

State of California
Department of Fish and Wildlife

Memorandum

Date: 9 April 2021

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

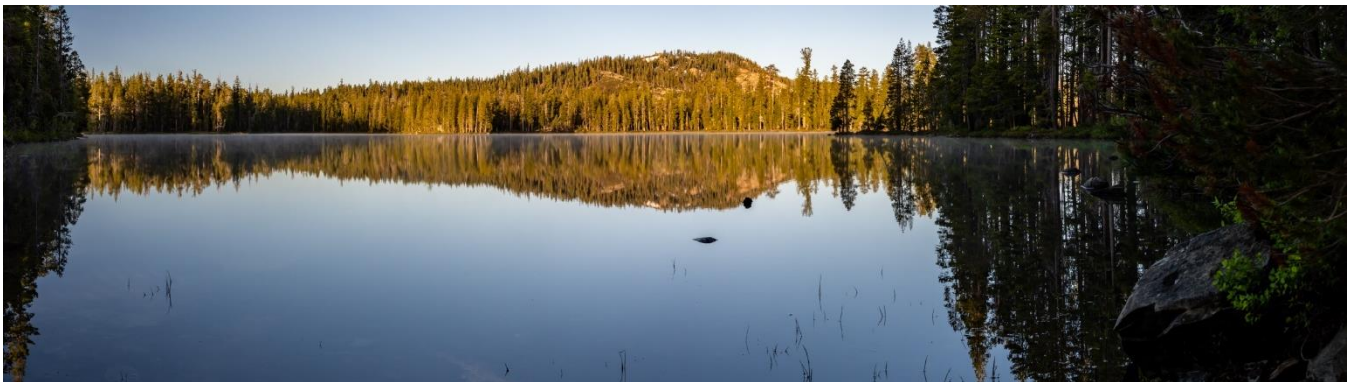
From: John Imperato, Scientific Aide;
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High Mountain Lakes;
North Central Region Fisheries

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Subject: Amphibian monitoring in Sierra County

- ***Rana sierrae* population monitoring along the Gold Lake Highway corridor**



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 (ft) (1,951 meters [m]) in elevation at Gold Lake Reservoir, to 7,500 ft (2,286 m) at an unnamed summit two kilometers (km) west of the reservoir. Most land in the Gold Lake Reservoir area is managed by Plumas National Forest (PNF), but the southeast section of the lake basin (including Snag Lake and a couple unnamed ponds) is managed by Tahoe National Forest (TNF; **Figure 2**). During visual encounter surveys (VES) in 2001, California Department of Fish and Wildlife (CDFW) crews observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) at four ponds in the area. Monitoring surveys conducted in the intervening years have revealed a small, but persisting, SNYLF population.

Howard Pond is also located in northern Sierra County, approximately 6 km east of Gold Lake Reservoir and 3.5 km east of the Gold Lake Highway (**Figure 1**). Local elevations range from 7,004 ft (2,197 m) at nearby Howard Creek Meadow, to 8,107 ft (2,471 m) at the summit of Haskell Peak, 2.5 km to the southeast. Most land around Howard Pond is managed by the TNF. However, a portion of the surrounding land, including the western edge of Howard Pond, is owned by Graeagle Land and Water Company (**Figure 3**).

