perpendicular to the shoreline with the wings extended at 70° angles from the lead. Sampling occurred during evening hours to maximize the type and number of fish captured.

All fish were identified to species. Each fish was measured to the nearest millimeter and assigned to a 10-mm size class based on total length (TL). Fish were weighed to the nearest 0.1 gram. Once we had weighed 5 fish per cm group for a given species, we took lengths only. The remaining weights were estimated using a simple length/weight (log_{10}) regression calculated from the sub-sample. Scales from black crappie were removed from up to five fish from each 10-mm size class for aging. 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 from the deepest part of the lake during mid-day on the 11 May 2011. Additional data shown in figures 2 and 3 were collected by the Surface Water Management Team, Snohomish County Public Works. Using a Hydrolab® probe and digital recorder, we measured temperature, dissolved oxygen, and pH every two meters and specific conductance (microsiemens/cm; µS/cm) and turbidity (nephelometric turbidity units; NTU) at the surface.

Species composition by weight (kg) and number was calculated using a total of eight electrofishing sections, six gill netting sections, and four fyke netting sections. One common problem with standardized surveys in Washington is reaching the minimum sample size needed to calculate precise estimates of catch per unit effort (CPUE), proportional stock density indices (PSDs), and relative weight (Divens et al. 1996). To sample more fish, we opted to electrofish the entire shoreline (eight 600-sec sections; averaging 362 meters long) and set six variable-mesh gill nets. Standardizing effort across all gear types is desirable in most cases to reduce biases between techniques (Bonar et al. 2000). However, we opted to increase electrofishing and gillnetting effort to increase the likelihood of catching the minimum number of fish required to calculate precise, reliable fishery metrics for largemouth bass and black crappie. Fish less than one year old, i.e., young-of-the-year, were excluded from all analyses. Eliminating young-of-the-year fish prevents distortions in analyses that may have occurred due to sampling location, size bias of the gear, 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 that was electrofished. Similarly, CPUE of gill netting and fyke netting was determined by dividing the number of fish captured by the total time the nets were deployed.

Relative weight (W_r) was used to evaluate the condition of fish in Lake Cassidy. 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 (young-of-the-year). Relative weights less than 50 were also excluded from our analyses as we suspected unreliable weight measurements.

Age and growth of black crappie was 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 black crappie were then compared to those of Western Washington averages (Fletcher et al.1993) and previous years' surveys (Downen et al. 1999).

The proportional stock density (PSD) of each warmwater gamefish species was determined following procedures outlined in Anderson and Neumann (1996). PSD uses two measurements, stock length and quality length, to provide useful 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 the approximate length when fish reach maturity (Table 1). Quality length is defined as the minimum size of a fish that most anglers like to catch or begin keeping. PSD is calculated using the number of quality size fish, divided by the number of stock size fish, multiplied by 100. Stock and quality lengths, which vary by species, are based on percentages of world-record lengths. Stock length was 20-26% of world record length, whereas quality length was 36-41% of world record length.

Relative stock density (RSD) of each warmwater gamefish species was examined using the fivecell model proposed by Gabelhouse (1984). In addition to stock and quality lengths, the Gabelhouse model adds preferred, memorable, and trophy categories (Table 1). Preferred length (RSD-P) is defined as the minimum size of fish anglers would prefer to catch. Memorable length (RSD-M) 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. Preferred length is 45-55% of world record length, memorable length is 59-64% of world record length, and trophy length is 74-80% 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.

Table 1. PSD/RSD length (TL, mm) categories for fish species collected from Lake Cassidy(Snohomish County) in May 2011.

	Size				
Species	**Stock**	**Quality**	**Preferred**	**Memorable**	**Trophy**
Yellow perch	130	200	250	300	380
Black crappie	130	200	250	300	380
Brown bullhead	130	200	280	360	430
Largemouth bass	200	300	380	510	630
Pumpkinseed sunfish	80	150	200	250	300

Creel Survey

We closely followed recommendations by Hahn et al. (2000) to survey Lake Cassidy during the summer of 2011 (June-Sept). We used a two-stage nonuniform probability sampling technique described by Malvestuto et al. (1978). Our survey was divided into time blocks of 1 month and the blocks divided into weekdays and weekends (secondary sampling units; SSUs). Although weekday and weekend SSUs were not further subdivided into AM/PM strata for analyses, sample days were broken into morning shifts (0800-1400) and evening shifts (1400-2000) so that a creel clerk was not recording data for more than six hours. For each month, we randomly selected four weekday and two weekend sampling units (6 days sampled per month). Sampling probabilities across secondary sampling units were kept uniform since fishing activity levels were unknown *a priori*.

We used a roving boat design to interview anglers, gather trip information, and record effort. Angler counts were taken every two hours by circumnavigating the lake, and took 15-30 minutes to complete. Neuhold and Lu (1957) found on Utah lakes that circuits which did not exceed 1 h gave angler counts that did not differ from instantaneous counts made from a vantage point. After each angler count, interviews were conducted with anglers actively fishing (incomplete trip information). Whenever possible, completed trip information was gathered from anglers exiting the fishery. When anglers' trips spanned the morning and evening shift, a second interview was conducted in the evening to update the incomplete trip information.

