State of California

Memorandum

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To: Sarah Mussulman
Senior Environmental Scientist
Sierra District Supervisor
North Central Region Fisheries

From: Isaac Chellman
Environmental Scientist
High Mountain Lakes
North Central Region Fisheries

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Subject: *RANA SIERRAE* POPULATION MONITORING IN THE GOLD LAKE RESERVOIR AREA

ENVIRONMENTAL SETTING:

The Gold Lake Reservoir area is located in northern Sierra County, between the Gold Lake Highway and Pacific Crest Trail (Figure 1). Elevations in the area range from 6,400 feet (1,951 meters [m]) in elevation at Gold Lake Reservoir, to 7,500 feet (2,286 m) at an unnamed summit 2 kilometers (km) west of the reservoir. During visual encounter surveys (VES) in 2001, California Department of Fish and Wildlife (CDFW) crews observed Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) at four ponds in the area (Figure 2). Monitoring surveys conducted in the intervening years have revealed a small, but persisting, SNYLF population (Figure 3).

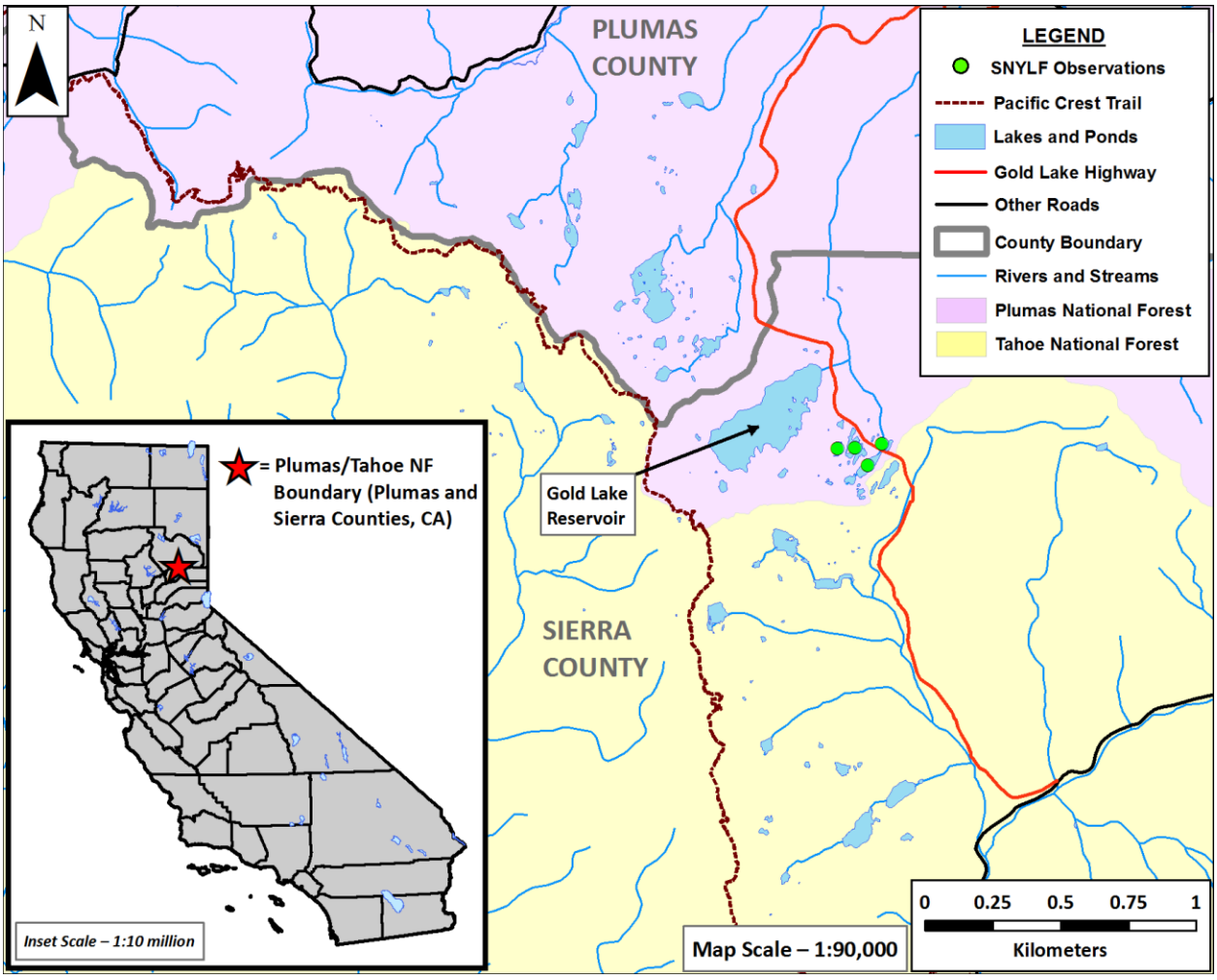


Figure 1: Gold Lake Highway area, Sierra County, CA. Green dots indicate positive detections of *Rana sierrae* (Sierra Nevada Yellow-legged Frog; SNYLF) by CDFW staff during visual encounter surveys (VES) between 2001 and 2017. Plumas National Forest is shown in light purple and Tahoe National Forest is shown in light yellow. Gold Lake Highway is highlighted in red.

INTRODUCTION

CDFW monitors the Gold Lake Reservoir area because it contains one of the few remaining SNYLF populations in the northern extent of the species' range. Additionally, this population is one of the few known extant SNYLF populations in Sierra County. In 2001, CDFW conducted baseline VES, during which crews observed adult and subadult SNYLF at site ID 50122, subadult SNYLF at Goose Lake (site ID 12273), and adult SNYLF at Haven Lake (site ID 12291) and Site 50123. On 21 June 2017, CDFW crews surveyed Goose Lake, Papoose Lake (site ID 12283), and site ID 12294 (Figure 2).

THREATS

- ***Marginal Habitats*** – The Gold Lake Reservoir area SNYLF population is small and isolated to a few small ponds. Most ponds in the area, including those occupied by SNYLF, have a maximum depth of 4 m or less. The exception is Haven Lake, which has a maximum depth of 6 m. However, Haven Lake formerly contained Brook Trout (*Salvelinus fontinalis*, BK), which may still be present. Any disturbance, natural or otherwise, that threatens overwintering habitats in the Gold Lake Reservoir area presents a potential extirpation risk. Among the habitat risks to the population are disturbance by humans, possible exposure to severe winter conditions, and desiccation from drought conditions, any of which could eliminate this small SNYLF population.

