Sallie Keyes Lakes 2012 summary report

August 2 to September 11, 2012

State of California

Department of Fish and Wildlife

Heritage and Wild Trout Program

Prepared by Stephanie Hogan, Cameron Zuber, Claire Buchanan, and Garret Schacht

Introduction

Sallie Keyes Lakes support a wild population of California golden trout (*Oncorhynchus mykiss aguabonita*) and are located approximately 60 miles northeast of Fresno, CA (Fresno County; Figure 1). Sallie Keyes Lakes consist of two lakes located in the John Muir Wilderness at an elevation above 10,000 feet (Sierra National Forest). These lakes are directly south of Seldon Pass with access via the Pacific Crest Trail (PCT) and John Muir Trail (Figures 2-4). The outflow, Sallie Keyes Creek, flows due south for approximately two miles before entering the South Fork San Joaquin River in the vicinity of Blayney Meadows. The California Department of Fish and Wildlife (CDFW) Heritage and Wild Trout Program (HWTP) has evaluated Sallie Keyes Lakes for candidacy as designated Wild Trout Waters since 2011.

On an annual basis, the HWTP is responsible for recommending to the California Fish and Game Commission 25 miles of stream and one lake that fit the criteria for designation. Wild Trout Waters are those that support self-sustaining wild trout populations, are aesthetically pleasing and environmentally productive, provide adequate catch rates in terms of numbers or size of trout, and are open to public angling (Bloom and Weaver 2008). Wild Trout Waters may not be stocked with catchable-sized hatchery trout. The HWTP evaluates candidate waters using a phased approach to systematically collect data and determine whether or not a stream or lake meets designation criteria.

Due to the popularity of backcountry recreation in California, the HWTP is interested in identifying and designating high-elevation waters in the Sierra Nevada Mountains and other remote locations throughout the state as “wilderness” Wild Trout Waters. In 2011, the HWTP conducted a Phase 1 (initial resource) assessment of Sallie Keyes Lakes (Weaver and Mehalick 2011). In 2012, the HWTP moved to Phase 2 (candidate water) assessment to gather baseline fisheries, habitat, and angler use data. Survey methods included a mark-recapture survey, angler creel, and use of remote cameras with the following goals and objectives:

- Determine fish abundance, size class distribution, and catch rates in the southern-most Sallie Keyes Lake (hereafter referred to as Lake #1).
- Determine the efficacy of mark-recapture techniques using angling and gill nets in a small and remote mountain lake.
- Document angler use, satisfaction, catch rates, catch sizes, and gear preferences using voluntary angler survey form data.
- Collect ancillary angling data for a HWTP research study evaluating the instances of foul-hooking with different types of terminal tackle.
- Garner private landowner and public support for potential Wild Trout designation.

Methods

Angling

A reconnaissance of Sallie Keyes Lakes was conducted on August 2nd and 3rd, 2012 by HWTP staff (Headquarters) to determine catch rates and the feasibility of a mark-recapture survey via angling. Anglers used fly fishing gear and recorded total effort per day (hrs). All landed fish were identified to species and measured for total length (nearest inch) using a calibrated landing net. Catch per unit effort (CPUE; fish/hr) was calculated for each angler and day.

Angler survey forms

Data from voluntary angler survey forms distributed at the Muir Trail Ranch were examined to better understand angler use, catch rates, and catch sizes for Sallie Keyes Lakes. Forms missing pertinent information (date, number of hours fished, and/or fish size classes) were not included in the analysis; all complete forms were examined.

Remote cameras

Angler use was evaluated from August 2nd through September 10th, 2012 using remote cameras at key locations in the vicinity of Lake #1. Seven Reconyx HyperFire cameras were installed around the Lake #1 perimeter to quantify the percent of recreationists that were angling. Each camera was assigned an alpha-numeric name: C1, C2, CR2, C3, C4, C5, and C6 (Figures 7-8 and Table 1). The cameras were installed with two types of detection modes:

- Infrared (IR) triggered the camera to take a series of photographs when a subject was within a certain range and zone of the camera.
- Interval took a photograph every 15 minutes during daylight hours.

To capture all recreationists entering and exiting the area, cameras were installed with the IR detection mode at the northern and southern end of Lake #1 and were aimed directly on the PCT (cameras C3 and C6). A popular and much-used trail, the PCT travels directly along the western shore. When triggered, the cameras were programmed to take either three (C3) or five (C6) consecutive photographs; the difference was due to programming error but later proved useful in evaluating the number of photographs necessary to assess the different parameters.

The trail cameras were used to determine the total number and type of recreationists, using the following categories: angler, non-angler, or unknown. An angler was someone in possession of identifiable fishing gear (such as a rod or rod case). Non-anglers did not have any visible fishing gear. If someone could not be identified as either (e.g. all gear was stored inside a backpack and not visible), the subject was classified as unknown.

Five cameras installed around the lake perimeter (interval capture mode; cameras C1, C2, CR2, C4, and C5) were used to determine whether anglers seen on the trail were later observed actively fishing in Lake #1. Cameras C4 and C5, located near the trail, were also programmed for IR detection.

Those observed actively fishing or walking towards Lake #1 with an assembled rod were classified as active anglers. Those observed with a fishing rod who appeared in transit (i.e. captured on both trail cameras within a relatively short period of time) or had the rod stored away were classified as non-active anglers. Gear type (fly rod, spinning rod, or unknown) was recoded for each angler, using all available photographs, whether captured on trail or shore cameras.

Anglers were categorized as either day users or backpackers. Day users were those without large overnight backpacks; however, due to the remote nature of this location, they were likely not true day hikers, but rather camping or staying nearby and visiting the lake from a different base camp (i.e. Muir Trail Ranch).

