State of California
The Resources Agency
Department of Fish and Wildlife

Clear Lake General Fish Survey
Fall, 2008

By

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Summary

In an effort to evaluate the fishery of Clear Lake, a general fish survey was conducted on September 16 and 17, 2008. For the survey, 20 random sites were selected for sampling using two electrofishing boats. Fish collected during the survey included largemouth bass (LMB) (*Micropterus salmoides)*, goldfish (GF) (*Carassius auratus*), black crappie (BCR) (*Pomoxis nigromaculatus*), white crappie (WCR) (*Pomoxis annularis*), sculpin (Cottus genus), Sacramento sucker (SS) (*Catostomus occidentalis)*, channel catfish (CCF) (*Ictalurus punctatus*), redear sunfish (RES) (*Lepomis microlophus*), green sunfish (GSF) (*Lepomis cyanellus*), bluegill (BG) (*Lepomis macrochirus*), Clear Lake hitch (HCH) (*Lavinia exilicauda chi*), and common carp (CC) (*Cyprinus carpio*). After the survey was conducted, Clear Lake was determined to have a wide diversity of healthy fish species. The fall, 2008 data will be compared to future fall survey efforts in order to monitor the status of this fishery.

Introduction

Clear Lake is the largest and oldest lake completely within the California border (Macedo 1988). The lake was formed by a lava flow blocking Cache Creek. Volcanic activity in the area provided heat to drive hydrothermal systems that created rich mineral deposits (Suchanek et. al 2002). Beginning in the mid -1870s, abundant mineral springs attracted thousands of health-conscious citizens to the region (Simoons 1952). Cache Creek Dam was constructed at the outlet in 1915 to manage the water level for agricultural irrigation with typical fluctuation in water level of only a few feet (Cox 2007). Clear Lake is located in Lake County within the northern coast range at an elevation of 402 m (1,319 ft.) above mean sea level. It is surrounded by a complex geological formation which includes an area of substantial geothermal activity. Clear Lake has a surface area of 43,663 acres, an average depth of 21.3 feet, and a maximum depth of 59 feet (Figure 1).

Figure 1. Clear Lake, Lake County.

The lake is highly eutrophic, frequently beset by thick, blue-green algae blooms (Week 1982). The lake is located approximately 13 miles east of the city of Hopland and is used for storage of agricultural irrigation water for downstream Yolo County. The Yolo County Flood and Water Conservation District owns the right to use the water in the lake and regulates the flow of releases from the single outlet dam to Cache Creek (Suchanek et. al 2002)

Methods and Materials

The crew consisted of at least two forward netters and one boat operator. Twenty sites were sampled for an average of 586.5 electrofishing seconds (9.8 minutes) using two 18 ft. Smith-Root electrofishing boats. Pulsed DC current (2-12 amps) was used to “stun” the fish. When an electrical field was applied to the water it was measured on a counter and this time was recorded as generator seconds for each transect. Fish under electronarcosis were netted and placed in a holding tank. An effort was made to capture all shocked fish except inland silverside (*Menidia berylilina*) and threadfin shad (*Dorosoma petenense*), which were noted for their presence. Small fish (< 25 mm) sometimes eluded capture as did those fish on the outer edge of the electrical field. The mean length and weight for each species was determined and an analysis of population parameters were evaluated for selected species. These parameters include Catch per Unit of Effort (CPUE) weight-length relationships, relative Weight (Wr), and proportional stock density (PSD) (Anderson, R.O. and R.M. Neumann 1996). For each transect, fish were identified to species and had measurements recorded for total length (TL) in mm and weights in grams (g). Weights were determined using a digital scale.

Catch Per Unit of Effort

Catch per unit effort (CPUE) is defined as the number of fish collected per minute of shocking time. The data was used to estimate (CPUE) for all species combined and for individual species.

