California Department of Fish and Wildlife
North Central Region
Sierra District

Summary of the Clear Lake Hitch Population Estimate for Cole and Kelsey Creeks, Lake County

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Introduction and Location

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). The 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). The lake is highly eutrophic, frequently beset by thick blue-green algae blooms (Week 1982). Beginning in the mid 1870's, 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). The lake is used for storage of agricultural irrigation water for downstream Yolo County. The Yolo County Flood and Water Conservation District owns the rights to use the water in the lake and regulates the flow of releases from the single outlet dame to Cache Creek (Suchanek et. al 2002).

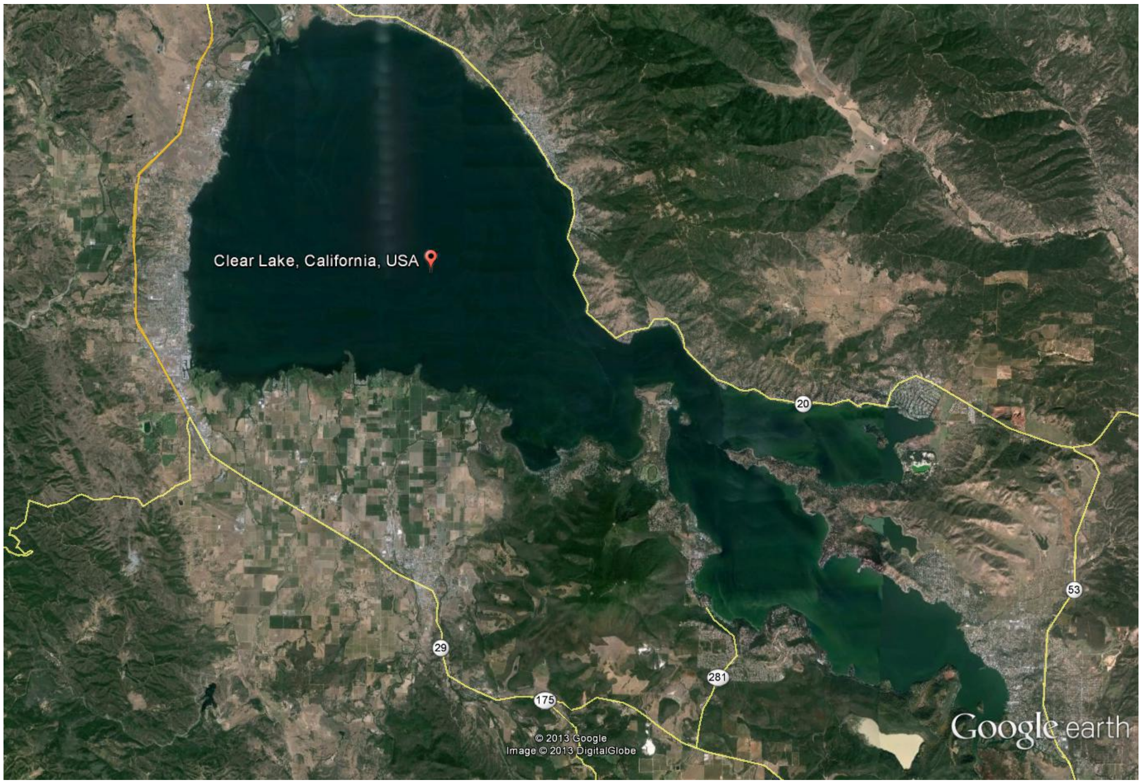

Figure 1**.** Map of Clear Lake.

In September of 2012, The Center for Biological Diversity submitted a petition to the United States Fish and Wildlife Service (USFWS) and the California Department of Fish and Wildlife (CDFW) to list the Clear Lake Hitch (*Lavinia exilicauda chi*) (hitch) as a threatened and/or endangered species. This is pursuant to the federal Endangered Species Act and the California Endangered Species Act (CESA) (Fish and Game Code, 2050). In March of 2013, the California Fish and Game Commission voted to move the hitch to candidacy under CESA.