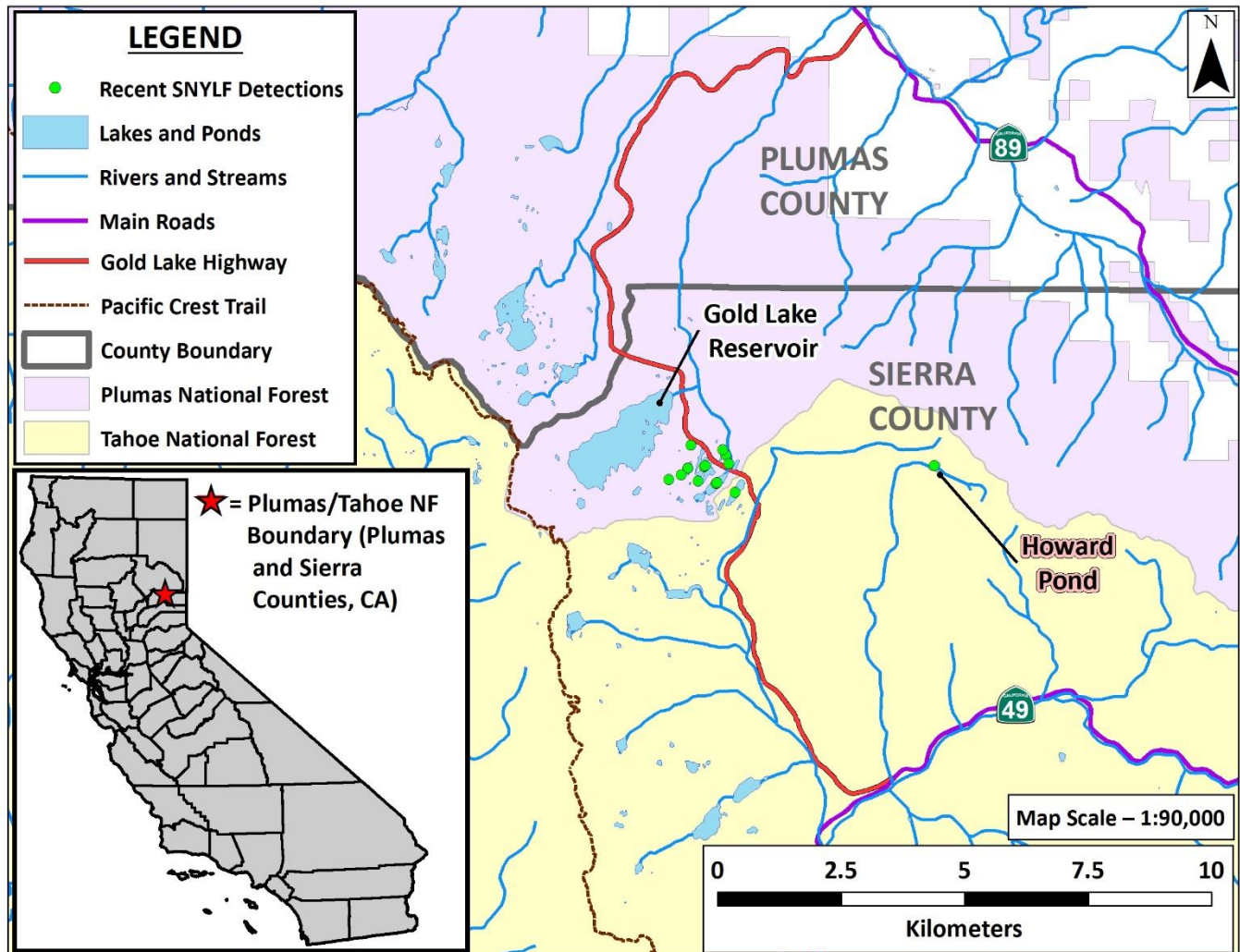


Figure 1: Gold Lake Highway area, Sierra County, CA. Green dots indicate positive detections of *Rana sierrae* (Sierra Nevada Yellow-legged Frog; SNYLF) by California Department of Fish and Wildlife (CDFW) staff during recent visual encounter surveys (VES). Plumas National Forest is shown in light purple 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 10 and 11 June 2020, CDFW crews surveyed 19 waterbodies in the area (**Figure 2**).