Results

Standardized Warmwater Survey

Water chemistry

Hypoxic conditions were present below one meter on 24 August and below three meters on 24 September, 2011 (Figure 3; Snohomish County Public Works) suggesting that the principal volume of water becomes hypoxic in late summer.

Table 2. Water quality data from the deepest point on Lake Cassidy (Snohomish County) collected mid-day on 11 May 2011. Secchi depth = 1.4 m.

Depth (m)	Temp (°C)	DO (mg/L)	pH	Conductance (μS/cm)	Turbidity
Surface	12.77	7.77	6.96	34.6	3.3
2	12.35	7.65	6.92		
4	10	6.5	6.98		
6	9.35	5.38	6.73		
8	9.24	5.28	6.68		

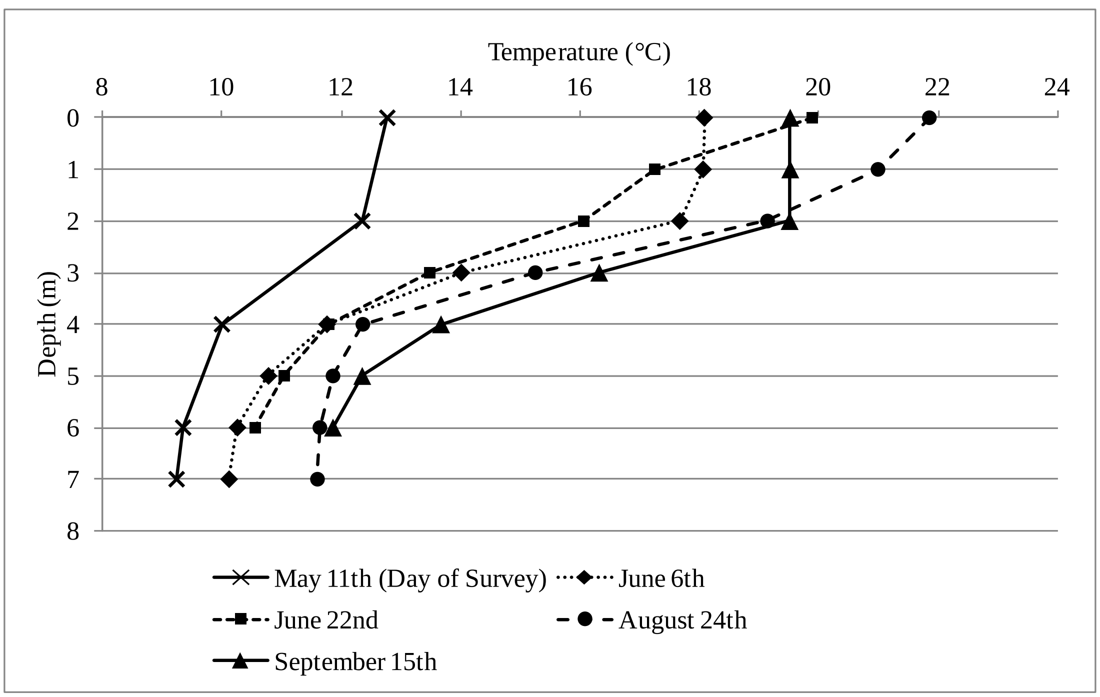

Figure 2. Vertical temperature profiles of Lake Cassidy taken during 2011. Data from June-September were collected by the Snohomish County Public Works, Surface Water Management.

