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CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

Lahontan Cutthroat Population Estimate For Heenan Lake 2013

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Introduction

Heenan Lake contains a population of the federally listed threatened Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) (LCT) that provides the broodstock source for the California Department of Fish and Wildlife's (CDFW) statewide LCT stocking program. Furthermore, in 1983 the California Fish and Game Commission designated Heenan Lake a Wild Trout water and in 1999 further designated Heenan Lake a Heritage Trout water. Heritage Trout waters support populations that best exemplify indigenous strain of native trout within their historic drainages. A native trout is a trout that was originally found in the water before human interference while a wild trout is a trout that is born in the wild and spends its entire lifecycle in the wild regardless of the origin of it parents or ancestors. The lake is a popular angling destination for trophy-sized LCT and is open to public fishing the Friday before Labor Day through the last Sunday in October on Friday, Saturday, and Sunday using only artificial lures with barbless hooks with a zero bag limit. No gas powered boats are allowed on the lake.

CDFW has extensive data on the LCT population in Heenan Lake. Total lengths and sex ratios are taken on a subset of the spawning run of LCT in the lake. In June or July, 3000 yearling are stocked back into the lake to maintain the population. CDFW monitors angling catch rates and length frequency of the angler landed LCT in the lake during September and October through an Angler Survey Box. This survey is a voluntary questionnaire asking anglers: date, hours fished, number and size class of landed LCT, and their satisfaction with the fishery. However, managers do not know the LCT population size in Heenan Lake.

This report presents estimates of population size with 95% confidence intervals, for LCT in Heenan Lake. Various methods exist for estimating fish populations throughout the United States, such as angler catch (Gablehouse and Willis 1986) (Gresswell et al. 1997), underwater surveys (Davis et al. 1997), creel census (Farman et al. 1982), or catch depletion techniques (Maceina et al. 1995). Based on the results seen at Diamond Valley Lake, (Granfors and Giusti 2008) it was determined that angling provides a reliable population estimate as fish occupying deeper portions of the lake are now included which would not be sampled by electrofishing or seining.

In an effort to evaluate the LCT fishery of Heenan Lake, a LCT population estimate was conducted from September 27, 2013 – October 27, 2013. This data will be used to help manage the Heenan Lake LCT fishery.

Location

Heenan Lake is located within the 1652 acre Heenan Lake Wildlife Area (a CDFW owned property) approximately 17 miles southeast of the city of Gardnerville, Nevada in Alpine County, Ca. (Figure 1.). The lake is at an elevation of 7100 ft. above mean sea level. Heenan Lake was formed by a dam built on Heenan Creek in 1924-25 by the Dangberg Land and Cattle Company for irrigating lands in the Carson Valley, Nevada (Titus 1986). At maximum pool the lake occupies 129 surface acres and has 2,948 acre-feet of water storage. CDFW owns 78.8 percent of the water, while 21.2% is owned by Parks Land and Livestock Company (Somer 2008). The Heenan Lake Wildlife Area is a Type C Wildlife Area where permits, passes, or reservations are not required. Photography, hiking, bird watching, and hunting are also other opportunities that are available at the Heenan Lake Wildlife Area.