CPUE = N/M

where:

N = total number of collected or the total number of a species and

M = number of minutes that the electric field was active in the water

Relative Weight (Wr)

Relative Weights (Wr) are used to represent the overall condition of the species in Clear Lake. A fish’s length is generally the primary determinant of its weight and increases in length will result in increases in weight. However, an increase in a fish’s length is not always in direct proportion with an increase in its weight. These fish tend to change shape as they grow which is allometric growth. Relative Weight represents a modification of the Relative Condition Factor

(Kn) that compensates for fish that exhibit these allometric growth patterns. The Wr is based on the assumption that the slope & intercept of the weight-length relationship are the same as in the "ideal" equation used in its calculation (Cone 1989). To determine the Wr for species sampled at Clear Lake, the following equations were used:

$$\mathbf{Wr = (W/Ws) \times 100}$$

Where:

Wr = the condition of an individual fish.

W = weight in grams

Ws = length-specific standard weight predicted by a length-weight regression for a species.

The equation to determine the Ws is:

$$\mathbf{\log10\ (Ws) = a' + b * \log10\ (L)}$$

Where:

a' = intercept value

b = slope of the log10 (weight) – log10 (length) regression equation

L = maximum total length

The intercept & slope parameters for standard weight (Ws) equations are taken from using the standard equations for that particular species found in Fisheries Techniques (1996) when possible. In concept, a mean Wr of 100 for a broad range of size-groups may reflect ecological and physiological optimality for populations (Murphy 1996). The relative weight index ranges for determining the condition of selected species are: 110 and above: excellent, 90-109: good, 70-89: average, and 69 and below: poor (Ewing and Granfors, personal communication).

If a minimum sample size of 30 of a given species is not collected or a minimum size is not met, no relative weights will be calculated.

Proportional Stock Density (PSD)

Proportional stock density (PSD) is a numerical description of length-frequency data. The PSD is the percentage of a given species which are of a stock length and those which are also of a quality length. Length categories that have been proposed by Gablehouse (1984) for various fish species are presented in Table 1.

PSD = (number of fish $\geq$ minimum quality length) / (number of fish $\geq$ minimum stock length) x 100

According to R.O. Anderson and R. M. Neumann (1996) when PSD is reported it should be rounded to the nearest whole number and should not include a percent symbol. If decimals are used they imply an accuracy which is not supported by this analysis.

Table 1. Proportional stock density length categories for selected species Gablehouse (1984). Measurements are minimum total lengths in millimeters for each category.

Species	Stock (mm)	Quality (mm)
Bluegill	80	150
Common carp	280	410
Largemouth bass	200	300
Redear sunfish	100	180

Relative Stock Density (RSD)

Similar to proportional stock density (PSD), the relative stock densities (RSD) is a percentage of a given species of a minimum stock length as compared to those which are of a preferred, memorable or trophy lengths.

RSD-P = (number of fish $\geq$ minimum preferred length) / (number of fish $\geq$ minimum stock length) x 100

RSD-M = (number of fish $\geq$ minimum memorable length) / (number of fish $\geq$ minimum stock length) x 100

For bluegill Gablehouse (1984) found the preferred size is 200 mm and the memorable size is 250 mm. For redear sunfish Gablehouse (1984) found the preferred size is 230 mm and the memorable size is 280 mm.

As with PSD, RSD should be rounded to the nearest whole number so as not to imply a greater accuracy than is supported by this analysis. According to Gablehouse (1984) a balanced population of largemouth bass PSD should be 40 to 70, with the RSD-P being 10 to 40 and RSD-M of 0 to 10 using the published smaller stock and quality sizes (Table 2). Anderson (1985) identified balanced populations of bluegill as having a PSD of 20 to 60, with RSD-P of 5 to 20 and RSD-M of 0 to 10 (Table 2).

Table 2. Generally accepted proportional stock density (PSD) index ranges for balanced fish populations (from Willis et al. 1993).