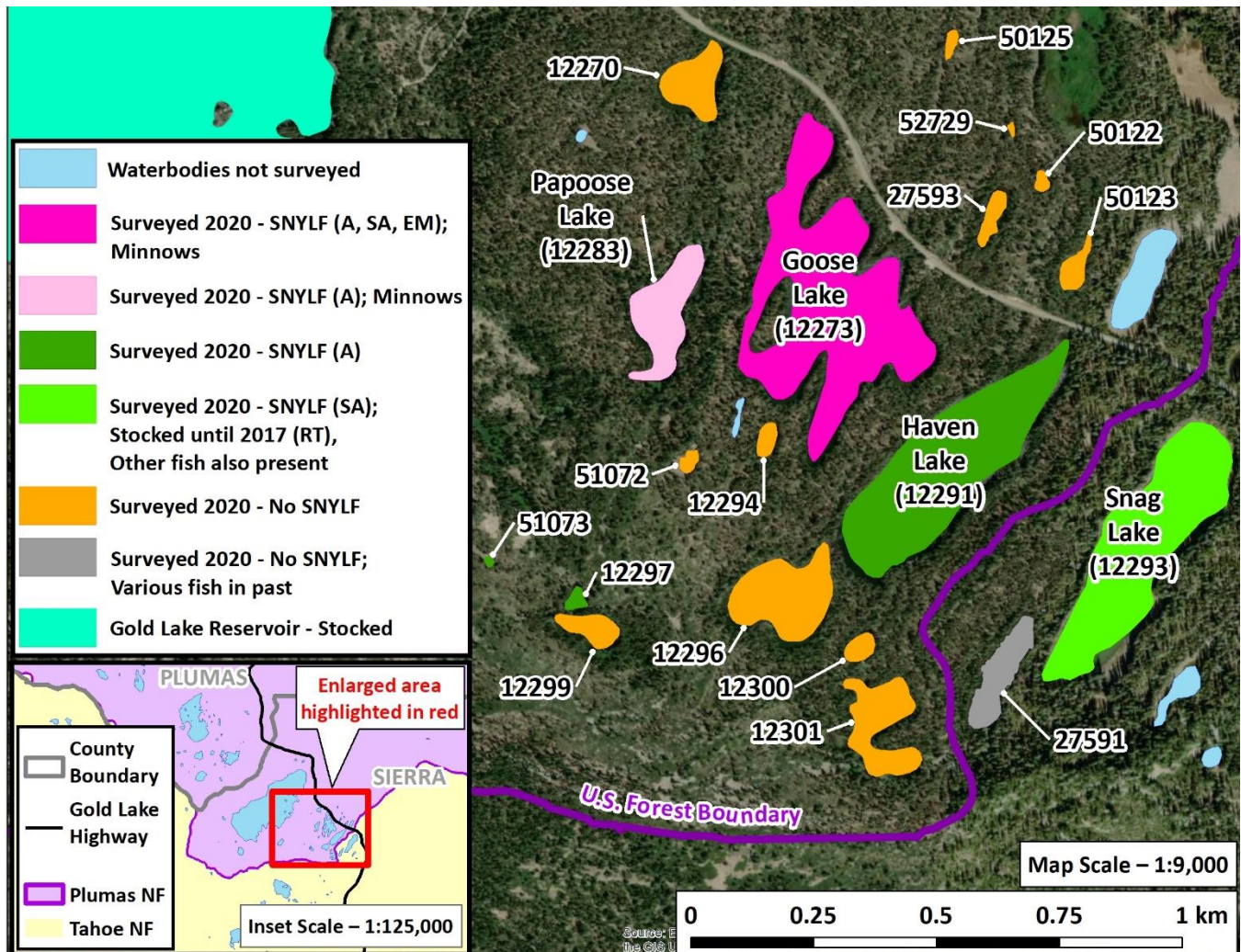


Figure 2: Gold Lake Reservoir area ponds in Plumas and Tahoe National Forests (PNF and TNF), Sierra County, CA. The purple boundary line demarcates PNF (to the west and north) and TNF (to the east and south). Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations occurred during visual encounter surveys (VES) in 2020. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults, “SA” = subadults, and “EM” = egg masses. 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*; BK). CDFW regularly stocks Gold Lake Reservoir with Brown Trout (*Salmo trutta*; BN) and Rainbow Trout (*Oncorhynchus mykiss*; RT). Numbers are CDFW Site IDs.

CDFW is interested in the Howard Pond 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 recent years, Howard Pond has been surveyed by TNF field staff (USFS 2016). However, beginning in 2019, CDFW has assisted TNF in surveying the site. CDFW staff surveyed Howard Pond for the second time on 11 June 2020. CDFW staff surveyed the main body of the pond, but staff did not survey any of the ephemeral inlets. During surveys, CDFW staff only surveyed public lands owned by TNF.