Mark and recapture

A mark and recapture survey was conducted in Lake #1 from September 6th through 11th, 2012 to estimate population size of California golden trout (Figure 6). Angling was used to capture and mark fish during the first stage of the survey and to gather information on catch rates and trout size class distribution. Fly fishing gear was used and anglers fished both from the shore and in float tubes. All captured trout were measured to the nearest inch using a calibrated landing net (total length), were marked with an upper-caudal fin clip, and were released live back into the lake. Any captured trout that were injured, appeared in poor condition, and/or were unlikely to survive were euthanized and not counted as marked fish. Anglers recorded effort (hrs) each day. CPUE was calculated for each angler day and averaged across the entire effort. Water and air temperature were measured in the shade (°C) and representative photographs were taken.

Trout were recaptured using seven experimental, sinking gill nets (Figures 7-8). Gill nets were placed in areas of presumed high trout densities (determined based on observations from the mark phase), as well as spaced throughout the lake to include both the littoral and limnetic zones. Coordinates were recorded for both ends of the gill nets using a hand-held Global Positioning Unit (GPS; North American Datum 1983). Gill nets were set in the evening and removed the following day with a minimum set time of 12 hours. Fish were processed separately by gill net. Each fish was identified to species; total length (mm) and weight (g) were measured. All live fish were recovered and released back into the lake. Mortalities resulting from the recapture phase were counted and dispatched (buried or dispersed in dense vegetation).

The NOREMARK closed population model was used to generate a population estimate (White 1996).

Results

Angling

During the reconnaissance, one angler captured 28 California golden trout in 2.25 hours with a mean CPUE of 13.7 fish/hr (Table 2). Based on this high catch rate, the mark and recapture study was initiated in September.

During the first phase of the mark and recapture study, four anglers captured 494 California golden trout in 213.2 hours. Catch rates ranged from 0 to 9.1 fish/hr with an average of 2.0 fish/hr. Among the combined August and September efforts, mean CPUE was 2.8 fish/hr. The majority of captured trout were between nine and ten inches in total length (Figure 9).

Angler survey forms

Data from angler survey forms distributed at the Muir Trail Ranch were examined for the years 2011 and 2012 (Table 3). Seven forms were analyzed with a reported effort of 18.5 hrs and a total catch of 93 trout. Reported mean CPUE was 4.6 trout/hr in 2011 and 4.0 trout/hr in 2012. The majority of trout reported caught were between 6-12 inches for both years.

Remote cameras

Over the course of approximately one month, 2,588 recreationists were observed and 96% did not appear to have angling gear (2472). Of the 77 anglers observed with angling gear (3%) most were backpacking (56%). Only 31% were observed actively fishing and these active anglers mostly appeared to be on a day trip (86%). Gear type included 46% fly rods, 33% spinning rods, 17% unknown, and 4% with both fly and spinning rods.

Twelve pack trips were detected on the cameras. The pack trips consisted of one to two packers and their horse(s) with a string of three to ten mules. Due to the nature of pack stock and the stowing of gear, most of the recreationists on the pack trips were categorized as unknown.

Mark and recapture

The 494 California golden trout marked during phase one of the mark recapture ranged in total length from 4 to 13 inches (101.6 to 330.2 mm) with a mean of 9 inches (228.6 mm; Figure 10 and Table 8). Seven gill nets were set for 118.75 hours; effort of individual nets ranged between 14 and 20 hours, depending on staff availability and how quickly they were processed (Table 9).

Gill nets captured 656 California golden trout, 9% of which were marked (60). Size ranged from 3 to 12 inches (77 to 306 mm) in total length, with a mean of 8 inches (208 mm); weights were between 4.5 and 226.7 g (average of 92.2 g). Water temperature ranged from 13 to 18 °C and air temperature was between 7 and 21 °C, depending on time of day. Using the Lincoln-Peterson model, population size was estimated at 5330.4 California golden trout (+/- 1183.5) in Lake #1.

A comparison of trout size classes between the two different capture methods (angling and gill nets) was used to evaluate potential survey bias (Figure 10). Greater than 75% of all trout captured, whether by angling or gill nets, were between eight and ten inches in length. Trout less than or equal to seven inches comprised 6% of the angling catch and 22% of the gill net catch. Conversely, trout greater than and equal to 11 inches comprised 11% of the angling catch and one percent of the gill net catch.

A two sample t-test was used to test the null hypothesis of equal means: the mean total length of fish captured by angling during the mark phase is equal to the mean total length of fish captured by gill nets during the recapture phase. The following conditions or assumptions were met:

- Equal variance: A preliminary F-test indicated that the variances of the two groups were not equal (test-statistic=2.35, F-critical (α = .05) = 1.15).
- Normality (normal distribution): The distribution of each sample set was tested for normality. Neither the angling nor gill net sample sets distributed normally; however, a t-test was used because the central limit theorem holds for the sample sets due to the large sample sizes.

A two-sample t-test was performed that assumed unequal variances and which rejected the null hypothesis. The p-value for this test was less than or equal to 0.001. As further support to reject the null hypothesis, a comparison was done between the critical value of t (+/- 1.96) and the two tailed calculated t-statistic (-12.37). The calculated t-statistic is outside the critical value, which also supports rejection of the null hypothesis.

A rejection of the null hypothesis shows the mean total length of fish captured in the gill nets (8.2 inch) was smaller than those captured by angling (9.3 inch) and suggests survey bias. Due to the possible difference between capture methods, a second population estimate was generated removing individuals less than 4.5 inches (< 115 mm). The adjusted abundance was estimated at 5368.2 California golden trout (+/- 1192.3) in Lake #1, which is similar to the original abundance estimate of 5330.4 California golden trout (+/- 1183.5).

Discussion

Angling

Sallie Keyes Lakes appear to be fast-action fisheries (>2 fish/hr) with catch rates exceeding 15 fish/hr. These lakes are currently not stocked with hatchery trout and all trout captured during the survey effort appeared to be of wild origin. Due to the low return on voluntary angler forms, the limited data evaluated for this report may not be representative of overall angler experiences.