Species	PSD	RSD-P	RSD-M	Source
Bluegill	20-60	5-20	0-10	Anderson (1985)
Crappie	30 - 60	>10		Gablehouse (1984)
Largemouth bass	40-70	10-40	0-10	Gablehouse (1984)

Weight-Length Relationship

Linear regression values for the length-weight relationship were determined for selected species. The linear regression line slope and intercept values enabled us to estimate the weight of a fish if the total length is known. The regression equation is expressed as:

$$y = a + bx$$

Where:

y = estimated weight

a = intercept of the line

b = slope of the line

x = independent variable of total length

The intercept and slope values were generated using Microsoft Excel©.

If the R^2 value was less than 0.8, no figure would be made due to the unreliability of calculating a weight from a given total length and vice versa.

Results and Discussion

Table 3 summarizes the species composition, mean total length and weight, catch per unit effort, length ranges, and mean relative weights of species collected whenever possible. A total of 1185 fish representing thirteen species were collected during the survey (Table 3). Largemouth bass comprised over 75.7% of the total fish sampled. Bluegill followed with 15.5% of the total fish sampled. Black crappie made up 4.1% of the total fish sampled followed by white crappie with 1.4%. Common carp and channel catfish comprised of 0.8% of total fish sampled while GF, GSF, and sculpin were 0.3% of the catch. Lastly, SS, CLH, RES , and inland silverside each represented 0.1% of the total fish sampled in Clear Lake. The total CPUE for this survey effort was 6.06 fish/min.

Table 3. Species composition from Clear Lake, September 16 and 17, 2008.

	Species	Number	Percent	CPUE	Mean TL (mm)	Mean Weight (g)*	Length Ranges	Mean Relative Weight
1	Largemouth bass	897	75.7%	4.59	314.6	969.2	70 - 576	109
2	Bluegill	191	16.1%	0.98	120.6	62.1	46 - 183	110
3	Black crappie	48	4.1%	0.25	267.6	476.9	95 - 375	NA
4	White crappie	16	1.4%	0.08	92.2	334.4	53 - 342	NA

Table 3 continued

5	Common carp	10	0.8%	0.05	295.0	8.0	95 - 606	NA
6	Channel catfish	10	0.8%	0.05	606.5	2628.8	545 - 650	NA
7	Goldfish	3	0.3%	0.02	300.3	1160.5	131 - 390	NA
8	Green sunfish	3	0.3%	0.02	169.7	122	97 - 145	NA
9	Sculpin	3	0.3%	0.02	82.5	8	NA	NA
10	Sacramento sucker	1	0.1%	0.01	NA	NA	NA	NA
11	Clear Lake hitch	1	0.1%	0.01	230.0	117.0	NA	NA
12	Redear sunfish	1	0.1%	0.01	175.0	125	NA	NA
13	Inland Silverside	1	0.1%	0.01	NA	NA	NA	NA
	Total	1185						
	Generator minutes:	195.5						
	CPUE (Fish/ gen. min)	6.06						

*Weights were only collected when the minimum total length for channel catfish was 70 mm, bluegill, tule perch, redear sunfish, green sunfish was 80 mm, 90 mm for goldfish, sucker, hitch, Sacramento blackfish, 100 mm for crappie, 150 mm for largemouth bass.

**Water temperature was an average taken from one to multiple transects on three different days.

Largemouth bass

As seen in Table 3, LMB total length ranged from 70 – 576 mm (2.8 – 22.7 in.). The length frequency distribution for LMB is presented in Figure 2. The length class with the highest frequency was the 400 mm (15.7 in.) class. This length class was at least four years old (Moyle 2002a). The length frequency distribution shows a LMB population did not have an even distribution but rather a binomial distribution (Figure 2).

