State of California Department of Fish and Wildlife

Memorandum

Date: 7 March 2023

- To: Leslie Alber, Senior Environmental Scientist; Sierra District Supervisor; North Central Region Fisheries
- From: Isaac Chellman, Environmental Scientist; High Mountain Lakes; North Central Region Fisheries
- Cc: Region 2 Fish Files
- Ec: CDFW Document Library

Subject: Native amphibian restoration and monitoring in Desolation Wilderness;

- *Rana sierrae* monitoring in the Highland Lake drainage: update.
- *Rana sierrae* translocation from Highland Lake to 4-Q Lakes: 2018–2022 summary.



Evening at 4-Q Lakes in July 2022. (CDFW)

SUMMARY

The Highland Lake drainage is an area from which California Department of Fish and Wildlife (CDFW) staff removed Rainbow Trout (*Oncorhynchus mykiss*, RT) from 2012–2015 to benefit Sierra Nevada Yellow-legged Frogs (*Rana sierrae*, SNYLF). Amphibian monitoring data from 2003 through 2022 indicate that the Highland Lake drainage now contains one of the largest known SNYLF populations in the northern Sierra Nevada.

Since at least 2015, annual visual encounter surveys (VES) have revealed that the Highland Lake drainage contains a sufficient adult SNYLF population to provide a source for translocations to nearby suitable fishless habitats. The Interagency Conservation Strategy for Mountain Yellow-legged Frogs in the Sierra Nevada (hereafter "Strategy"; MYLF ITT 2018) highlights translocations as a principal method for SNYLF recovery. In 2016, CDFW applied for funding through the U.S. Fish and Wildlife Service (USFWS) endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973) to translocate SNYLF from the Highland Lake drainage to 4-Q Lakes, a nearby fishless drainage, where VES conducted by CDFW in 2003, 2015, and 2018 suggested SNYLF were not present. The grant was awarded by the USFWS in November 2016 (Federal Grant Award #F17AP00001) and allowed staff from CDFW and Eldorado National Forest (ENF) to undertake two translocations from Highland Lake to 4-Q Lakes, one in July 2018 (60 adult frogs) and another in August 2019 (40 adult frogs).

After initial success of the first two translocations—as evidenced by many adults surviving overwinter, rapid growth of recaptured adults, and observations of early life stage SNYLF at 4-Q Lakes in June 2020—CDFW applied for another round of funding through Section 6 to conduct two additional translocations in 2021 and 2022. USFWS awarded the grant in mid-January 2021 (Federal Grant Award #F21AP00483). As a result, in July 2021 and 2022, CDFW and ENF staff biologists translocated an additional 51 and 26 adult SNYLF, respectively. In total, CDFW and ENF staff have translocated 177 adult SNYLF (98 females and 79 males) from the Highland Lake drainage to 4-Q Lakes.

Each year from 2018–2022, CDFW field staff revisited 4-Q Lakes two–three times per summer to monitor the new SNYLF population. During those visits, CDFW has recaptured 86 of the 177 translocated SNYLF (49%) at least once since release at 4-Q Lakes. In 2020, CDFW observed the first signs of SNYLF breeding, including observing a recently hatched egg mass, tadpoles, and subadults. In 2021 and 2022, CDFW staff observed additional egg masses, tadpoles, subadults, and new young adults, which were unmarked with passive integrated transponder (PIT) tags and, therefore, born at 4-Q Lakes. All recaptured SNYLF originally translocated to 4-Q Lakes from Highland Lake had grown noticeably and appear to be in excellent body condition. CDFW plans to continue monitoring in the Highland Lake drainage and 4-Q Lakes basin during summer 2023 and beyond.



Figure 1. Desolation Wilderness, El Dorado County, CA. The areas discussed in this memorandum are circled.

ENVIRONMENTAL SETTING

Highland Lake and 4-Q Lakes are in Desolation Wilderness, northeast El Dorado County (**Figure 1**). Highland Lake sits in a granite cirque at approximately 7,800 feet in elevation and drains northeast into Rockbound Lake (**Figure 2**). No official trails access Highland Lake, but a use trail from nearby Forni Lake, which proceeds over a saddle just south of Tells Peak, indicates regular visitation by hikers. 4-Q Lakes are located approximately 3.5 km southeast of Highland Lake drainage. 4-Q Lakes sit in a granite basin at approximately 7,500 feet in elevation and drain north into Rubicon Lake. The McConnell Lake Trail provides access to the site from the Leland/McConnell/Horseshoe Lakes drainage (to the west) and Camper Flat (to the east). ENF manages this section of Desolation Wilderness and the surrounding land.

INTRODUCTION

The Aquatic Biodiversity Management Plan (ABMP) for the Desolation Wilderness Management Unit (CDFG 2012) identifies Highland Lake (Site ID 13904; **Figure 2**) and the surrounding habitat, approximately one kilometer (km) of outlet stream (Site IDs 52648, 52649, 52650, 52670, and 52671), and three associated ponds (Site IDs 13892, 13896, and 13903) as a Native Species Reserve (NSR; **Figure 3**) for SNYLF (**Figure 4**).