Mark and recapture

The population estimate generated from the mark and recapture survey had a relatively low confidence interval. This is likely because a sufficient proportion of the population was marked. The high catch rates and concerted angling effort over the course of four days likely contributed to development of a reliable estimate.

The HWTP recommends that future surveys using these techniques consider effort, catch rates, and species during sample design. A concerted effort was made to capture fish in all portions of the lake, during both angling and gill netting, to ensure equal probability of capture in the event that mixing does not occur. This is an assumption of the model that may or may not hold true depending on fish movement patterns and gill net placement in relation to fish capture. In addition, consideration should be given to angling regulations and pressure; if catch and keep angling is occurring, the closed population assumption would be violated. During this study, surveyors camped on-site for the duration of the effort and were able to verify no anglers caught and kept fish.

Remote cameras

The vicinity of Sallie Keyes Lakes appears to be a very popular backcountry recreational area, with nearly 2600 people observed walking along the PCT in a one-month period. The majority were backpackers. Not all subjects were captured on both trail cameras; Camera C6 captured more individuals than Camera C3. Camera placement is an important consideration; camera C3 was in more wide-open area, possibly allowing subjects to divert from the trail. Having two trail cameras proved useful to capture more subjects. In addition, they each captured different angles; C3 was a side profile while C6 was a front/back profile. This combination proved useful by providing multiple views, allowing for easier identification of fishing rods, rod cases, and camping equipment. However, both cameras were mounted on the west side of the PCT; future studies should consider capturing multiple directions and angles. Availability of mounting structures (such as trees) may be a limiting factor in camera placement.

A relatively small number of the recreationists using this trail appeared to be anglers. Previous creel surveys conducted by the HWTP in the John Muir Wilderness Area (relatively close to Sallie Keyes Lakes) in 2007 and 2009 showed the percent of people encountered who were fishing in the backcountry was 22% and 19%, respectively. Due to the inherent difficulties in identifying rods that may be stowed in packs, some anglers may have been misclassified as non-anglers. A creel survey is often used in the front country to evaluate angler use; however, due to high costs, this may not feasible in remote locations. In these instances, cameras provide a relatively cost-effective way to remotely monitor these fisheries.

Anglers were the focus of this study (i.e. camera placement was determined based on assumed access points and corresponding areas of high angler use, along with careful scrutiny during photographic analysis). Due to the number of non-anglers captured in photographs and time constraints, non-anglers were not given as much scrutiny during photographic analysis. If a backpacker was hiking through, camped at the lake, and walked past the cameras without a large pack, he or she may have been double counted.

The cameras set around the perimeter of the lake proved problematic during analysis. In many instances, they were too far from shore to detect and identify anglers. Only those cameras within 350 feet of shore appeared effective. In addition, due to the large volume of photographs taken (between 2,642 and 36,565 per perimeter camera), it wasn't cost effective to closely scrutinize each photograph but, rather, advance relatively quickly through a series and look for differences/changes in the frame. In some cases, if an angler appeared to be walking towards the shore, as seen from a trail camera, photographs from nearby perimeter cameras were examined during the same time period. This technique wasn't reliable and often the angler was not found on a perimeter camera. For instance, two anglers were captured on C3 walking multiple times toward and away from Lake #1 over the course of five days. A photograph captured one of these anglers with a harvested trout, but zero of the perimeter cameras captured either of these anglers actively fishing.

An original goal of the study was to assess the amount of time active anglers spent fishing Lake #1 but, due to low detection on the perimeter cameras, this goal was not met.

Conclusion

Following this assessment, the HWTP recommended designation of Sallie Keyes Lakes as Wild Trout Waters to the California Fish and Game Commission and this recommendation was adopted in November, 2012. Currently, Sallie Keyes Lakes fall within Sierra District General sport fishing regulations which allows for the take of five trout per day with a total of ten trout in possession (open to fishing all year). The HWTP is currently writing the Sallie Keyes Lakes Wild Trout Management Plan; this document will provide management goals, strategies, and a framework for future monitoring efforts.

References

Bloom, R., and J. Weaver. 2008. The California Heritage and Wild Trout Program Handbook (Draft). State of California Natural Resources Agency. Department of Fish and Game. Heritage and Wild Trout Program.

Weaver, J. and S. Mehalick. 2011. South Fork San Joaquin River 2011 summary report. State of California Natural Resources Agency. Department of Fish and Game. Heritage and Wild Trout Program.

White, Gary C. 1996. NOREMARK Reference Manual. Department of Fishery and Wildlife. Colorado State University.