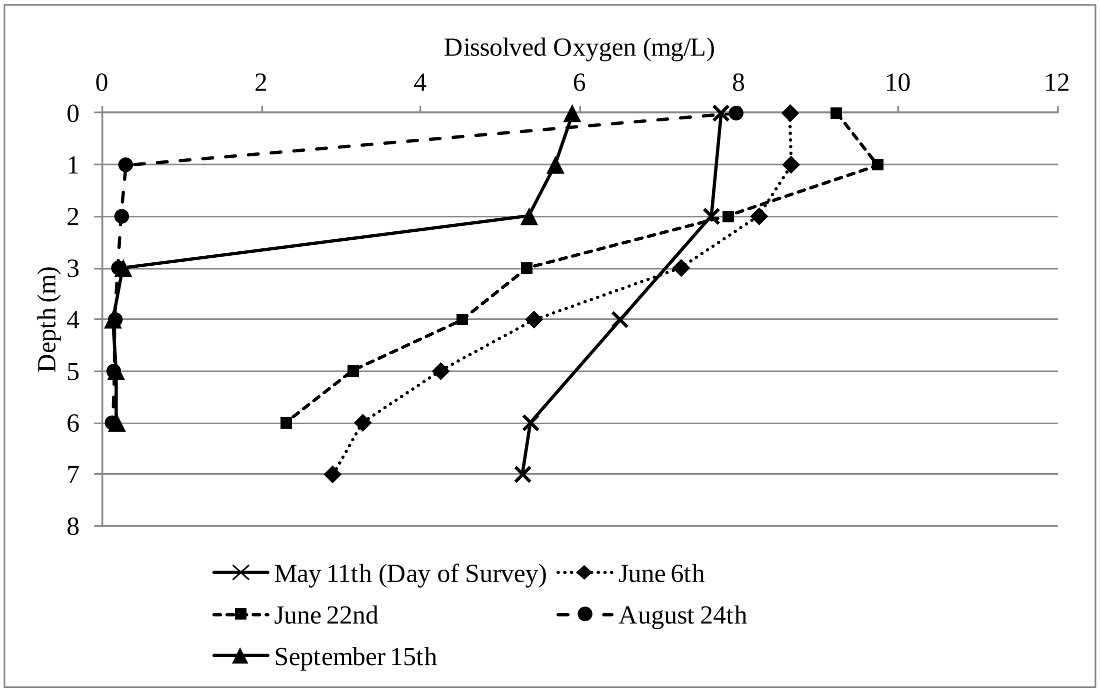

Figure 3. Vertical dissolved oxygen profiles of Lake Cassidy taken during 2011. Data from June-September were collected by the Snohomish County Public Works, Surface Water Management.

Species Composition

A total of 531 individuals representing seven species were collected during the three-day sampling effort on Lake Cassidy. Yellow perch were by far the most abundant species, accounting for 76.5% of the catch by number and 40.7% of the biomass (Table 3). Twenty five largemouth bass ranging from 142 to 482 mm comprised 25.5% of the biomass. Black crappie was the second most abundant species by number (9.6%), but only accounted for 6.1% of the biomass. Twenty four rainbow trout ranging from 211 to 433 mm comprised 21.6% of the biomass. Pumpkinseed sunfish (n=16), brown bullhead (n=6), and cutthroat trout (n=3) were present in low numbers, and comprised 6% of the biomass sampled.

Table 3. Species composition, by weight and number, of fish sampled at Lake Cassidy (Snohomish County) during May 2011.

	Species Composition				
	by weight		by number		Size range
Species	**(kg)**	**(%)**	**(#)**	**(%)**	**(mm TL)**
Largemouth bass (*Micropterus salmoides*)	15.4	25.5	25	4.7	142–482
Black crappie (*Pomoxis nigromaculatus*)	3.7	6.1	51	9.6	93–280
Yellow perch (*Perca flavescens*)	24.6	40.7	406	76.5	91–282
Pumpkinseed sunfish (*Lepomis gibbosus*)	1.5	2.4	16	3.0	104–180
Brown bullhead (*Ameiurus nebulosus*)	1.8	2.9	6	1.1	228–318
Rainbow trout (*Oncorhynchus mykiss*)	13.0	21.6	24	4.5	211–433
Cutthroat trout (*Oncorhynchus clarkii*)	0.4	0.7	3	0.6	190–311

Catch per unit effort (CPUE)

Electrofishing captured more fish (n=393) in Lake Cassidy than gill nets (n=138) or fyke nets (n=0). Electrofishing catch rates were highest for yellow perch (35.5 fish/hr), black crappie (4.6 fish/hr), and largemouth bass (2.8 fish/hr; Table 4). Gill netting catch rates were highest for yellow perch (19.5 fish/net-night). Yellow perch tend to inhabit limnetic water, particularly as adults, and are sampled more effectively using gill nets (Hamley 1975). No fish were caught in fyke nets.

Table 4. Mean catch per unit effort and 80% confidence intervals, by sampling method, for fish stock length and larger collected from Lake Cassidy (Snohomish County) during May 2011.

	Gear Type					
Species	**Electrofishing (#fish/h)**	**n (shock sites)**	**Gill netting (#fish/h)**	**n (net nights)**	**Fyke netting (#fish/h)**	**n (net nights)**
Largemouth bass	2.8 ± 1.3	8	0.3 ± 0.4	6	0	4
Black crappie	4.6 ± 2.7	8	2.3 ± 1.1	6	0	4
Pumpkinseed sunfish	1.8 ± 1.2	8	0.2 ± 0.3	6	0	4
Brown bullhead	0.7 ± 0.9	8	0	6	0	4
Yellow perch	35.5 ± 9.3	8	19.5 ± 8.3	6	0	4
Rainbow trout	2.7 ± 2.3	8	0.3 ± 0.6	6	0	4

Stock density indices

Electrofishing sample sizes were low for all stock-length fishes, with the exception of yellow perch (n=223; Table 5). Gill netting sample sizes of stock length fish were also high for yellow perch (n=116), but low for other species. Although the sample size was less than preferred, largemouth bass PSD and RSD values from electrofishing indicate a population with quality fish present. Stock density values for black crappie and yellow perch were consistent between gears, and suggest that 20-30% of stock fish are greater than or equal to quality size.

Table 5. Traditional stock density indices, including 80% confidence intervals, of fish collected from Lake Cassidy (Snohomish County) in May 2011, by sampling method.