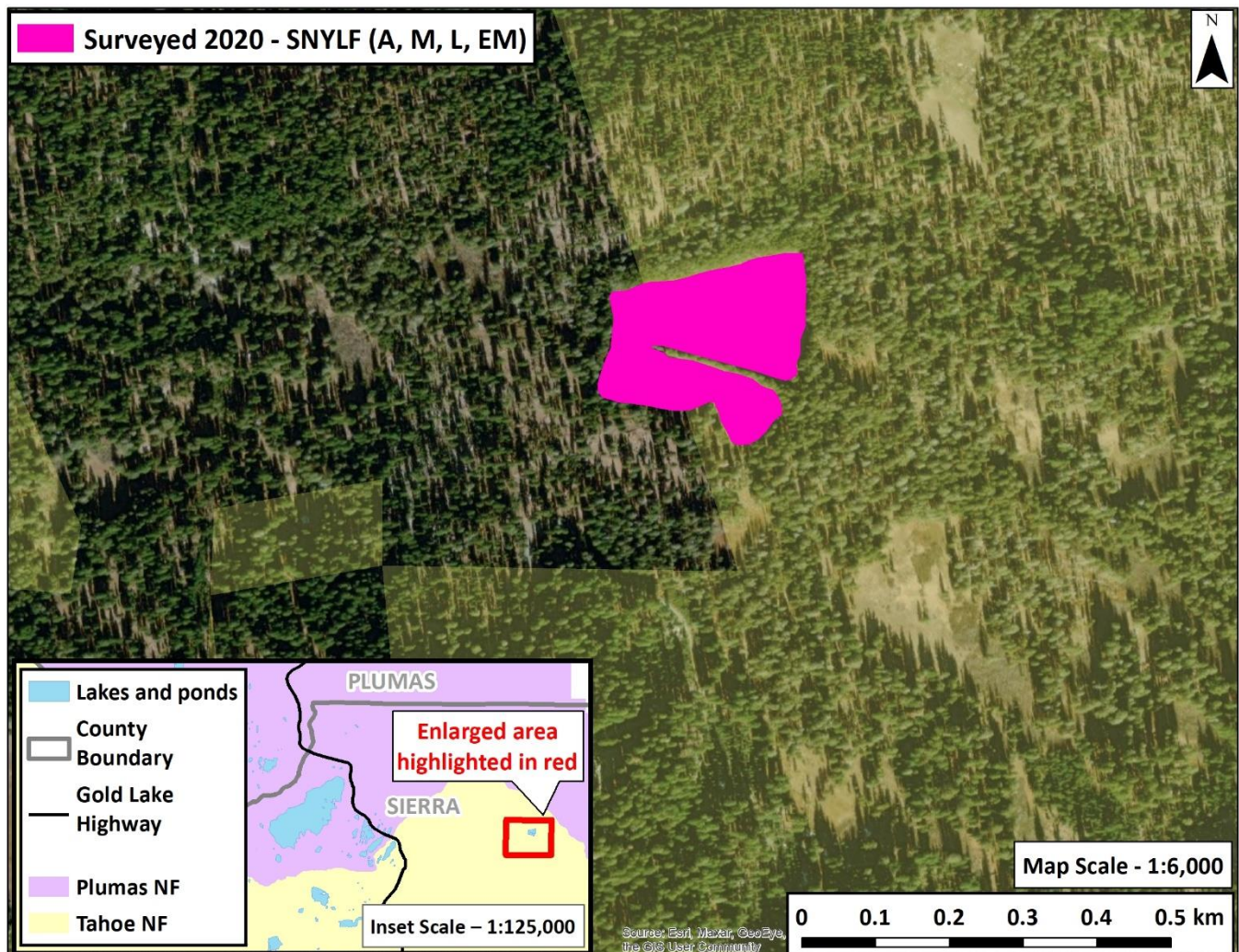


Figure 3. Howard Pond, Tahoe National Forest (TNF), Sierra County, CA. Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations occurred during California Department of Fish and Wildlife (CDFW) visual encounter surveys (VES) in 2020. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults, “M” = metamorphs, “L” = larvae, and “EM” = egg masses. Land shaded in yellow is owned by TNF and land without shading is privately owned. The parcel situated on the western side of Howard Pond is owned by Graeagle Land and Water Company. CDFW only surveyed areas owned by TNF.

THREATS

Marginal Habitats

The Gold Lake Reservoir area and Howard Pond SNYLF populations are small and isolated. Most ponds, including those occupied by SNYLF, have a maximum depth of 4 m or less. Water levels at Howard Pond will occasionally drop to the point where less than half of the pond remains, when compared to full pool (Google Earth imagery, August 2012). 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 presents a potential extirpation risk for SNYLF. Among the habitat risks are human disturbance, exposure to severe winter conditions, and desiccation from drought conditions, any of which could eliminate these small SNYLF populations.