Figure 1. Vicinity map of 2012 Sallie Keyes Lakes survey location

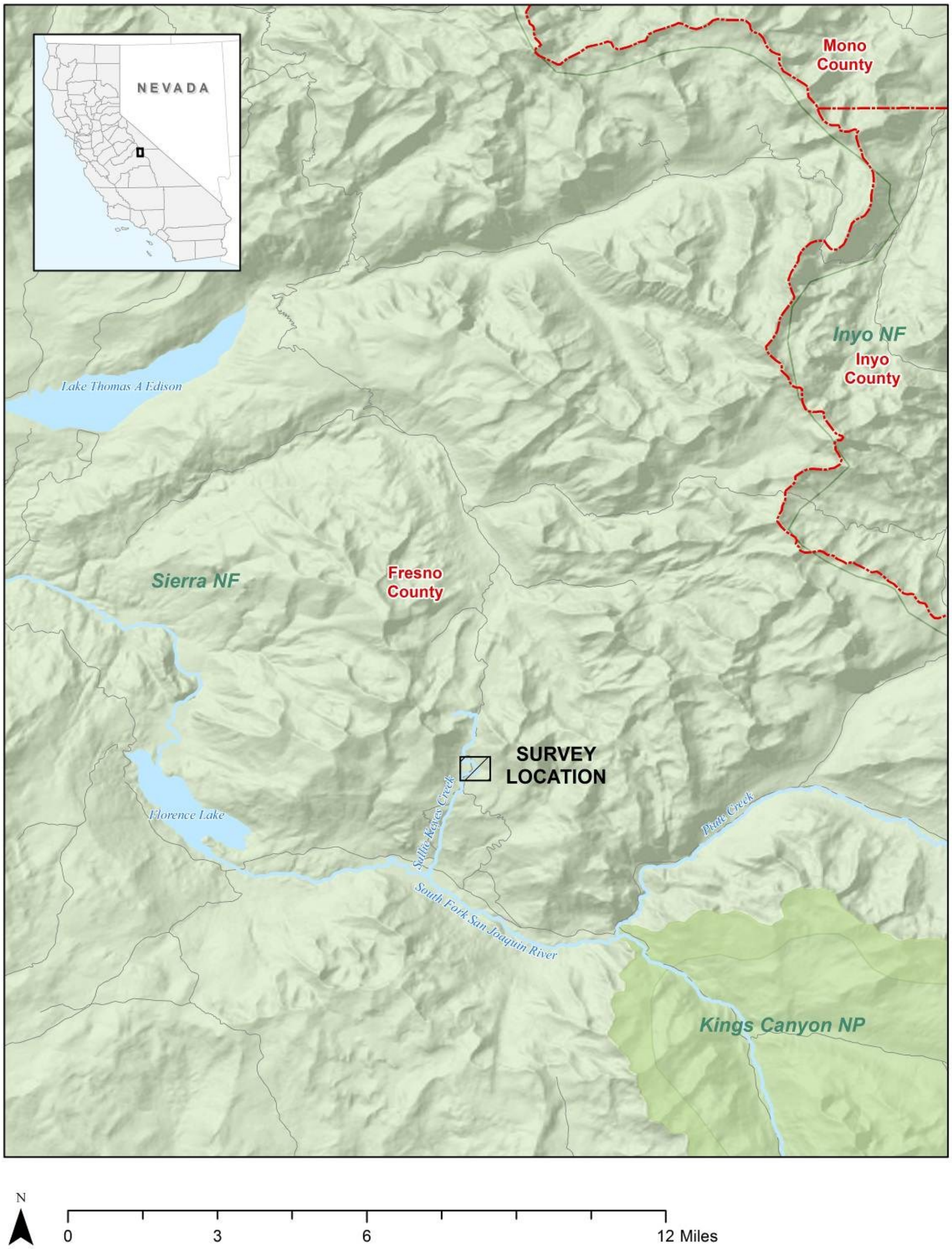

Figure 2. Detail map of Sallie Keyes Lakes

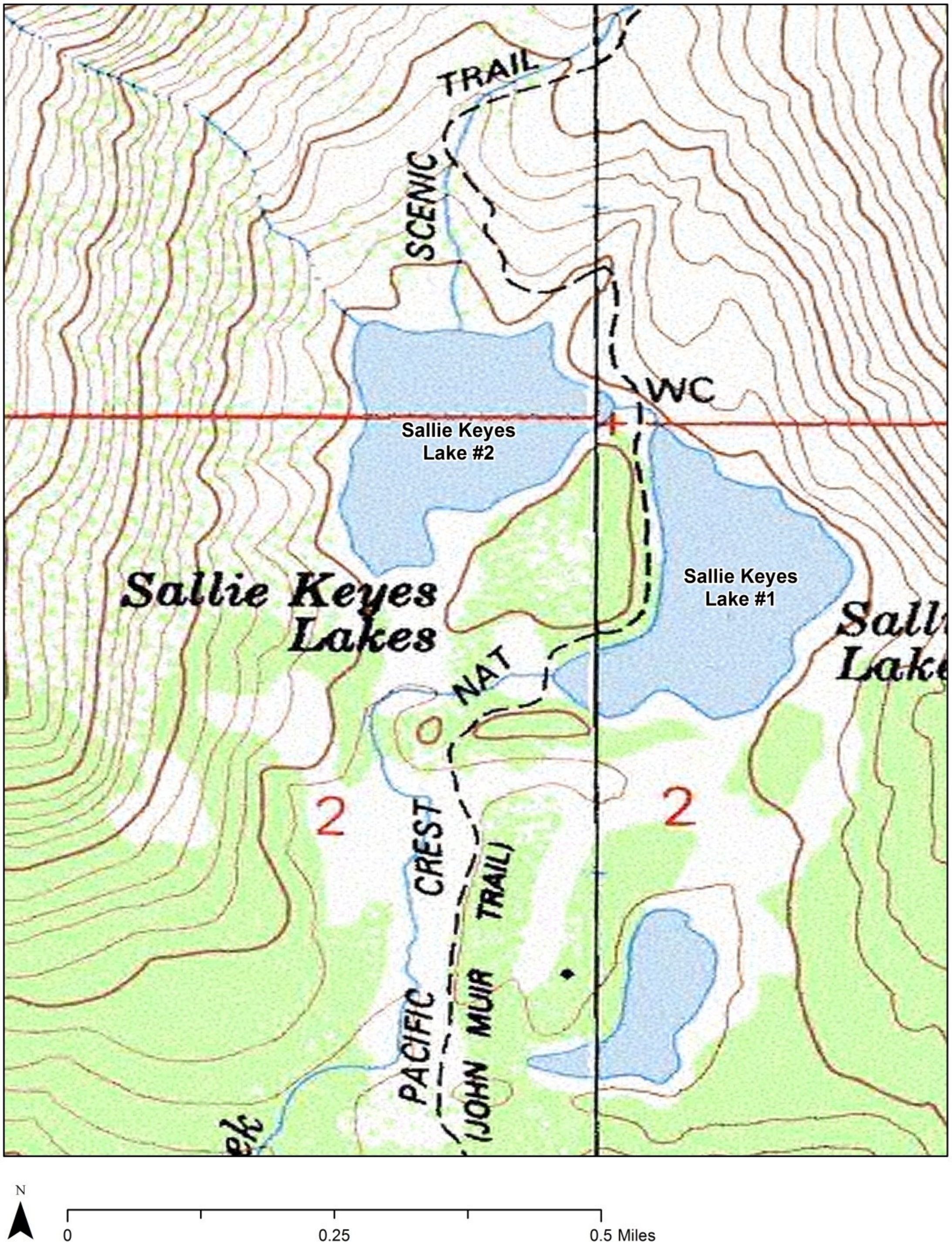

Figure 3. Aerial map of Sallie Keyes Lakes