Species	Gear Type	# stock length fish	PSD	RSD-P	RSD-M	RSD-T
Largemouth bass	EB	22	64 ± 13	23 ± 11	0	0
	GN	2	100*	0	0	0
	FN	0				
Black crappie	EB	21	29 ± 13	24 ± 12	0	0
	GN	10	20 ± 16	20 ± 16	0	0
	FN	0				
Pumpkinseed sunfish	EB	15	80 ± 13	0	0	0
	GN	1	0	0	0	0
	FN	0				
Brown bullhead	EB	6	100*	17*	0	0
	GN	0				
	FN	0				
Yellow perch	EB	223	28 ± 4	0	0	0
	GN	116	25 ± 5	0	0	0
	FN	0				

Largemouth Bass

Largemouth bass sampled from Lake Cassidy ranged in length from 142 to 482 mm total length (Table 3; Figure 4). The condition of largemouth bass varied from 71 to 113, with a mean of 95 (Figure 5). There was no observed relation between fish size and condition.

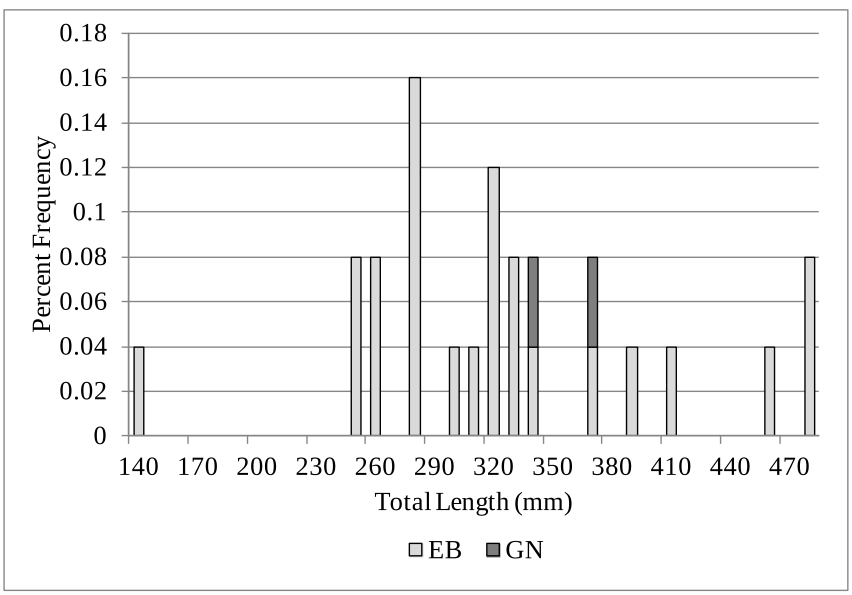

Figure 4. Length frequency distribution of largemouth bass, excluding young-of-the year, sampled by electrofishing (EB) and gill netting (GN) at Lake Cassidy (Snohomish County) during May 2011.

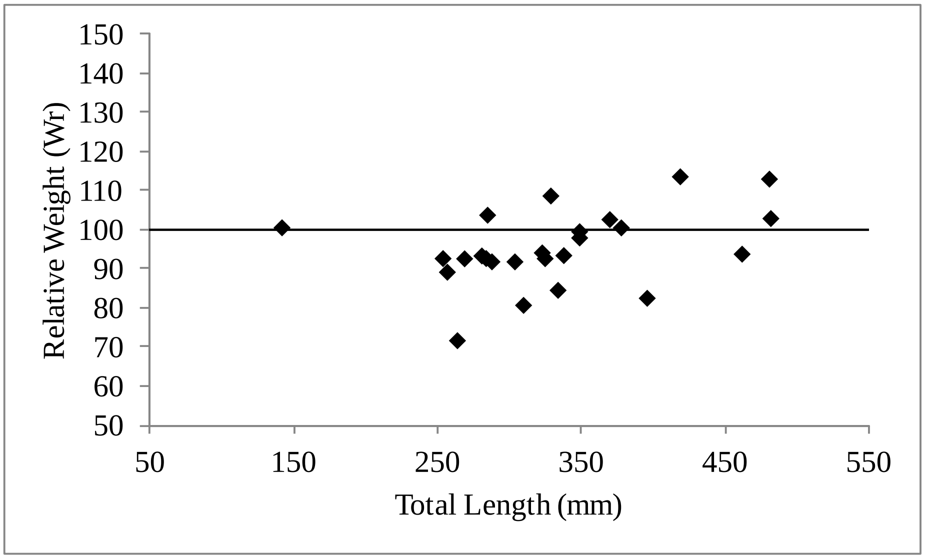

Figure 5. Relative weights of largemouth bass (n=25), excluding young-of-the year, sampled at Lake Cassidy (Snohomish County) during May 2011, as compared to the national average, Wr=100 (Anderson and Neumann 1996).