Introduced Fish

Golden Shiner (*Notemigonus crysoleucas*), Lahontan Redside (*Richardsonius egregius*; LRS), and Speckled Dace (*Rhinichthys osculus*) are present at most ponds in the Gold Lake Reservoir area. 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 last captured in the lake during an overnight gill net set in 2001. In 2020, CDFW staff again set a gill net overnight in Haven Lake and did not capture any BK. This suggests that BK may have died out in the absence of stocking, but is not conclusive evidence that the lake contains no BK. Nearby Snag Lake contains self-sustaining Brown Bullhead (*Ameiurus nebulosus*), and possibly BK and Rainbow Trout (*Oncorhynchus mykiss*; RT). CDFW stocked Snag Lake with BK until 2000 and RT until 2017. 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, 2010, and 2020 field crews genetically sampled SNYLF collected at Goose Lake with epithelial swabs and screened them for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR). Crews collected two swabs in 2008, four swabs in 2010, and one swab in 2020. Results for the three years were highly variable: *Bd* zoospore loads were zero in some samples, light in most, and one was heavy. Additionally, at Goose Lake, CDFW staff observed three dead SNYLF during surveys in 2017, four dead SNYLF adults during surveys in 2019, and one dead SNYLF subadult during surveys in 2020. The cause of death cannot be determined, but these observations may suggest that there is 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 and 2018–2019 (during both of which there were high precipitation totals and late season snowpack) and the other factors discussed in this section.

Loss of Genetic Diversity

The Gold Lake Reservoir area and Howard Pond SNYLF populations are highly isolated from the nearest robust SNYLF populations. Outside of the Gold Lake corridor, the closest known extant SNYLF populations, which are also small, are located about 30 km southeast, in the Independence Creek area. The closest large SNYLF metapopulations is over 35 km away in Nevada County. This geographic isolation effectively eliminates 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).

VES AT GOLD LAKE RESERVOIR AREA

CDFW performed baseline VES in the Gold Lake Reservoir area in 2001, during which staff encountered a small breeding SNYLF population occupying four ponds. Twenty years of occasional monitoring data suggest the Gold Lake Reservoir area SNYLF population is currently stable, despite its small size (**Figure 4**). The primary location of interest for SNYLF conservation is Goose Lake (**Figure 5**), in which CDFW and PNF personnel have occasionally observed egg masses (**Figure 6**). Detections have remained relatively consistent, albeit low, since CDFW began survey efforts in 2001. Observations of SNYLF adults were lower in 2020 than in the previous three survey years. However, observer bias, variation in survey effort, weather conditions, habitat complexity, and the low number of detections all make deriving trends difficult. For example, in 2019, CDFW surveyed 17 ponds in the Gold Lake Reservoir area, compared to only three ponds in 2017.

In 2020, CDFW staff detected SNYLF (a single subadult) in Snag Lake (Site ID 12293) for the first time. All egg masses observed in Goose Lake in 2020 were either the remnants of hatched out eggs or non-viable egg masses that had not fully developed (**Figure 6**). When compared with the year before—during which CDFW observed far more SNYLF egg masses than staff had observed during previous years—2020 was warmer and drier, following a winter with below average snowpack. Due to these conditions, SNYLF bred earlier in 2020 than 2019, and CDFW surveys missed the primary window during which fresh egg masses would have been available for detection. CDFW will continue to survey the Gold Lake Reservoir area at least every other year to monitor SNYLF population trends over time. CDFW plans to next survey the Gold Lake Reservoir area in 2021 or 2022.