CDFW conducted a population estimate of hitch in two of the tributaries of the lake to estimate the abundance and distribution of hitch, which will help in the status review process under CESA. This report presents estimates of population size with 95% confidence intervals, for Clear Lake Hitch in Kelsey and Cole Creeks. The estimate with accompanying confidence intervals was based on multiple mark and recapture survey efforts.

The lake is located approximately 13 miles east of the city of Hopland (Figure 2).

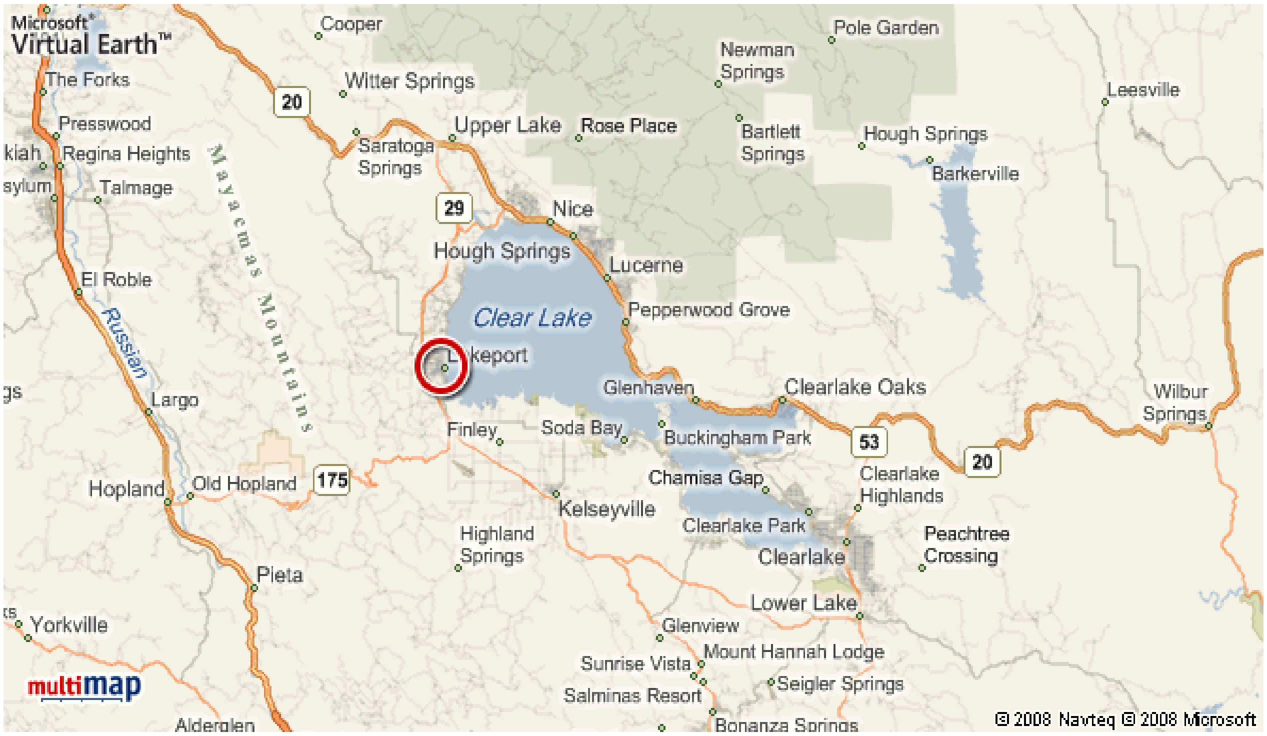

Figure 2. Map of Clear Lake in relation to Hopland.

Methods

In estimating the population of hitch in these historic spawning tributaries, we considered the populations to be "closed". According to, Anderson and Newman, 1996; Krebs 1999; and Seber 1982; the following assumptions have to be true for the estimates to be reliable.

(a) The population is closed, so that N (the population) is constant.

(b) All animals have the same probability of being caught in the first sample

(c) Marking does not affect the catchability of an animal.

(d) The second sample is a simple random sample, i.e. each of the possible samples has an equal chance of being chosen.

(e) Animals do not lose their marks in the time between the two samples.

(f) All marks are reported on recovery in the second sample.