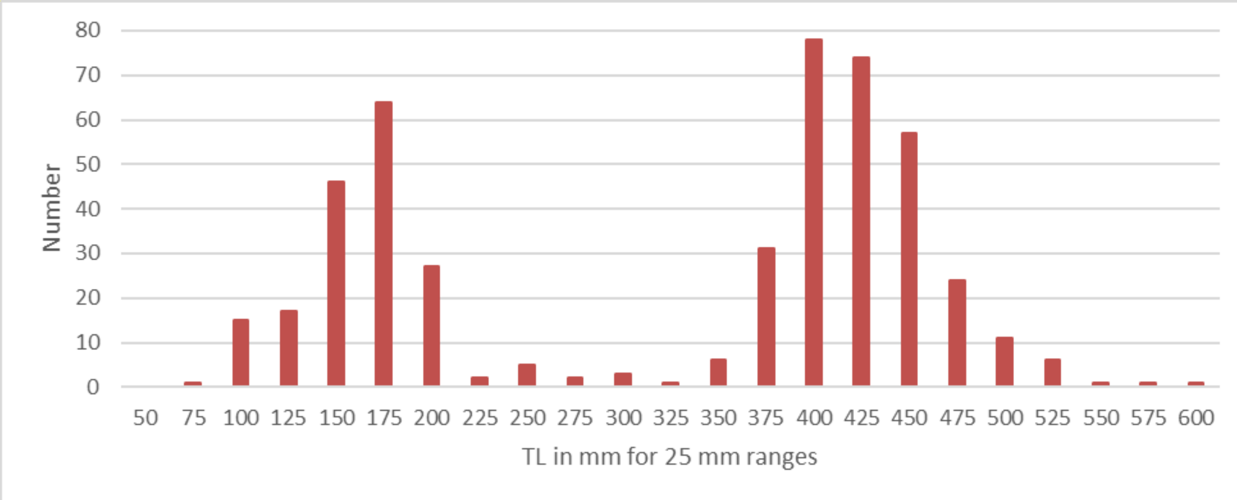

Figure 2. Length frequency for largemouth bass capture by electrofishing at Clear Lake, Fall, 2008.

PSD for LMB was 96 and RSD was 83. Both of these numbers indicate that the LMB fishery in Clear Lake has an unbalanced population with more quality and preferred- sized fish present than stock- sized ones. The Wr of LMB was 109, indicating that they are good condition. With an R^2 of 0.8654, a linear regression model is reliable enough to predict the length of LMB in Clear Lake with a given weight (Figure 3).

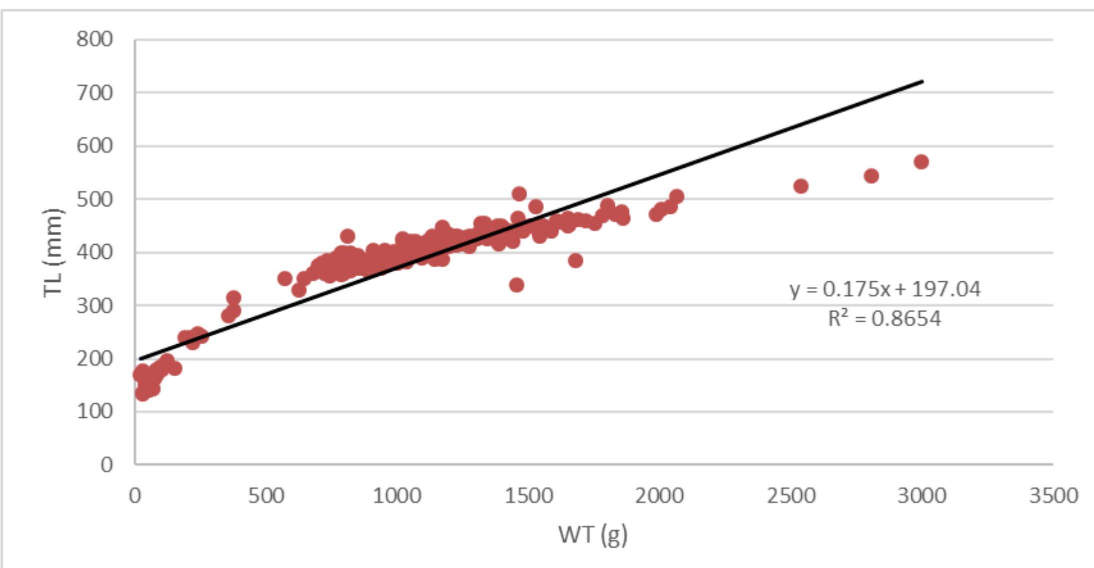

Figure 3. Total length-weight scatter plot with linear regression line for largemouth bass captured at Clear Lake, Fall, 2008.