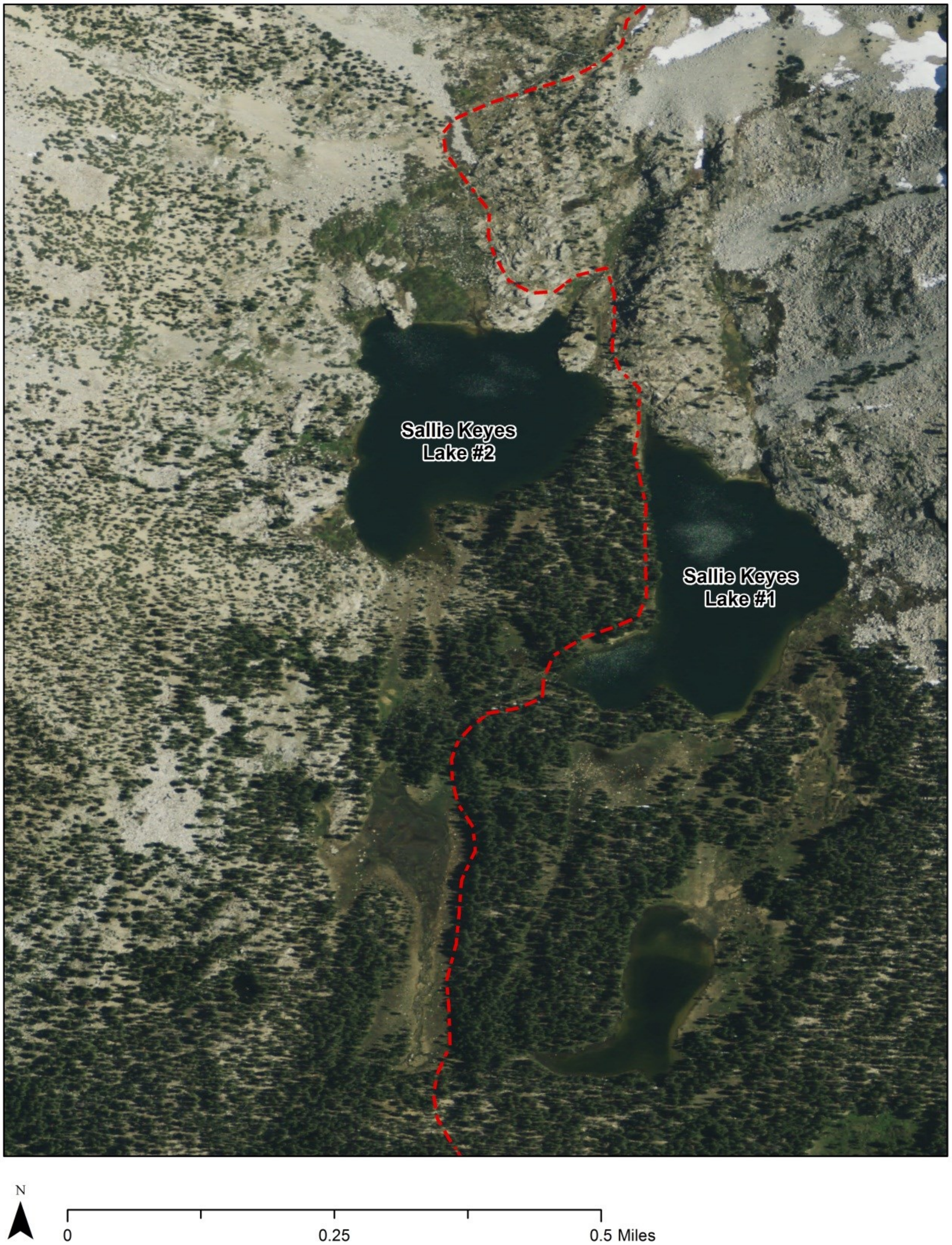

Figure 4. Representative photographs of Sallie Keyes Lake #1

Figure 5. Photographs of HWTP personnel collected from photographs from camera C3 (top) and C6 (bottom) installed around Lake #1