In a closed population it is assumed that the population size is constant without recruitment or losses. This includes fish growing into the specific size range during the sampling period. When the assumptions are not met, the estimate is not reliable and will result in large confidence intervals.

Schnabel Method

The Schnabel Method (SM) relies on a series of marking and recapturing efforts to determine the population size. A single mark is used is for all sampling efforts. The following equations were taken from Krebs, 1999. For each sample time (*t*) the following are recorded:

C_t = Total number of individuals caught in sample *t*.

R_t – Number of individuals already marked when caught in sample *t*.

U_t = number of individuals marked for the first time and released in sample *t*.

The population estimates are weighted average of Petersen Estimates:

$$N \frac{\sum_t (C_t M_t)}{\sum_t R_t}$$

The variance of the Schnabel estimator is calculated on the reciprocal of N:

$$Variance\left(\frac{1}{\hat{N}}\right) = \frac{\sum R_t}{\left(\sum C_t M_t\right)^2}$$

Standard error of $\frac{1}{\hat{N}} = \sqrt{Variance\left(\frac{1}{\hat{N}}\right)}$

Confidence Intervals

According to Krebs (1999) and Seber (1982) when recaptures exceed 50 it is best to use the standard error and a *t*- table value to get confidence intervals for ($\frac{1}{\hat{N}}$). The following equation was used:

$$\frac{1}{\hat{N}} \pm t_{\alpha} S.E.$$

Where S.E. = standard error of 1/N

t_{α} = value from Student's t-table for $(100-\alpha)$ % confidence limits.

Enter the t-table with (s-1) degrees of freedom, where s is the number of samples.

When the total number of recaptures is less than 50, confidence limits for the Schnabel population estimate should be obtained from the Poisson distribution (Table 2.1) (Krebs 1999).

Schumacher Eschmeyer Method

Like the Schnabel Method the Schumacher Eschmeyer Method (SEM) is a multiple mark recapture technique for estimating the size of the population. This method uses linear regression techniques to determine the population size assuming that there is a line passing through the origin when the values are plotted.

The appropriate formula for this estimation is (Krebs 1999):

$$\hat{N} = \frac{\sum_{t=1}^{s}\left(C_t M_t^2\right)}{\sum_{t=1}^{s}\left(R_t M_t\right)}$$

The variance and standard error are then calculated for the reciprocal of the population. The following equations are used to obtain these values:

$$\text{Variance of } \left(\frac{1}{\hat{N}}\right) = \frac{\sum\left(R_t^2/C_t\right) - \left[\left(\sum R_t M_t\right)^2 / \sum C_t M_t^2\right]}{s-2}$$

Where s = Number of samples included in the summation.

$$\text{Standard error of } \left(\frac{1}{\hat{N}}\right) = \sqrt{\frac{Variance\left(1/\hat{N}\right)}{\sum\left(C_t M_t^2\right)}}$$

Confidence Intervals

According to Krebs (1999) and Seber (1982) when recaptures exceed 50 it is best to use the standard error and a *t*- table value to get confidence intervals for ($\frac{1}{\hat{N}}$). The following equation was used:

$$\frac{1}{\hat{N}} \pm t_{\alpha} S.E.$$

Where S.E. = standard error of 1/N

t_{α} = value from Student's t-table for $(100-\alpha)$ % confidence limits.

Enter the t-table with (s-2) degrees of freedom, where s is the number of samples.

A total of six sampling efforts were conducted to mark and recapture hitch. CDFW first survey effort was on February 26 and the last effort was on April 3. The population estimates will only be for hitch collected in Kelsey and Cole Creeks (Figure 3). Each electrofishing sampling effort took a total of one day using one boat. With the one boat and one day, both tributaries where hitch historically spawned were sampled. Electrofishing was completed using an 18 ft. Smith-Root SR electrofishing boat. Pulsed DC current (8-12 amps) was used to "stun" the fish. The crew consisted of two forward netters, at least one person marking/checking for recaptures at the livewell, and one boat operator. The boat navigated in a continuous line parallel to shores of Kelsey and Cole Creeks and along the shelf at the mouth of Kelsey and Cole Creeks (Figure 3). Hitch under electronarcosis were netted and placed in a holding tank. An effort was made to capture all shocked fish; however, sometimes hitch eluded capture on the outer edge of the electrical field.