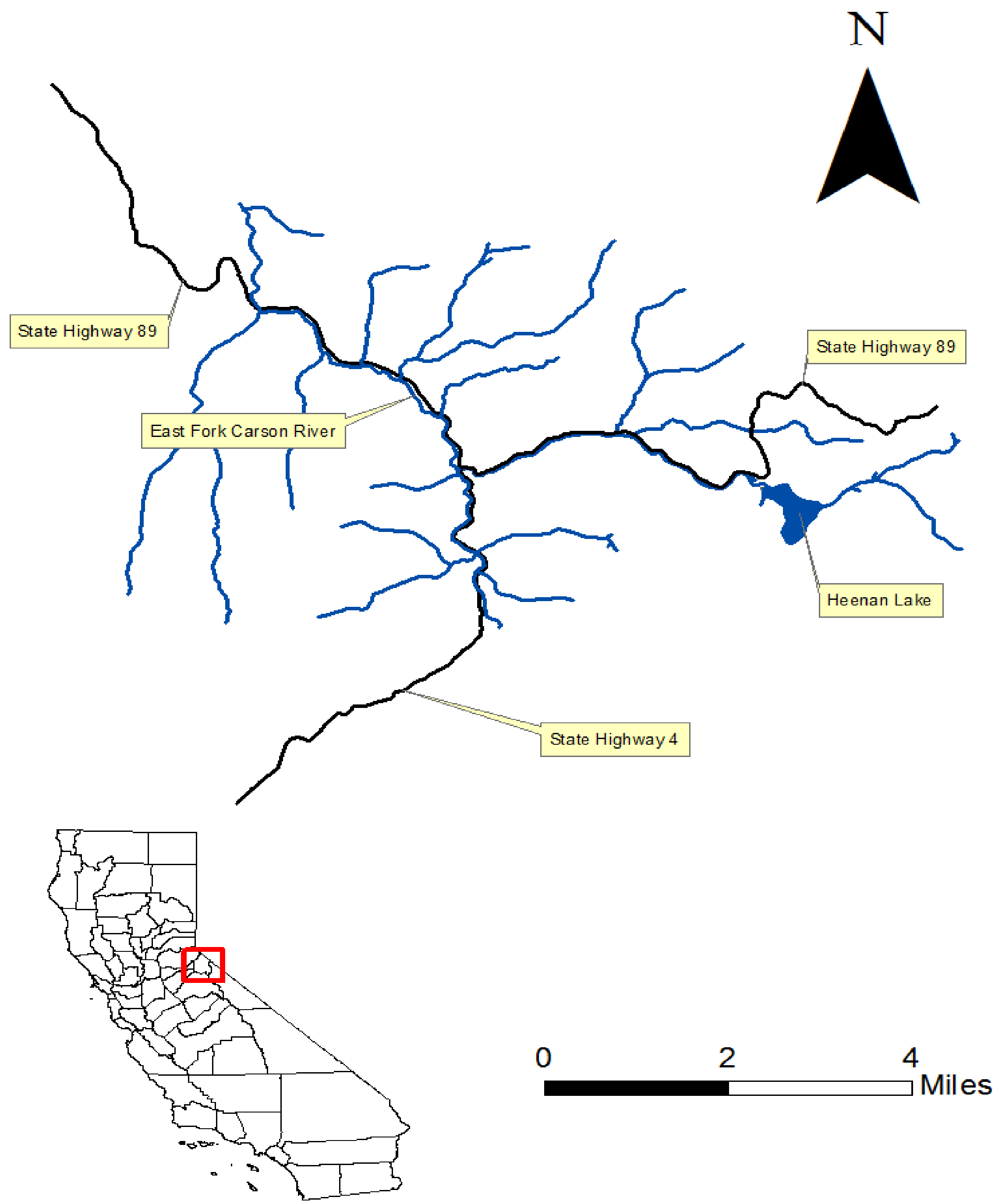

Figure1. Map of Heenan Lake, Alpine County, California

Methods

Several assumptions must be met for the estimate to be reliable (Krebs 1999; and Seber 1982). We assumed that Heenan Lake and angling as the capture method met all of the following assumptions:

(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.

The LCT population within Heenan Lake was considered to be “closed”. In a closed population it is assumed that the population size is constant without recruitment or losses. During the 21 days of the survey, recruitment into the population was considered nonexistent since few to no LCT exist in the inlet stream and the only recruitment is from the stocking of LCT in July. 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. Angling was used to capture fish due to the ability to sample fish at all depths of the lake, randomness, and cost effectiveness (Grinstead and Wright 1973, Holbrook II 1975, Goudy 1981, Gablehouse and Willis 1986) since the angling public could assist CDFW in conducting the study. Artificial lures or flies with barbless hooks were used because of the angling regulation for the lake. Studies suggest higher mortality rates for fishes caught on baited barbed hooks than artificial lures or flies with either barbed or barbless hooks (Butler and Loeffel 1972; Payer et al. 1989; and Taylor and White 1992). A secondary reason to use barbless hooks was to minimize stress to the LCT during the angling process. The use of barbless hooks show a significant decrease in fish handling time compared to barbed hooks (Dubois and Dubielzig 2004).

Each public sampling effort started when the Heenan Lake fishery opened at sunrise and ended at sunset. Additionally, CDFW sampled on days that Heenan Lake was closed to the public. Up to two CDFW fishery biologists and four scientific aides were deployed around the lake based upon angler usage to monitor the angler's sampling effort. Any angler observed with a hooked fish was approached by the closest staff member. Each landed LCT was first examined for a mark. Unmarked fish were marked with a hole-punch on the upper lobe of the caudal fin, measured for total length, and released back into the water. A standard loose leaf binder hole-punch was used to mark the LCT creating a hole approximately 1/4 inch in diameter in the caudal fin. These fish were recorded as a marked fish for that day. Marked fish that were captured were released back into the water and recorded as a recapture. The hole punch marking method was used due to cost effectiveness and simplicity. It is a known way to mark fish and has been used to conduct population estimates of various fish species (Granfors and Giusti 2011, Gablehouse and Willis 1996).