Figure 6. Photographs of 2012 mark-recapture survey in Lake #1

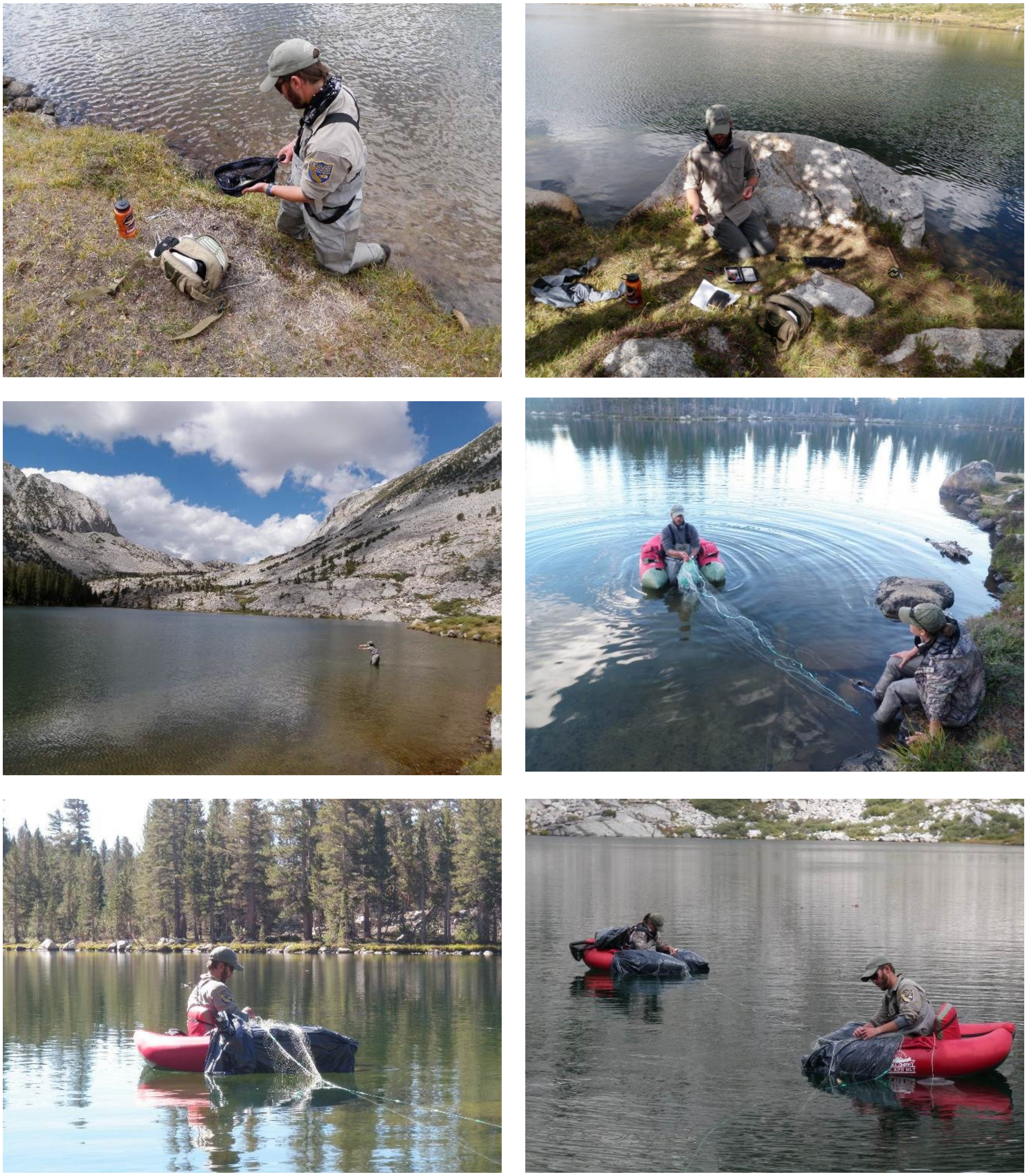

Figure 7. Detail map of 2012 Sallie Keyes Lake #1 gill net and remote camera locations

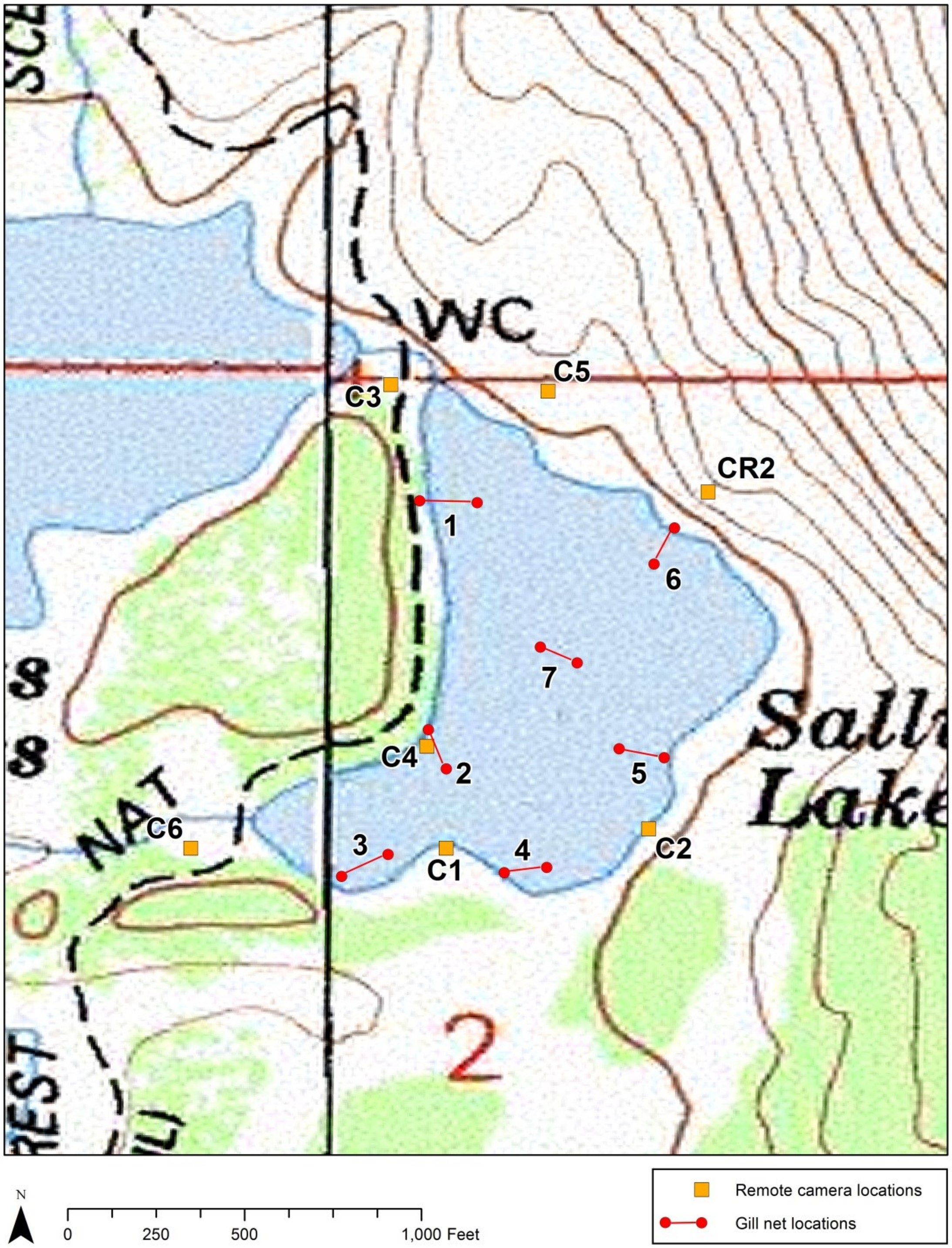

Figure 8. Aerial map of 2012 Sallie Keyes Lake #1 gill net and remote camera locations