Figure 2. Highland Lake on 5 July 2022, looking west toward the saddle between Highland and Forni Lakes, which was beneath cloud cover when staff took this photograph. (CDFW)



Figure 3. Highland Lake Native Species Reserve (NSR). California Department of Fish and Wildlife (CDFW) staff have observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) throughout the drainage. Following surveys in 2022, CDFW added new geographic information system (GIS) site polygons to the drainage to allow for additional spatial detail in presenting survey results. In previous years, CDFW staff surveyed inlets to Highland Lake and associated marsh/meadow habitat. However, these locations were not shown in earlier maps. The addition of new polygons allows more accurate visualization of SNYLF distribution in the Highland Lake area. 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 "L" = larvae. Number labels shown are unique site identification codes that CDFW uses for data collection. All flowing waters drain northeast into Rockbound Lake.



Figure 4. Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) basking in a splash zone of the Highland Lake outlet stream on 7 July 2022. (CDFW)

CDFW stocked Highland Lake with RT from 1935 until 2000. The lake contains limited spawning habitat and RT exhibited little natural reproduction. In 1955, CDFW constructed a stonemasonry streamflow maintenance dam at the outlet (USFS 1955, CDFG 1980). The dam forms an effective barrier to fish moving from the outlet stream into the lake, thereby further reducing spawning potential. In 1993, ENF biologists observed a very small SNYLF population in the Highland Lake outlet stream (USFS 1993). Staff also detected RT in Highland Lake and the outlet stream. Gill net surveys in 2003 and 2010 indicated that RT were persisting at low density in the absence of stocking. In the 2000's, CDFW managers, in partnership with ENF, determined that eradicating the low-density RT population using gill nets and backpack electrofishers would be feasible, and provide an opportunity to recover the SNYLF population

in the Highland Lake drainage (CDFG 2012). As a result, in 2012, CDFW and ENF personnel began removing RT from Highland Lake NSR to benefit SNYLF. In 2017, CDFW and ENF determined that the NSR was fishless, following two years without any fish captures or observations. Although field staff have not seen or captured any fish since 2015, CDFW will continue monitoring the site for presence of any latent non-native trout. Those interested in learning more details about fish removal in the Highland Lake drainage may consult the <u>2017</u> Highland Lake survey memorandum (CDFW 2018).

Now that fish removal is complete in the Highland Lake drainage, the SNYLF population has grown substantially, from only a handful of post-metamorphic frog detections in the 1990's, to an average of 452 adults, 290 subadults, and 974 larvae observed during VES from 2014 to 2022 (**Figures 5 and 6**). The large SNYLF population allows for translocating a subset of adult frogs to establish new SNYLF populations nearby. The Desolation Wilderness ABMP identifies 4-Q Lakes (located 3.5 km to the southeast; **Figure 1**) as a site to receive SNYLF translocated from the Highland Lake drainage (CDFG 2012). 4-Q Lakes provide an interconnected, fishless aquatic basin that may provide the foundation for establishing another healthy SNYLF population in the Upper Rubicon drainage.

From at least 1931 until 2000, CDFW regularly stocked the three largest 4-Q Lakes with Brook Trout (*Salvelinus fontinalis*; BK). During overnight gill net surveys in 2003, CDFW field staff captured six BK in the basin. However, subsequent gill net surveys in 2010 (one-night net set) and 2016 (one-month net set) returned zero fish, confirming that BK were not self-sustaining and the lakes were fishless.

In addition to gill net surveys, CDFW completed VES of the entire 4-Q Lakes basin to check for potential occupancy by fish, SNYLF, or other special status herpetofauna. VES conducted by CDFW in 2003, 2015, and 2018 resulted in no SNYLF observations, although field staff did observe other amphibian and reptile species. Therefore, CDFW and ENF personnel had not observed SNYLF in 4-Q Lakes basin during any surveys prior to translocations in 2018. Given the habitat composition and relative nearness of extant populations, SNYLF likely occupied 4-Q Lakes before fish stocking began in 1931. However, CDFW is not aware of any museum or earlier survey records to confirm former SNYLF occupancy in 4-Q Lakes basin.

THREATS

Disease

All SNYLF populations in El Dorado County are positive for chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*). CDFW sampled Site IDs 13903 and 13896 in 2009 and 2010 using epithelial swabs and had the swabs screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. Staff collected eight swabs and results from both years detected very light to moderate *Bd* infection intensity. In 2019, CDFW staff collected an additional 26 SNYLF epithelial swabs at Highland Lake (Site ID 13904). In fall 2020, partner scientists at the Sierra Nevada Aquatic Research Laboratory (SNARL) screened the new swabs for presence of *Bd* DNA using real-time qPCR analysis (Knapp and Lindauer 2020). The swab analyses detected either no *Bd* (n = 6), or very light (n = 8), light (n = 9), to moderate infection (n = 3). These designations of infection intensity are subjective; however, no swabs collected from SNYLF at Highland Lake in 2019 had high *Bd* loads (i.e., *Bd* loads high enough to suspect increased likelihood of mortality from severe chytridiomycosis).