- ***Introduced Fish*** – Golden Shiner (*Notemigonus crysoleucas*) are present at most ponds in the Gold Lake Reservoir area. Dace (*Rhinichthys* spp.) may also be present in Goose Lake. These minnow species may compete with, or directly harm, smaller life stages of SNYLF (e.g., eggs and larvae). However, little information is available regarding effects of minnows on SNYLF (see Discussion). Brook Trout may also be present in Haven Lake: BK were captured during an overnight gill net set in 2001 and CDFW has not conducted subsequent overnight gill net surveys at Haven Lake. Additionally, Haven Lake is the deepest waterbody in the cluster of ponds east of Gold Lake Reservoir. Therefore, BK may be persisting in Haven Lake, despite a lack of visual detections during amphibian monitoring. Nearby Snag Lake contains self-sustaining Brown Bullhead (*Ameiurus nebulosus*), Lahontan Redside (*Richardsonius egregious*; LRS), and possibly BK and Rainbow Trout (*Oncorhynchus mykiss*; RT). CDFW stocked Snag Lake with BK until 2000 and RT until 2015. The persistent fish populations in Snag Lake may preclude any SNYLF reproduction and reduce the likelihood of post-metamorphic frog occupancy (Knapp and Matthews 2000). CDFW regularly stocks the largest lake in the area, Gold Lake Reservoir, with RT and Brown Trout (*Salmo trutta*). Monitoring data show that Gold Lake Reservoir contains self-sustaining populations of Lake Trout (*Salvelinus namaycush*), BK, and LRS (CDFW, unpubl. data).

- ***Disease*** – All SNYLF populations in Sierra County are chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*) positive. In 2008 and 2010, field crews genetically sampled SNYLF collected at Goose Lake with epithelial swabs to detect the presence of *Bd.* Crews collected two swabs in 2008 and four swabs in 2010. Results for both years were highly variable: *Bd* zoospore loads were zero in some samples, light in most, and one was heavy. Additionally, crews detected three dead SNYLF at Goose Lake during the 2017 surveys. The carcasses were highly degraded and the cause of death cannot be determined. These observations suggest that there may be consistent, low-level *Bd*-induced mortality in this population. However, other causes may also be contributing to the consistent low abundance observed in this SNYLF population, including overwinter mortality in 2016–2017 (during which there were record high precipitation totals) and the other factors discussed in this section.