Black Crappie

Black crappie sampled from Lake Cassidy ranged in length from 93 to 280 mm total length (Table 3; Figure 6). The condition of black crappie varied from 86 to 131, with a mean of 103 (Figure 7). There was no observed relation between fish size and condition. Fish ranged in age from 1 to 7 years (Table 6). Growth of age-2 and age-3 black crappie was below the western Washington average; growth of age-4 and age-6 was above the western Washington average, but sample size was low for all age classes greater than two years (≤ 6 individuals). Black crappie length frequency (Figure 6) and age data (Table 6) suggest unstable year-class strengths. Length at age of black crappie was not significantly different between sampling years or between Lake Cassidy and the western Washington average (ANOVA; P-value >0.05).

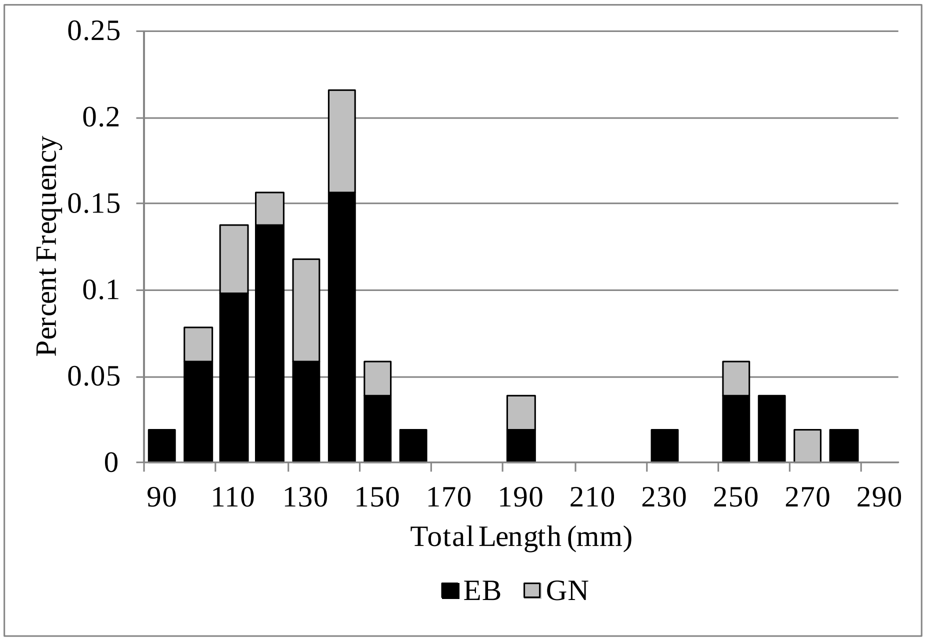

Figure 6 Length frequency distribution of black crappie, excluding young-of-the year, sampled by electrofishing (EB) and gill netting (GN) at Lake Cassidy (Snohomish County) during May 2011.

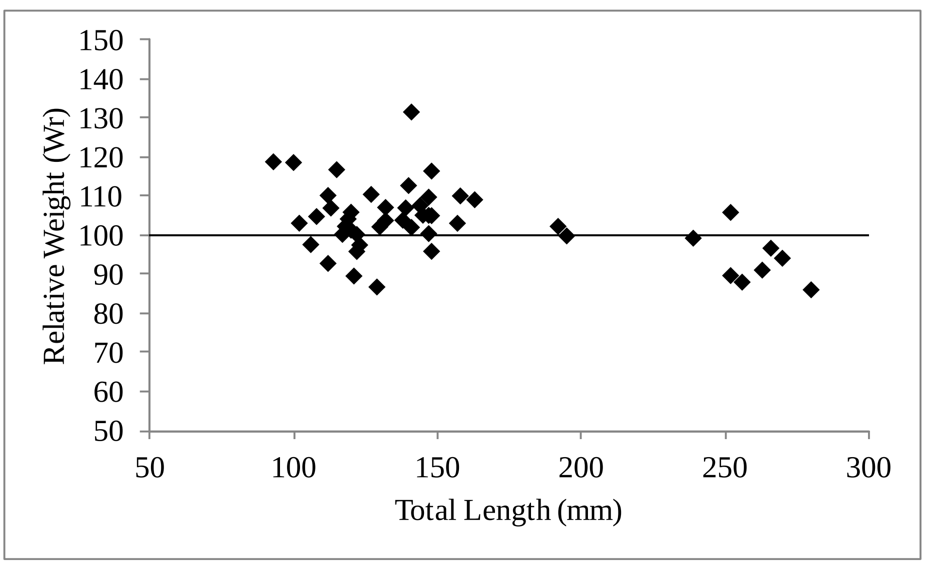

Figure 7 Relative weights of black crappie (n=51), excluding young-of-the year, sampled at Lake Cassidy (Snohomish County) during May 2011, as compared to the national average, Wr=100 (Anderson and Neumann 1996).

Table 6. Back calculated mean length at age (mm) of black crappie collected at Lake Cassidy (Snohomish County) during May 2011. Unshaded values represent length at age calculated using the direct proportion method (Fletcher et al. 1993). Shaded values represent length at age calculated using Lee's modification of the direct proportion method (Carlander 1982).