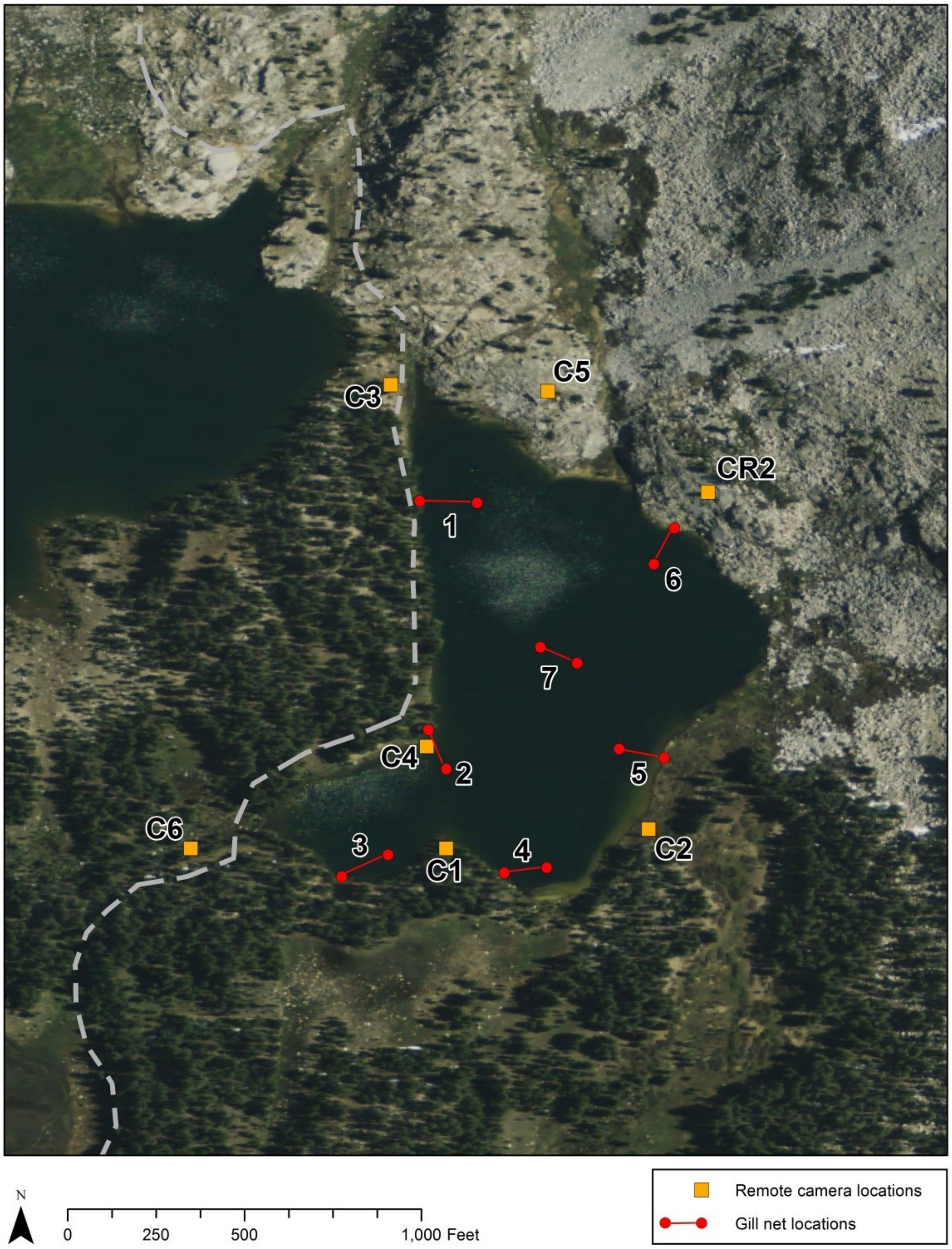

Figure 9. Photographs of California golden trout captured in Sallie Keyes Lake #1 in 2012

Figure 10. Comparison of size class distribution of California golden trout captured by survey methodology during 2012 mark-recapture survey on Sallie Keyes Lake #1