- ***Loss of Genetic Diversity*** – The Gold Lake Reservoir area SNYLF population is highly isolated from the nearest robust SNYLF populations. The closest known extant SNYLF population, which is also small, is located about 4.5 km east, at a site called Westall Pond (USFS 2016). The closest large SNYLF metapopulation is over 30 km southwest, in Nevada County. This geographic isolation limits potential for gene flow between populations and increases risk for local extirpation. Isolated populations can also suffer from inbreeding depression, genetic drift, fixation of deleterious alleles, and loss of genetic diversity, all of which are population genetic factors exacerbated when the population is small (Frankham et al. 2009).

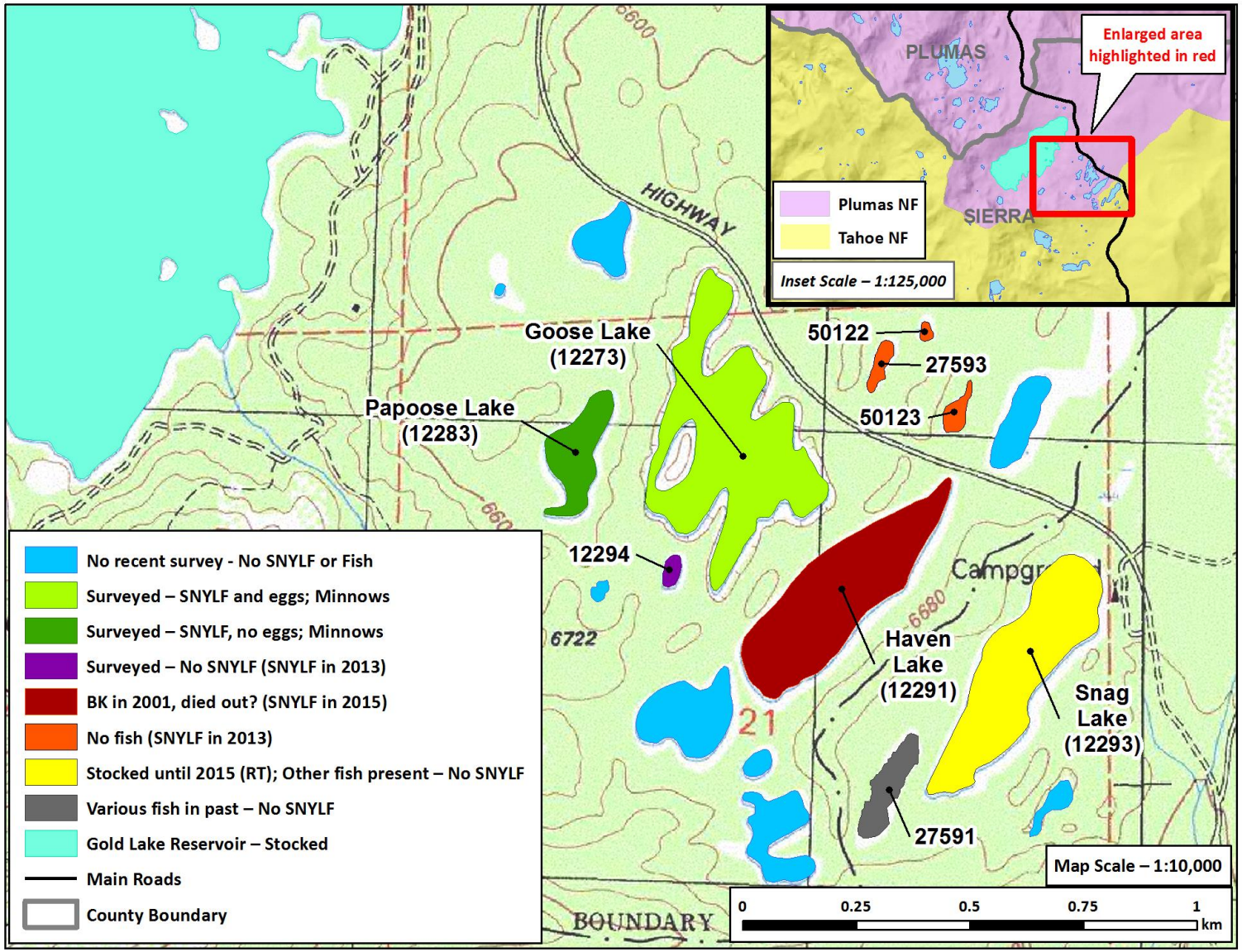
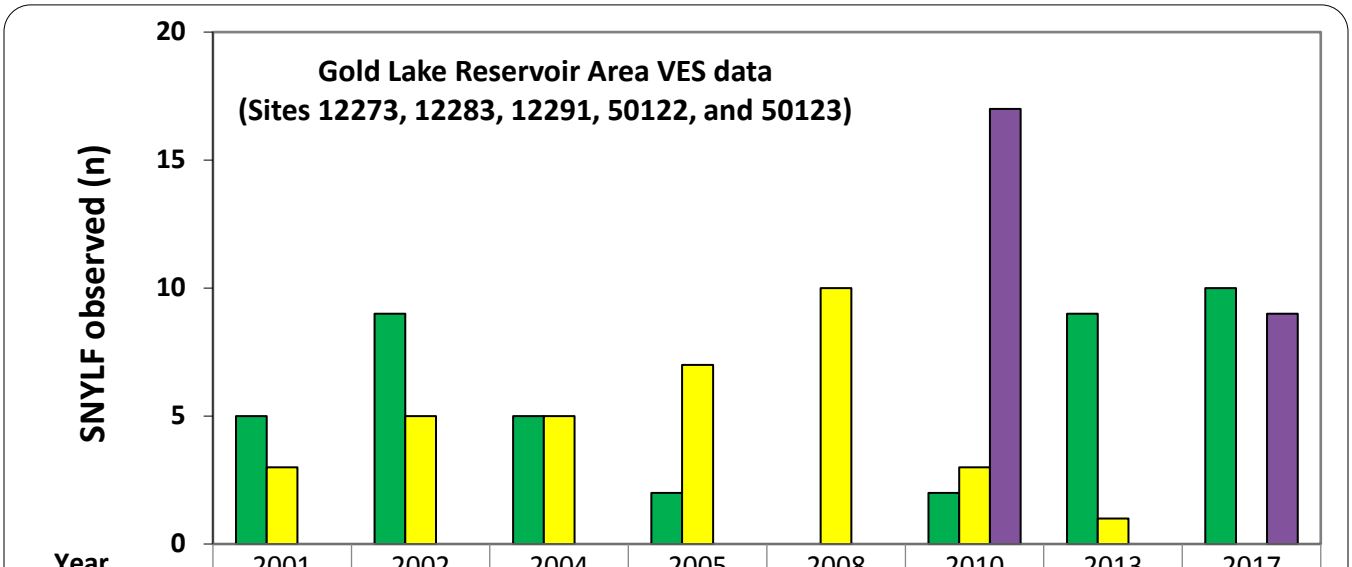