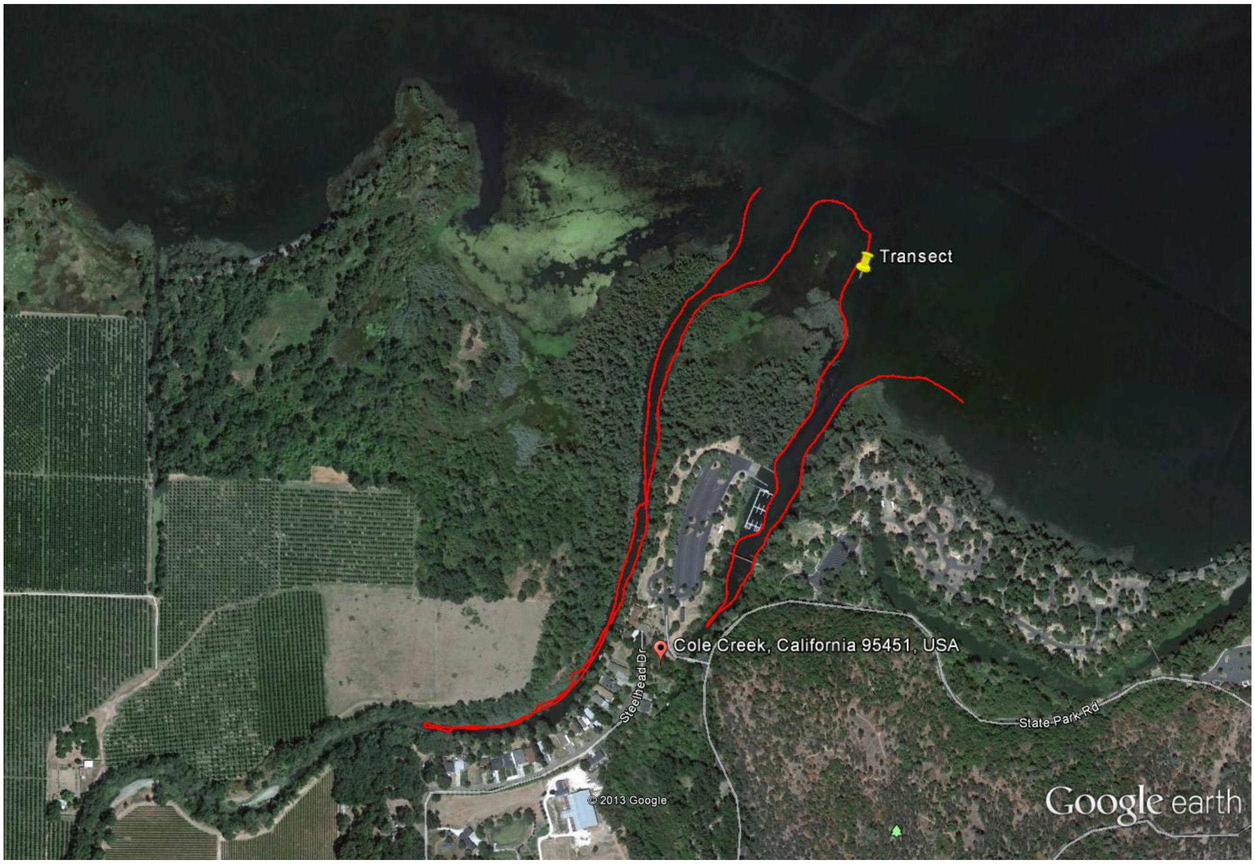

Figure 3. Map of electrofishing transect for Kelsey and Cole Creeks, including their mouth into Clear Lake (Lake County, Ca).

All hitch in the 2013 estimate were marked with a caudal punch on the upper part of the fin. This marking combination identifies a marked hitch as being part of this year's estimate.