The Petersen method is the simplest form of a mark-recapture study because it relies on a single sample for marking the fish and a second single sample for the recapture of fish (Krebs 1999). The data collected in the Petersen method is:

M = Number of individuals marked in the first sample

C = Total number of individuals captured in the second sample

R = Number of individuals in the second sample that were marked

From these variables we wish to estimate the population N at the time of marking from the proportion

$$N/M = C/R$$

or

$$N = CM/R$$

The Schnabel (SM) and Schumacher Eschmeyer (SEM) methods were used to estimate the LCT population within Heenan Lake. Both population estimates were based on multiple mark-recapture sampling efforts collected by angling.

Schnabel Method

The Schnabel Method 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*.
M_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:

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

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

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 is a multiple mark recapture technique for estimating the size of the population. This method use 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

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.

Results

A total of 21 days were surveyed with the first day consisting of marking and the last day only checking for marks. A total of 905 LCT were sampled over the survey period of which 860 were marked. Of the 905 sampled LCT, 45 were recaptures (Table 1.). Average size of the fish marked during the tagging season was 17.3 inches (Table 2).

Mark recapture sample results used for SM and SEM are presented in Table 1. The number of LCT captured during a sample period ranged from two to 162 fish while the number of recaptures during a sample period ranged from zero to 19 LCT. The greatest number of captures and recaptures occurred on October 25, 2014 which was during last weekend of the study. Slightly more than 42% of all recaptures occurred on October 25, 2014 while 64% of all recaptures occurred during the last week end of the sample period.

Table 1. Mark-recapture sample data for 2013.

Date	C_t	R_t	U_t	M_t	C_tM_t	$C_tM_t^2$	R_tM_t	R^2/C_t
09/27/13	23	0	23	0				
09/28/13	47	0	47	23	1,081.00	24,863.00	0	0.000
09/29/13	11	0	11	70	770.00	53,900.00	0	0.000
10/04/13	34	1	33	81	2,754.00	223,074.00	81	0.029
10/05/13	51	1	50	114	5,814.00	662,796.00	114	0.020
10/06/13	15	1	14	164	2,460.00	403,440.00	164	0.067
10/09/13	2	0	2	178	356.00	63,368.00	0	0.000
10/10/13	8	1	7	180	1,440.00	259,200.00	180	0.125
10/11/13	64	0	64	187	11,968.00	2,238,016.00	0	0.000
10/12/13	53	2	51	251	13,303.00	3,339,053.00	502	0.075
10/13/13	13	1	12	302	3,926.00	1,185,652.00	302	0.077
10/16/13	19	0	19	314	5,966.00	1,873,324.00	0	0.000
10/17/13	14	0	14	333	4,662.00	1,552,446.00	0	0.000
10/18/13	52	2	50	347	18,044.00	6,261,268.00	694	0.077
10/19/13	61	3	58	397	24,217.00	9,614,149.00	1191	0.148
10/20/13	63	4	59	455	28,665.00	13,042,575.00	1820	0.254
10/23/13	34	0	34	514	17,476.00	8,982,664.00	0	0.000
10/24/13	57	0	57	548	31,236.00	17,117,328.00	0	0.000
10/25/13	162	19	143	605	98,010.00	59,296,050.00	11495	2.228
10/26/13	99	7	92	748	74,052.00	55,390,896.00	5236	0.495
10/27/13	23	3	20	840	19,320.00	16,228,800.00	2520	0.391
Totals	905	45	860	905	365,520.00	197,812,862.00	24299	3.986

The LCT population was estimated at 8,123 (95% C.I. 6,212 and 11,323) in Heenan Lake during October 2013 using the SM. A slightly higher estimate of 8,141 with larger confidence intervals (6,030 and 12,523) was calculated using the SEM.

The Heenan Lake LCT population is supported by stocking yearling trout into the lake. Since 2006, 3000 yearling LCT were stocked into the lake each spring for a stocking rate of 23.3 LCT/ surface acre. The SM method the density of LCT in Heenan Lake was estimated to be 63.0 LCT/acre (95% C.I. 48.2 and 87.8 LCT/ acre). The SEM method produced similar results with 63.1 LCT/acre (95% CI 46.7 and 97.1 LCT/acre.

Table 2. The average, minimum, and maximum total lengths of marked Lahontan cutthroat trout landed in Heenan Lake, fall, 2013.