Figure 2: Gold Lake Reservoir area ponds in Plumas and Tahoe National Forests, Sierra County, CA. *Rana sierrae* (Sierra Nevada Yellow-legged Frog; SNYLF) observations occurred during visual encounter surveys (VES) between 2001 and 2017. ***For lakes CDFW did not survey in 2017, the year of last SNYLF detection during U.S. Forest Service (USFS) amphibian surveys are shown in the legend in parentheses.*** Goose Lake is a consistent breeding site for SNYLF, whereas field crews have not observed egg masses or tadpoles in any other ponds. Minnows are present in most of the larger ponds in the area. Haven Lake may still contain Brook Trout (*Salvelinus fontinalis*). CDFW regularly stocks Gold Lake Reservoir with trout. Numbers are CDFW site IDs.

VES AT GOLD LAKE RESERVOIR AREA

CDFW performed baseline visual encounter surveys in the Gold Lake Reservoir area in 2001. Staff encountered a small breeding SNYLF population occupying four small ponds (Figure 2). Seventeen years of occasional monitoring data suggest the Gold Lake Reservoir area SNYLF population is currently stable, despite being small (Figure 3). The primary location of interest for SNYLF conservation is Goose Lake, in which CDFW and U.S. Forest Service (USFS) personnel have occasionally observed egg masses (Figure 4). Detections have remained relatively consistent, albeit low, since CDFW began survey efforts in 2001. Observer bias, variation in survey conditions, habitat complexity, and the low number of detections all make deriving trends difficult. CDFW will continue to survey the Gold Lake Reservoir area at least every other year to monitor SNYLF population trends over time. The next planned survey of the area will occur during summer 2019.