		Mean total length (mm) at age						
Year Class	# Fish	1	2	3	4	5	6	7
2010	0							
2009	37	36.4	128.8					
		61.5	129.1					
2008	3	31	86.9	168.7				
		58.6	102.9	168.7				
2007	1	20.3	63.5	145.8	239			
		52.3	89.2	159.5	239			
2006	0							
2005	6	30.1	75.5	132.3	198.6	239	263.8	
		61.1	100.5	149.7	207.2	242.3	263.8	
2004	1	23.7	52.1	101.1	175.4	211.8	238.6	256
		55.5	80	122.3	186.4	217.8	240.9	256
Overall Mean		28.3	81.4	137.0	204.3	225.4	251.2	256.0
Weighted Mean		61.0	122.0	153.3	208.6	238.8	260.5	256.0
1982 Survey mean		41.9	95.8	154.4	194.3	207.5		
1998 Survey mean		26.8	103.0	184.4	240.2			
Western WA average		46	111.2	156.7	183.4	220	224	261.1

Yellow Perch

Yellow perch sampled from Lake Cassidy ranged in length from 91 to 282 mm total length (Table 3; Figure 8). The condition of yellow perch varied from 86 to 131, with a mean of 85 (Figure 9). Fish condition decreased as fish size increased, but a trend was not observed (R^2=0.16).

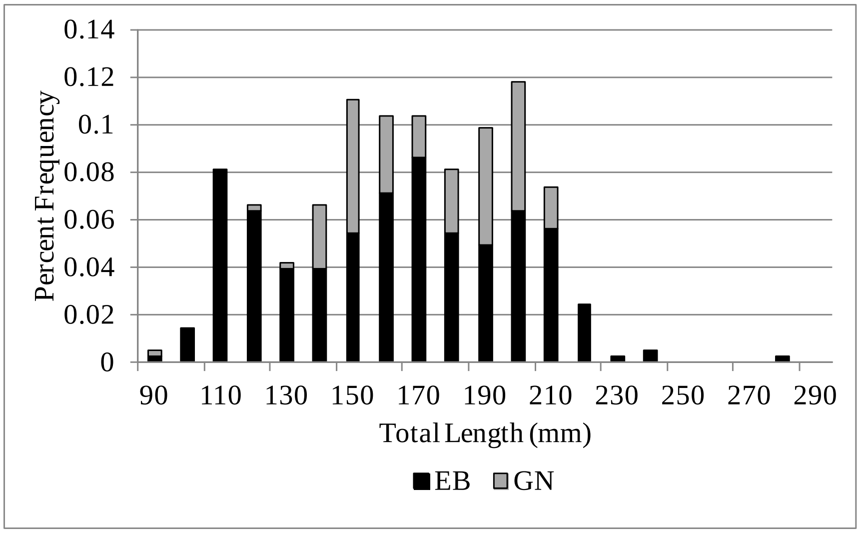

Figure 8. Length frequency distribution of yellow perch, excluding young-of-the year, sampled by electrofishing (EB) and gill netting (GN) at Lake Cassidy (Snohomish County) during May 2011.

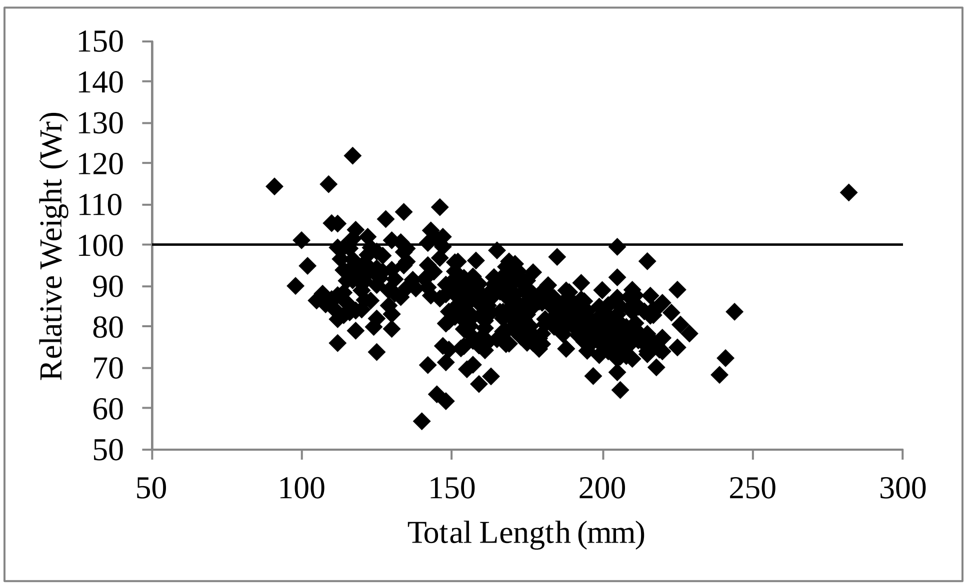

Figure 9. Relative weights of yellow perch (n=406), excluding young-of-the year, sampled at Lake Cassidy (Snohomish County) during May 2011, as compared to the national average, Wr=100 (Anderson and Neumann 1996).