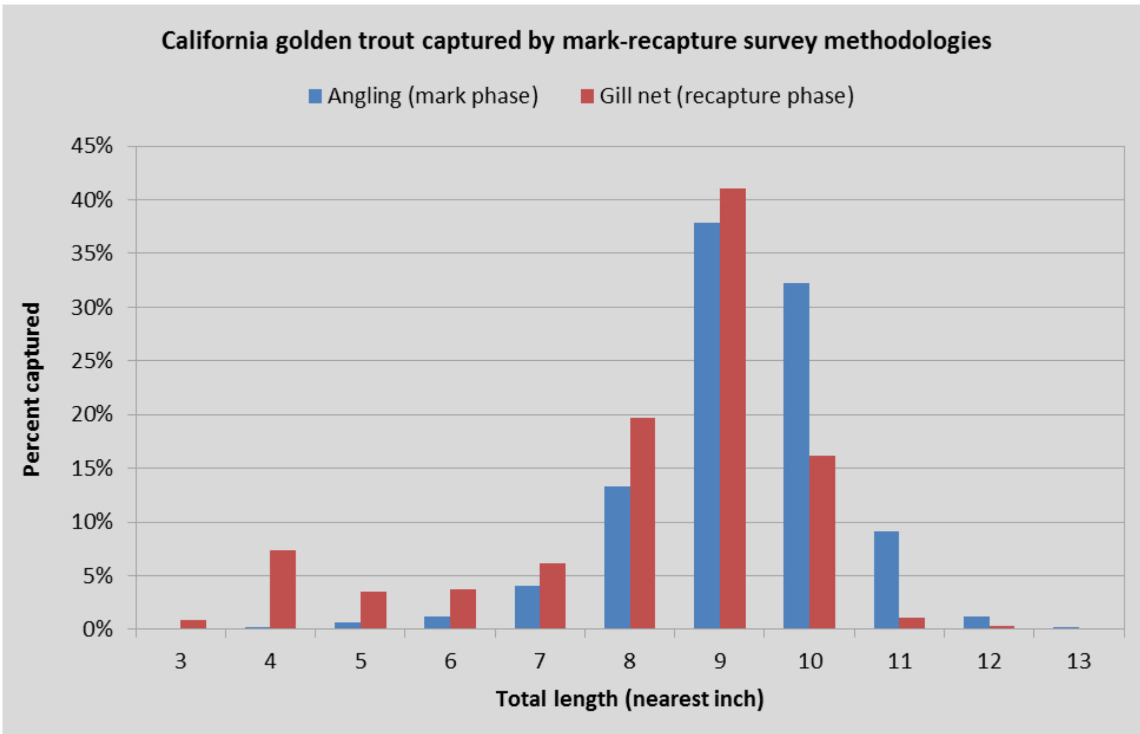

Table 1. Sallie Keyes Lake #1 remote camera information

Camera	Date installed	Date removed	Number of photographs	Detection mode	Location
C1	8/2/2012	9/10/2012	2739	interval	perimeter
C2	8/2/2012	9/10/2012	2835	interval	perimeter
CR2	8/3/2012	9/10/2012	2642	interval	perimeter
C3	8/3/2012	9/10/2012	4165	IR 1/5[a]	trail
C4	8/2/2012	9/10/2012	36,565	IR 1/5[a] and interval	perimeter
C5	8/3/2012	9/10/2012	14,050	IR 1/5[a] and interval	perimeter
C6	8/2/2012	9/10/2012	7539	IR 1/3[a]	trail

[a]1/5 and 1/3 denote an IR triggered series of five or three photographs respectively

Table 2. Sallie Keyes Lake #1 2012 angling data

Angler	Date	Effort (hrs)	Number of California golden trout captured				CPUE (fish/hr)
			Small < 6"	Medium 6" - 11.9"	Large 12" - 17.9"	Total	
Bloom	8/2/2012	1.50	0	15	0	15	10.0
Bloom	8/3/2012	0.75	0	13	0	13	17.3
Corbett	9/6/2012	4.75	0	8	0	8	1.7
Dettmar	9/6/2012	5.50	0	2	0	2	0.4
Higginson	9/6/2012	4.75	0	1	0	1	0.2
Webster	9/6/2012	4.75	0	8	0	8	1.7
Zuber	9/6/2012	4.25	0	11	0	11	2.6
Corbett	9/7/2012	10.00	0	15	0	15	1.5
Dettmar	9/7/2012	9.75	0	7	0	7	0.7
Higginson	9/7/2012	11.25	0	19	0	19	1.7
Webster	9/7/2012	10.00	1	12	0	13	1.3
Zuber	9/7/2012	9.66	0	42	1	43	4.5
Corbett	9/8/2012	10.00	0	12	0	12	1.2
Dettmar	9/8/2012	9.75	0	14	2	16	1.6
Higginson	9/8/2012	10.75	0	15	0	15	1.4
Webster	9/8/2012	10.00	0	12	0	12	1.2
Zuber	9/8/2012	10.00	0	36	0	36	3.6
Corbett	9/9/2012	10.00	0	0	0	0	0.0
Dettmar	9/9/2012	10.00	0	7	0	7	0.7
Higginson	9/9/2012	11.00	0	19	1	20	1.8
Webster	9/9/2012	10.00	0	21	0	21	2.1
Zuber	9/9/2012	9.50	0	40	1	41	4.3
Corbett	9/10/2012	10.00	0	6	0	6	0.6
Dettmar	9/10/2012	7.50	0	6	0	6	0.8
Higginson	9/10/2012	9.00	0	23	1	24	2.7
Webster	9/10/2012	9.25	0	18	0	18	1.9
Zuber	9/10/2012	1.75	1	15	0	16	9.1
			Average				2.8

Table 3. Summary of angler survey forms from Sallie Keyes Lakes

Year	Number of forms analyzed	Effort (hrs)	Number of California golden trout captured			CPUE (fish/hr)
			Small < 6"	Medium 6"-11.9"	Total	
2011	6	16.5	30	55	85	4.63
2012	1	2.0	0	8	8	4.00
Average						4.54

Table 4. Summary of anglers photographed in 2012 on remote cameras from Lake #1

Usage type	Camera detected on			Total
	C3	C6	C3 and C6	
Day use	14	7	13	34
Backpackers	2	17	24	43
Total	16	24	37	77

Table 5. Sallie Keyes Lake #1 2012 gill net data

Gill net number	Start time	End time	Total time (hr)	Total number of golden trout captured	Number of recaptures (upper-caudal fin clip)	Number of mortalities
1	18:00	9:23	15.38	67	8	35
2	18:18	11:24	17.1	112	14	78
3	17:40	14:05	20.42	146	8	118
4	17:40	12:04	18.4	89	7	39
5	18:00	9:38	15.63	107	9	60
6	18:40	8:10	13.5	65	8	28
7	18:48	13:07	18.32	70	6	33
	Total		118.75	656	60	391