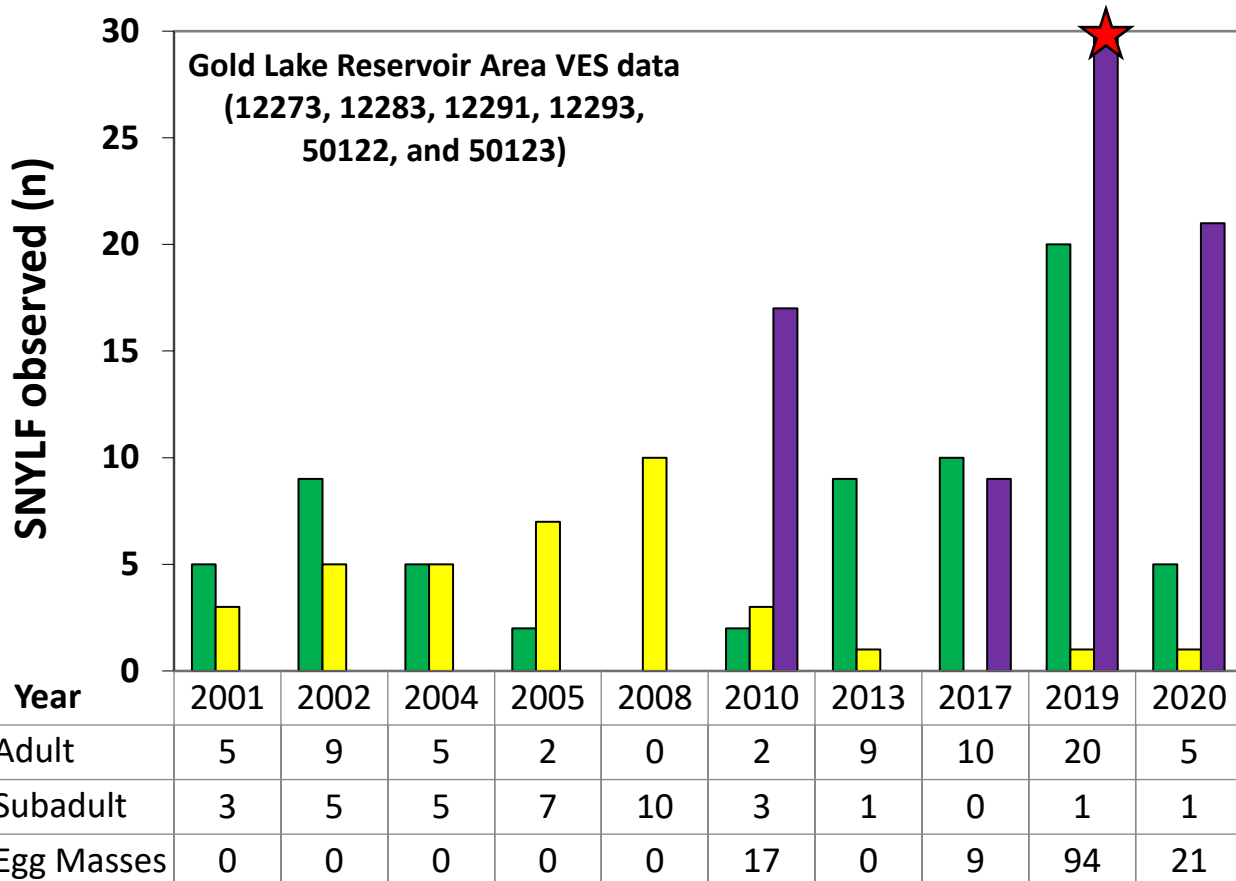


Figure 4: California Department of Fish and Wildlife (CDFW) visual encounter survey (VES) data displayed by life stage at a subset of Gold Lake Reservoir area ponds from 2001 through 2020. Goose Lake (Site ID 12273) is the only waterbody in which CDFW staff have observed SNYLF egg masses and the only waterbody surveyed during every visit to the area. CDFW staff did not survey the following locations during the specified years: Haven Lake (Site ID 12291) in 2008 and 2013–2017; Papoose Lake (Site ID 12283) 2004–2008; Snag Lake (Site ID 12293) from 2002–2008 and 2013–2019; and Site IDs 50122 and 50133 in 2002–2005 and 2013–2017.

★ [red star] Indicates an outlier value beyond the range of the figure (94 egg masses).

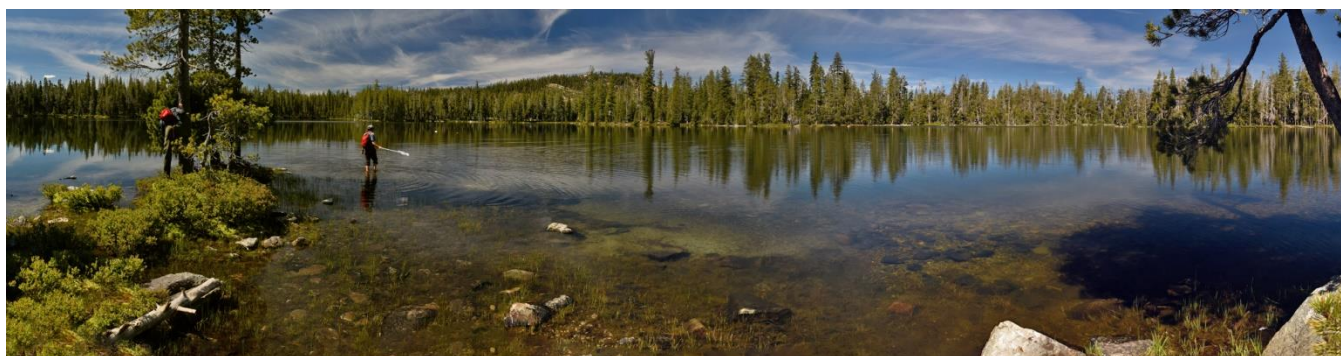


Figure 5: Goose Lake (Site ID 12273), looking south from the northern shore, on 10 June 2020. (CDFW)