Results and Discussion

The water temperature was 48° F (9° C) at the time of the first survey (Tables 1, 2, and 3) and was likely too cold for the hitch to spawn in (Moyle 2002). CDFW's second effort was conducted on March 6. The water temperature was 50° F (10° C) at the time of the sampling and again was likely too cold for hitch to spawn in. The CDFW on March 13 conducted a third survey with a water temperature of 53° F (12° C). On March 19th, the fourth survey was conducted with a water temperature of 50° F (10° C). On March 28th, the fifth survey was conducted with a water temperature of 53° F (12° C). On April 3, the last survey was conducted with a water temperature of 57° F (14° C).

For each sampling effort, Table 1 provides the following data for both creeks. Identifier = ID gives the sample's chronological order: Values 1 – 6 correspond respectively to dates 2/26, 3/6, 3/13, 3/19, 3/28, and 4/3. Ct = total number of individuals caught in sample t; Rt = number of individuals already marked when caught in sample t; Ut = number of individuals marked for the first time and released in sample t; Mt = number of marked individuals in the population just before sample t is taken. The relevant data for spring, 2013 is summarized below.

Table 1. Mark-recapture combined sample data for Cole and Kelsey Creeks, 2013. (see following text for nomenclature)

ID	Date	Water Temp	Ct	Rt	Ut	Mt
1	2/26/2013	48°F	0		0	
2	3/6/2013	50°F	0	0	0	0
3	3/13/2013	53°	3	0	3	0
4	3/19/2013	50°	30	0	30	3
5	3/28/2013	53°	6	0	6	33
6	4/3/2013	57°	43	1	42	39

Table 2 provides the following data for Cole Creek.

Table 2. Mark-recapture combined sample data for Cole Creek, 2013.

ID	Date	Water Temp	Ct	Rt	Ut	Mt
1	2/26/2013	48°F	0		0	
2	3/6/2013	50°F	0	0	0	0
3	3/13/2013	53°	3	0	3	0
4	3/19/2013	50°	7	0	7	3
5	3/28/2013	53°	3	0	3	10
6	4/3/2013	57°	0	0	0	13

Table 3 provides the following data for Kelsey Creek.

Table 3. Mark-recapture combined sample data for Kelsey Creek, 2013.

ID	Date	Water Temp	Ct	Rt	Ut	Mt
1	2/26/2013	48°F	0		0	
2	3/6/2013	50°F	0	0	0	0
3	3/13/2013	53°	0	0	0	0
4	3/19/2013	50°	23	0	23	0
5	3/28/2013	53°	3	0	3	23
6	4/3/2013	57°	43	1	42	26

The 2013 Kelsey Creek population estimates using the Schnabel and Schumacher-Eschmeyer methods was SM = 1,187 (95% C.I. 223 and 23,274) and SEM = 1,179 (434 and NA).

The combined population estimate of Cole and Kelsey Creeks using the Schnabel and Schumacher-Eschmeyer methods was SM = 1,965 (95% C.I. 369 and 38,529) and SEM = 1,851 (1,028 and 9,318).

An estimate could not be made for Cole Creek because hitch were not recaptured in subsequent sampling.

Due to the low number of hitch collected during all six surveys, reliable population estimates were not attained which is supported by the large confidence intervals. Due to staffing issues, time, and the large amount of shoreline at Clear Lake, only the mouths of two tributaries and the tributaries themselves that have had recent runs of spawning hitch were sampled during the survey. Ideally, the entire shoreline including the tributaries needs to be sampled to confidently estimate the whole population in the lake. In past surveys where lake population estimates have been extrapolated from random transects, the estimates tended to overestimate the population size, had extremely wide confidence intervals, and are considered unreliable (Giusti 2004, 2005, 2007). The wide confidence intervals were likely formed because the population (n) was calculated by an unreliable theory. This survey did not extrapolate the population from a given amount of shoreline sampled.

The dry winter and spring in Lake County resulted in a reduced amount of runoff coming out of the tributaries. The reduced runoff combined with water diversion and water quality issues likely contributed to less than optimum spawning conditions for hitch. Spawning takes place mainly in riffles of stream tributaries to lakes after flows increase in response to spring rains (Moyle 2002). It is possible with the dry spring that hitch decided to remain in the main body of the lake and did not move up the tributaries to spawn.

Future projects will focus on sampling the same transects at the same time of year to keep survey techniques consistent and allow for comparison and to evaluate different survey methods to help obtain a statistically valid population estimate.

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