Bluegill

Bluegill ranged in total length from 46–183mm (1.8 –7.2in) (Table 3). The total lengths are distributed fairly even though the majority of the fish are less than quality-size (Figure 4). BG had a PSD of seven and RSD-P of zero. This indicates that the BG population is unbalanced with stock-sized fish out numbering quality and preferred-sized fish. The mean relative weight of BG was 110. This indicates that they are in excellent condition. A length-weight linear regression was performed, but since the R^2 came out to 0.7152, the model was not reliable.

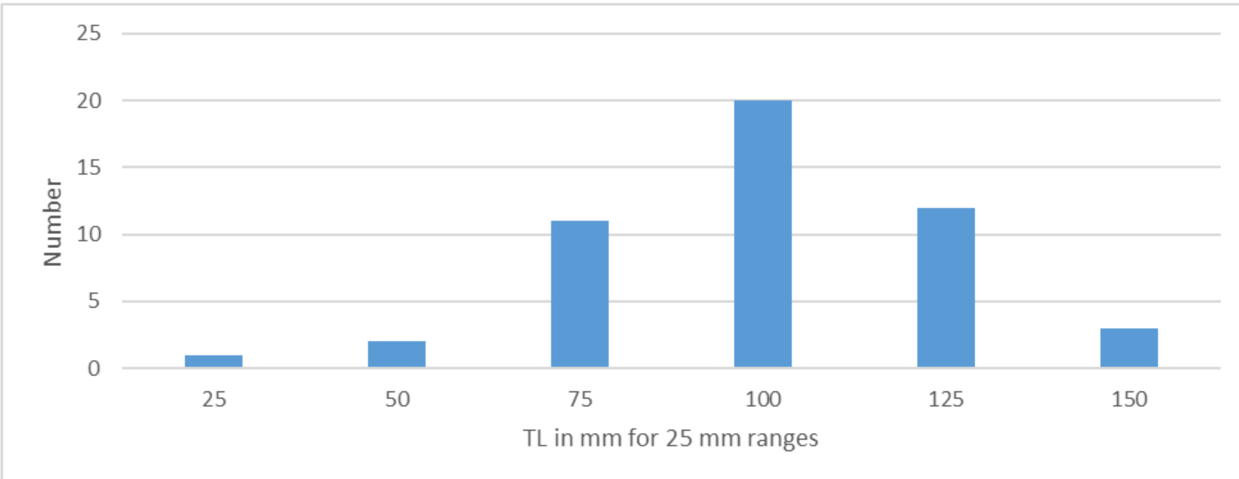

Figure 4. Length-frequency for bluegill capture by electrofishing at Clear Lake, Fall, 2008

Black crappie

Black crappie of Clear Lake ranged in total length from 95-375mm (3.7-14.8in) (Table 3). Of the 48 BCR caught, 17 were measured and 11 were weighed. Total lengths were unevenly distributed and the most frequency size cohort encounter was 300mm (11.8in) (Figure 5). Both the PSD and RSD-P was 73, making the population unbalanced. This imbalance favors quality and preferred-sized fish. There were not enough weights available to form a linear regression model or calculate the mean relative weight.