Creel Survey

Effort

Boat and shoreline angling effort was fairly consistent across months, though peak angling effort occurred during the month of August (Table 7). Among boat anglers, largemouth bass was by far the most popular target species (46% of interviews), followed by "any species" (26%), rainbow trout (11%), and yellow perch (10%; Table 8). Among shoreline anglers, "any species" was most popular (52%), followed by yellow perch (26%), rainbow trout (10%), and largemouth bass (7%).

Catch and Harvest

Among boat anglers, yellow perch was the most successful fishery in terms of seasonal catch rate (2.13 fish/hr; Table 9) and seasonal catch (66%; Table 10). Seasonal catch rates for largemouth bass (0.67 fish/hr) and black crappie (0.76 fish/hr; Table 9) were similar, though more anglers targeted largemouth bass (47%) than black crappie (5%; Table 8). Not surprisingly, total seasonal catch of largemouth bass (28%) exceeded black crappie (5%; Table 10). Most fish caught during the survey were released, shown as "percent harvested" in Table 10. The only observed exception occurred during the month of July when 24% of yellow perch caught were harvested. Shoreline angling results for Lake Cassidy were inconsequential to this report for the following reasons: (1) the majority of the estimated seasonal catch (74%) was recorded from boat anglers; and (2) 94% of the estimated seasonal catch by shoreline anglers was yellow perch. Thus, we report catch/harvest data for boat anglers to derive more detailed information about these fisheries.

Table 7. Estimated monthly and seasonal angling effort (hours) for Lake Cassidy by angler type, including standard error and percent relative contribution for each month.

Angler Type	Month	Total Effort (hrs)	SE	% Relative
Boat	June	7305	850	28
	July	4921	348	19
	August	8609	1246	33
	September	5109	1059	20
	TOTAL	25944	1876	
Shore	June	3807	743	23
	July	3683	309	23
	August	6331	607	39
	September	2417	371	15
	TOTAL	16237	1074	

Table 8. Number of interviews, percent relative, and estimated number of trips by target species for Lake Cassidy during the summer 2011.

Angler Type	Target Species	N Interviews	% Relative	N Trips
Boat	Largemouth bass	53	47	3538
	Any	29	26	1936
	Rainbow trout	12	11	801
	Yellow perch	11	10	734
	Black crappie	6	5	401
	Brown bullhead	1	1	67
	TOTAL			7477
Shore	Any	22	52	2683
	Yellow perch	11	26	1341
	Rainbow trout	4	10	488
	Largemouth bass	3	7	366
	Brown bullhead	2	5	244
	TOTAL			5122

Table 9. Mean monthly and seasonal catch rates (fish/hour) for species specific and general anglers (boat anglers only) at Lake Cassidy from June to September 2011. Sample sizes (N) and standard errors (SE) are reported. Totals refer to seasonal estimates.

Target Spp	N; Mean; SE	June	July	August	September	Total
Largemouth bass	N	9	18	17	9	53
	Mean	0.58	0.68	0.70	0.49	0.67
	SE	0.29	0.17	0.25	0.15	0.11
Yellow perch	N	2	4	6	0	12
	Mean	0	1.81	3.06	0	2.13
	SE	--	0.65	1.19	--	0.69
Black crappie	N	1	1	2	2	6
	Mean	0	0.40	0.83	1.25	0.76
	SE	--	--	--	--	0.44
Rainbow trout	N	5	5	2	1	17
	Mean	0.06	0	--	--	0.02
	SE	--	--	--	--	0.02
Any	N	10	4	3	11	28
	Mean (Largemouth bass)	0.05	0.78	0.15	0.27	0.25
	SE (Largemouth bass)	0.05	0.65	0.15	0.18	0.12
	Mean (Yellow perch)	0.27	2.12	1.05	2.88	1.65
	SE (Yellow perch)	0.18	0.79	0.54	1.32	0.57
	Mean (Black crappie)	0	0	0	0.54	0.21
	SE (Black crappie)	--	--	--	0.36	0.15

Table 10. Total monthly catch and harvest by species for Lake Cassidy during June-September 2011 (boat anglers only). Standard errors for catch and harvest estimates and percent harvested are shown.

Species	Month	Catch	SE(Catch)	Harvest	SE(Harvest)	%Harvested
Largemouth bass	June	1113	342	0	--	0
	July	3610	665	29	15	1
	August	4054	682	24	17	1
	September	2580	446	14	8	1
	Total	11357 **(28%)**				
Yellow perch	June	1707	454	4	4	0.2
	July	4273	777	1022	185	24
	August	9175	1296	467	99	5
	September	11412	590	23	10	0
	Total	26568 **(66%)**				
Black crappie	June	0	--	0	--	0
	July	83	43	0	--	0
	August	1636	367	0	--	0
	September	397	188	5	5	1
	Total	2116 **(5%)**				
Rainbow trout	June	74	76	4	4	5
	July	41	30	0	--	0
	August	0	--	0	--	0
	September	0	--	0	--	0
	Total	116 **(<1%)**				

Discussion

Historical creel data suggests that Lake Cassidy once supported a highly popular crappie fishery in western Washington. However, the creel data we collected in 2011 suggests this fishery may have declined since the early-90s. In 1993, a creel survey of 128 anglers showed the catch of 128 fish was predominantly black crappie (39%) with the remainder split evenly between largemouth bass (21%), rainbow trout (20%), and yellow perch (18%; Curt Kraemer, WDFW, unpublished data). In 2011, we found that black crappie only comprised 5% of the total catch and only 5% of anglers declared black crappie as their "target species."