Date	Number	Marked Trout Total Length (in)		
		Ave	Minimum	Maximum
09/27/13	23	17.2	9.6	24.0
09/28/13	47	16.5	10.0	22.0
09/29/13	11	16.2	10.5	22.0
10/04/13	35	17.3	10.5	23.0
10/05/13	48	18.4	10.5	23.0
10/06/13	14	18.1	12.0	23.0
10/09/13	2	13.5	11.0	16.0
10/10/13	7	19.3	17.3	22.5
10/11/13	64	17.0	9.0	23.0
10/12/13	51	17.5	10.5	24.0
10/13/13	12	18.0	11.8	21.8
10/16/13	19	19.0	15.5	21.5
10/17/13	14	18.0	12.5	22.0
10/18/13	50	17.5	10.0	25.5
10/19/13	58	16.2	9.0	21.0
10/20/13	59	16.1	9.0	22.0
10/23/13	34	17.1	9.8	25.3
10/24/13	57	15.2	9.8	21.3
10/25/13	143	17.8	9.8	23.5
10/26/13	92	17.8	10.0	23.5
10/27/13	20	19.0	12.8	23.5
Total	860	17.3	9.0	25.5

Discussion

A hole punch mark was chosen because it was easily applied and we assumed it would last over a sample time period of five weeks. The hole was distinguishable through the fifth week; however, it did appear that some of the holes were partially grown back. These relatively small holes could have possibly been overlooked in subsequent recaptures by the creel clerks.

Underrepresentation of marked LCT in the recapture sample will overestimate the population size (Van Den Avyle and Hayward 1999) Future mark recapture studies should consider using a larger diameter hole punch make the mark more obvious. Marking another fin may be another option. However, the adipose fin is clipped off of all Heenan Lake LCT before they are planted into the lake to identify pure Independence Lake strain broodstock. Furthermore, clipping a paired fin could be confused with fin erosion unless it is completely removed and could also increase mortality.

Angling conditions may have affected LCT vulnerability to capture. We assumed that the marked and unmarked were equally vulnerable to capture or recapture. Since Heenan Lake is a relatively small lake (129 surface acres), and shallow (35 feet maximum depth), it was presumed that the entire volume was available to the angler. This was likely true during most angling seasons; however, the 2013 angling season occurred during an unusually dry, sunny, and warm summer and fall. This may have contributed to an algal bloom that made angling difficult in the lake. During the early part of the study, the majority of the LCT landed were from the southeast area of the lake. Even as the season progressed, the majority of the LCT landed were from the eastern shore of the lake with few anglers landing LCT from the middle of the lake.

Based on the low incidence of recaptures of LCT, it appeared that LCT avoided recapture and either were more selective in feeding or moved into water not frequented by anglers. CDFW observed anglers fishing only a portion of the lake possibly to avoid the wind and heavy algae. Fish avoidance of anglers may have led to marked LCT becoming less vulnerable to angling. Also, the estimation may only apply to LCT greater than or equal to nine inches. While anglers generally report landing LCT less than six inches in total length, all LCT landed during the study were nine inches or greater.

There is an intrinsic assumption that the catchability of fish caught before and fish that have never been caught is equal. Askey et al (2006) found several reasons could contribute to the differences in catchability, including environmental factors, individual differences, and learned hook avoidance. The last weekend of the fishing season produced the highest (1.09 LCT/hr) catch per hour followed by the first weekend (0.90 LCT/hr) of the fishing season. The next highest were 0.55 LCT/hr. in the second weekend, 0.53 LCT/hr. in the fifth weekend, and 0.52 LCT/hr. in the eighth weekend. The first weekend of the fishery the LCT were possibly hook naïve when 25.7% of the total LCT were landed followed by only 4.7% of the total catch that were landed in the second weekend of the fishery. Almost 46% of the total catch occurred in the last two weekends when environmental factors contributed to better fishing.

Another issue with the sample design was a slow accumulation of tagged LCT and a low recover rate of the tags due to the low number of anglers and to the slow catch rates. The population sampling began on Sept 27 and ended on Oct 27 for a total of 21 sampling days. Angler catch rates did not increase until 10/25 the last Friday of the survey. Approximately 18% (162) of the total number LCT examined for marks were captured on that day alone. One day represented slightly less than 5% of the total sampling days. The last weekend produced nearly 32% (261 LCT landed) of the recaptured LCT. The slow angling was likely caused by the warm days which produced a lot of algae in the lake. Extending the study further into November on a dry, warm year such as 2013 may provide better angling conditions and may have improved the confidence intervals, thus improving the accuracy of the population estimate.

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