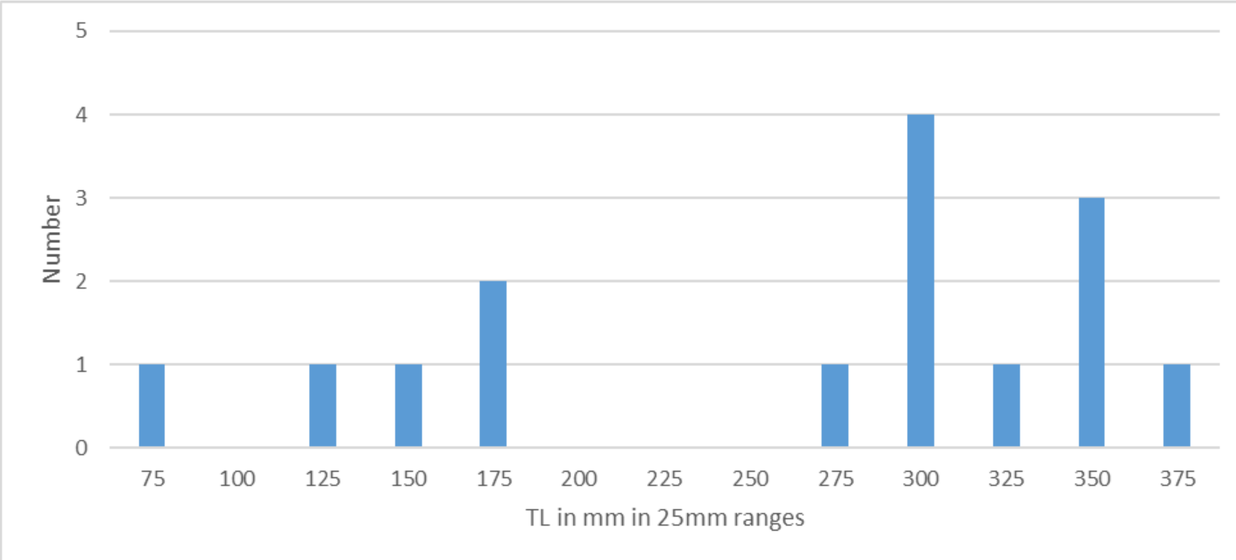

Figure 5. Length-frequency for black crappie by electrofishing at Clear Lake, Fall, 2008.

Conclusions

Clear Lake is home to a wide variety of fish species and provides a great recreational fishery for those wanting to fish in Lake County.

Black crappie were third most abundant in Clear Lake. They were observed to have a high PSD and RSD. These high PSD and RSD's show that 73% of stock length black crappie were longer than quality length. There was not enough weight data to assess their growth rates, but black crappie are known to grow at excellent growth rates in Clear Lake (Moyle 2002).

For BG, it was observed that they had a low PSD and RSD showing a population imbalance favoring stock -sized fish over quality and preferred- sized fish. Of all the stock -sized fish, none of them broached into the territory of quality or preferred lengths. In spite of low PSD and RSD values, according to their mean relative weight the BG sampled are in excellent condition. While bluegill are numerous enough to constitute 16.1% (Table 3) of the fish surveyed, the majority of them did not exceed 100mm (Figure 3). Angling for BG usually does not have an impact on the size distribution of a population because of the species high reproductive rates, A mixture of interspecies competition stunting individual growth and a possible limited genetic background for bluegill brought into California are more likely factors for why many of these fish did not reach quality or preferred sizes (Moyle 2002). While intraspecific competition has the potential to limit BG populations as well as their predators', (LMB) population, LMB still made up for 75.7% of the fish sampled (Table 3). Both the PSD and RSD values were very high for LMB, and both show that the proportion of the sizes in the population skew in favor towards the quality and preferred -sized fishes. With 96% of stock LMB measured beyond quality size and 86% of them measured exceeded preferred size this indicates the population is imbalanced. However, the mean relative weight indicates that as individuals, the LMB are in good condition. Largemouth bass is the main draw for anglers to Clear Lake. With the Clear Lake LMB population favoring quality and preferred sized fish over stock sized ones, there are great opportunities for anglers to catch big fish. All other species of fish caught made up of only 4.2% of the fish surveyed. Native species such as SS, sculpin, and CLH only consisted of 0.5% of the fish sampled.

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