Year	2001	2002	2004	2005	2008	2010	2013	2017
Adult	5	9	5	2	0	2	9	10
Subadult	3	5	5	7	10	3	1	0
Egg Masses	0	0	0	0	0	17	0	9

Figure 3: California Department of Fish and Wildlife (CDFW) visual encounter survey (VES) data displayed by life stage at Gold Lake Reservoir area ponds from 2001 through 2017. Survey effort varied throughout the timeframe shown. CDFW field crews surveyed the entire area (i.e., all waterbodies shown in Figure 2) during baseline surveys in 2001. Goose Lake (Site 12273, Figure 4) is the only waterbody in which SNYLF egg masses have been observed and the only waterbody surveyed during every visit to the area. Crews did not survey: Haven Lake (Site 12291) in 2008, 2013, and 2017; Papoose Lake (Site 12283) in 2004, 2005, and 2008; and Sites 50122 and 50133 in 2002, 2004, 2005, 2013, and 2017.

Figure 4. Site 12273 (Goose Lake) in June 2017, from UTM 10S 702563E 4394264N, looking east.

DISCUSSION

Most SNYLF-containing ponds in the Gold Lake Reservoir area also support Golden Shiner and/or other minnow species. The only known exceptions are the small ponds north of Gold Lake Highway that do not appear to contain fish. CDFW does not know if minnows affect SNYLF egg masses or tadpoles, and, therefore, influence recruitment to the adult life stage. However, CDFW and USFS field crews have observed SNYLF egg masses in Goose Lake in 2010, 2016, and 2017. CDFW crews observed nine SNYLF egg masses during the recent surveys in 2017, and crews detected 17 egg masses in 2010. Therefore, the presence of minnows does not preclude SNYLF breeding. However, minnows may still limit SNYLF development and recruitment into the adult population. Little quantitative data are available regarding direct interactions between minnows and early life stage SNYLF.

There is some evidence that other cyprinids can cause reduced survival and growth in amphibians. For example, a mesocosm study found that Fathead Minnows (*Pimephales promelas*) reduced the survival and growth rates of salamander larvae through competition and inflicting injury (Pearson and Goater 2009). Other small fish species have been linked with sublethal effects on amphibians, including Mosquitofish (*Gambusia* sp.; Pyke and White 2000; studies summarized in Kats and Ferrer 2003). Experimental evidence has shown that Three-spined Sticklebacks (*Gasterosteus aculeatus*) cause limb and tail damage in larval Western Toads (*Anaxyrus boreas*) identical to damage observed in the field (Bowerman et al. 2010). Undoubtedly, numerous fish species can affect amphibian larvae in different ways, and many of those effects may be deleterious, if not necessarily lethal (Wells 2007 pgs. 657–659).

The evidence for other common aquatic predators affecting larval amphibians further complicates isolating potential effects of minnows. For example, various species of dragonfly nymphs are voracious predators of amphibian larvae (See Table 14.2 in Wells 2007; Ballengée and Sessions 2009, Bowerman et al. 2010). Additionally, other amphibian larvae found in the northern Sierra Nevada are known to prey on conspecifics (e.g., *Ambystoma macrodactylum*; Wildy et al. 1998, Wildy et al. 2001).

In light of these complications and unknowns regarding interactions between minnows and SNYLF, CDFW and/or USFS will continue to monitor the Gold Lake Reservoir area populations to attempt detecting evidence of recruitment (particularly tadpoles), and observe potential interactions between minnows and SNYLF. This site, in combination with SNYLF populations in Bucks Lake Wilderness (some of which are also sympatric with minnows) also could provide a unique opportunity for CDFW to study the ecological interactions of native cyprinids and early life stage SNYLF.

RECOMMENDATIONS

CDFW will continue monitoring the Gold Lake Reservoir area populations to assess population status (i.e., determine relative abundance, look for signs of continued breeding and recruitment, and assess distribution of SNYLF on the landscape). Additionally, CDFW may work with local zoo and university partners to develop a research project (e.g., a graduate research masters study) on the interactions between cyprinids and SNYLF, especially early life stages, such as eggs and recently hatched larvae. The interactions of large predatory fish (e.g., trout) and SNYLF are well-studied, but there is much less currently known about the interactions of smaller forage fish and amphibians, especially studies investigating potential sublethal effects on frog populations (e.g., limited breeding success, reduced size at metamorphosis, limb damage).

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