Figure 6. One of several undeveloped Sierra Nevada Yellow-legged Frog (*Rana sierrae*) egg masses found in the vicinity of a partially submerged, fallen tree at Goose Lake (Site ID 12273) on 10 June 2020. (CDFW)

VES AT HOWARD POND

Biologists from TNF have been monitoring the SNYLF population at Howard Pond (**Figure 7**) and its tributaries since 2001. Depending on the survey, TNF biologists observed up to 15 SNYLF adults and nearly 100 larvae. Therefore, available records suggest a small, yet stable, breeding SNYLF population (TNF, unpubl. data).



Figure 7. Howard Pond (Site ID 12285) on 11 June 2020.

In 2020, CDFW field staff observed four adult SNYLF (**Figure 8**), five metamorphs, eight larvae, and 34 egg masses at Howard Pond (**Figure 9**). The number of SNYLF adults and larvae CDFW staff observed in 2020 was consistent with observations by TNF and CDFW in previous years, which suggests that the Howard Pond SNYLF population may be stable. In 2020, CDFW staff observed egg masses in Howard Pond after first observing them in 2019. In previous years, surveys may have occurred too late in the summer to detect egg masses. The number of SNYLF egg masses CDFW staff observed is an approximation because many of the egg masses were located underneath cover, where they could only be detected by touch and not observed directly (**Figure 10**). However, staff found it effective to use tactile sensation to gently estimate the number of egg masses located under cover.

Due to time constraints, CDFW staff did not survey any of the inlets to Howard Pond during the 2020 survey. Staff surveyed the inlets in 2019 and did not observe any SNYLF. TNF spatial records suggested that a portion of past SNYLF detections in the Howard Pond area occurred in the primary inlet stream, which flows through a meadow located east of the pond.



Figure 8. An adult male Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observed at Howard Pond on 11 June 2020. CDFW staff observed several adult male SNYLF in the same small area, close to recently laid SNYLF egg masses. (CDFW)



Figure 9. A dense cluster of recently laid Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) egg masses CDFW staff observed at Howard Pond on 11 June 2020. During the survey, CDFW staff observed all SNYLF egg masses in the same location. CDFW staff also observed several adult male SNYLF and larval SNYLF in the same area. (CDFW)



Figure 10. A California Department of Fish and Wildlife (CDFW) field crew member estimates the number of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) egg masses present by gently feeling under cover objects. Many SNYLF egg masses were located underneath cover, where they could not be observed directly. (CDFW)

DISCUSSION

SNYLF mortalities at Goose Lake

Observations of dead SNYLF adults at Goose Lake are disconcerting, but not unusual. CDFW staff have observed low numbers of SNYLF mortalities during multiple seasons in other locations (e.g., Dot Lake in Bucks Lake Wilderness; CDFW 2020a). The causes of death may be the result of many possible factors, including disease (Briggs et al. 2010, Smith et al. 2017), environmental conditions (Bradford 1983, CDFW 2020b), attempted predation (Feldman and Wilkinson 2000), or breeding competition (i.e., drownings during amplexus caused by overzealous males; Sztatecsny et al. 2006). Mortalities in SNYLF are often attributed to *Bd*, which has been present in this location since at least 2008 (see [Disease](#) section above).

Minnows and SNYLF

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 much smaller, unnamed ponds in the vicinity—many of which are ephemeral—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, 2017, 2019, and 2020. CDFW crews observed 17 SNYLF egg masses in 2010, nine in 2017, 94 in 2019, and 21 during the most recent survey in 2020. Therefore, the presence of minnows does not preclude SNYLF breeding. However, minnows may 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 to assess SNYLF population status (i.e., determine relative abundance, look for signs of continued breeding and recruitment, collect skin swabs for *Bd* and assess distribution of SNYLF on the landscape). CDFW will continue to monitor the Howard Pond population at least biennially if TNF biologists are unable to survey the site due other priorities or limited personnel availability. 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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