Biological data in 1999 and 2011 provide further support for the low relative abundance of black crappie in Lake Cassidy in recent years. Downen et al. (1999) reported that black crappie comprised only 4% of the population by number; 5% by weight. In 2011, black crappie were the second most abundant species by number (9.6%), but accounted for a small percentage of the total biomass (6.1%; Table 3) relative to yellow perch (40.7%), largemouth bass (25.5%), and rainbow trout (21.6%). Size structure (Figure 6) and length at age data (Table 6) suggests weak or missing year classes in the population.

Although WDFW has made a small investment in this fishery, black crappie have been stocked infrequently and at low densities in Lake Cassidy (Table 10). The majority of black crappie we sampled in 2011 were age-2s (77%), and likely the product of natural reproduction and recruitment. Thus, endogenous factors have likely been more influential to the crappie population in recent decades than stocking regime. Factors that may be negatively affecting crappie survival and recruitment include poor water quality during the summer and food availability coupled with interspecific competition.

Table 11. Stocking data for black crappie planted in Lake Cassidy in 2001 and 2003.

Year	Month	Class	Count	Fish/acre
2001	October	Legals	200	1.6
2003	May	Fry	3328	26.6
2003	May	Legals	50	0.4

Standardized surveys conducted in 1999 and 2011 suggest that yellow perch is the dominant species in terms of numbers, biomass, and year class strength. However, historical creel data suggests the proliferation of yellow perch has likely been more recent than other introduced species. In 1938, 938 fishermen caught 2135 fish, of which 79% were black crappie and only 0.4% were yellow perch (WDFW, unpublished data). In 2011, yellow perch comprised 66% of the total seasonal catch. Despite the large temporal gap between the 1930s and the 1990s, the large relative abundance of yellow perch in Lake Cassidy coupled with catch data leads us to hypothesize that interspecific competition between black crappie and yellow perch is occurring, and may partially explain the low relative abundance of black crappie. In the absence of natural predators yellow perch have been known to out-breed and out-compete other fish species, and can dominate smaller lake systems in just a few years (Scott and Crossman 1973; Shrader 2000).

In Phillips Reservoir, Oregon, Shrader (2000) showed a decline in abundance of smallmouth bass and black crappie following the introduction of yellow perch in 1991. Diet studies revealed that juveniles of all three species competed directly for large *Daphnia*; mean length of *Daphnia* decreased significantly from 1994 to 1999. The selection of larger zooplankton by yellow perch drove the zooplankton towards smaller species and individuals that could not be utilized by young-of-the-year and juvenile bass and crappie.

Overharvest is another variable that must be considered with regard to the low relative abundance of black crappie. During the summer of 2011, estimated seasonal harvest of black crappie was very low (5 fish) relative to seasonal catch (2116 fish). Most anglers targeting black crappie practiced catch-and-release, though most of the fish encountered during both the biological and creel survey were less than 9 inches total length (minimum size for harvest/retention). Although overharvest does not appear to be a threat to the black crappie population in 2011, the role harvest played in structuring this population in past years remains uncertain.

During the peak of the fishing season (June-August), anglers primarily caught yellow perch (66%) and largemouth bass (28%; Table 10). Monthly catch of rainbow trout was very low relative to warmwater species (Table 10). Rainbow trout are stocked annually in the spring to provide additional opportunity, though only 400 triploids were planted in 2011. Thus, monthly catch data for rainbow trout does not reflect the performance of this fishery during years when greater numbers of catchable trout (2-2.5 fish/lb) are planted. Anglers targeting trout only represented 11% and 10% of seasonal boat and shoreline effort respectively (Table 8); however, peak trout fishing activity likely occurs during April and May which were not sampled during this survey.

Largemouth bass accounted for the majority of effort; 47% of boat anglers identified largemouth bass as their target species (Table 8). Mean monthly catch rates for largemouth bass were consistent across the season (0.49-0.70 fish/hour; Table 9). Despite low catch rates relative to yellow perch (1.81–3.06 fish/hour), the quality size of largemouth in Lake Cassidy was cited by many anglers as being the primary reason for their trip; others cited the secluded and private setting that Lake Cassidy provides. Biological survey results paralleled angling success in that largemouth bass were measured at low relative abundance (4.7% by number; Table 3) with a majority of quality-size and larger fish present (PSDelectrofishing= 64±13; Table 5).

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