Loss of Genetic Diversity

VES data suggest that the Highland Lake drainage SNYLF population was very small and only recently expanded. This potential population bottleneck may have resulted in negative genetic consequences for the population, including loss of genetic diversity, inbreeding depression, and fixation of deleterious alleles (Frankham et al. 2009). However, the true size of the Highland Lake drainage population, during the time-period when it was smallest, is unknown. Population genetic analyses are necessary to estimate the level of inbreeding and degree of genetic bottlenecking, if any.

Isolation

Geographic isolation can limit potential for gene flow between populations and increases risk of local extirpation. Isolated populations and small populations can suffer from similar negative genetic effects. Fortunately, the Highland Lake drainage population is not completely isolated. There are a few SNYLF populations relatively close to Highland Lake (including Lake Zitella, McConnell Lake, and Leland Lakes). Lake Zitella is the only location SNYLF could conceivably immigrate from in the near term, but the other populations are close enough to allow for rare instances of gene flow. This situation contrasts SNYLF populations at the northern extent of the species' range, most of which are greatly isolated from one another.

Introduced Fish

Highland Lake, its outlet, and two small ponds along the outlet stream formerly supported a small RT population. The main lakes in 4-Q Lakes basin also formerly contained BK, although the populations were not self-sustaining. Trout prey on SNYLF and are a potential source of competition for food (e.g., benthic macroinvertebrates). Additionally, RT may have been limiting successful SNYLF breeding and recruitment in Highland Lake and the ponds below, which supply the only deep-water habitat in the basin. In the absence of stocking, RT

abundance declined, but sufficient natural reproduction was occurring in the inlet to Highland Lake and the upper segment of outlet stream to sustain a small trout population. Barriers to upstream fish movement (e.g., the Highland Lake dam and natural waterfalls) impeded or excluded trout living in stream segments and ponds from moving into Highland Lake. Trout are still present below the natural barrier that demarcates the downstream end of the NSR. Illegal movement of trout into the stream channel above the barrier, the NSR ponds, or Highland Lake presents a potential extirpation risk for SNYLF. However, CDFW has mitigated the immediate threat from trout predation through fish removal efforts.

HIGHLAND LAKE DRAINAGE SNYLF POPULATION STATUS: RESULTS

Although CDFW did not detect SNYLF in the Highland Lake drainage prior to 2008, ENF staff have been monitoring this population since 1993 (USFS 1993). VES data between 2013 and 2022 confirm that the population has increased dramatically when compared with survey results prior to 2014 (**Figures 5 and 6**). As the RT population declined, CDFW staff observed SNYLF moving into previously unoccupied microhabitats. Notably, as the RT population diminished, staff observed a large increase in tadpoles, particularly at Highland Lake, suggesting SNYLF had begun to successfully utilize additional breeding habitats.

For a detailed summary of VES results from 2014 to 2021, see the Highland Lake drainage results section from <u>the previous memorandum</u>, which provides an update on Highland Lake survey results through 2021 (CDFW 2022). What follows is a brief recap of results from 2014–2022, followed by more detailed <u>discussion</u> of survey results in 2022.

Each summer from 2014 and 2022, CDFW staff have surveyed the entire Highland Lake drainage at least once per season, including Highland Lake, inlets to the main lake, the Highland Lake outlet stream (which includes two stream-widening ponds), and adjacent wetted habitat (**Figure 3**). The only minor exceptions to survey coverage occurred in 2017, when staff did not survey Site ID 13892; and 2019, when staff did not survey the furthest downstream section of the Highland Lake outlet within the NSR (Site IDs 52670 and 52671; **Figure 3**). During the period 2014–2022, post-metamorphic SNYLF detections have varied, but staff have detected at least several hundred post-metamorphic SNYLF each season (**Figure 5**). During the same period, larval SNYLF observations have been more variable, with staff detecting anywhere from approximately 200 SNYLF tadpoles to nearly 3,000 tadpoles (**Figure 6**).

CDFW will continue monitoring to assess the long-term status of the Highland Lake drainage SNYLF population. During the next several years, CDFW will monitor the Highland Lake drainage at least once each summer. CDFW staff will also survey 4-Q Lakes, the translocation recipient site, to monitor the status of the translocated SNYLF population. CDFW completed another translocation in 2022—using the same methods implemented in 2018, 2019, and 2021—and staff visited 4-Q Lakes on two separate occasions following the 2022 translocation (see details in the <u>SNYLF TRANSLOCATION</u> section below).



Figure 5. Number of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2022. From 2014 to 2018, and 2020–2022, surveys occurred throughout the entire drainage, including Highland Lake, the outlet stream, and the two downstream ponds.

*2008 surveys only included Highland Lake and the larger downstream pond (Site ID 13896).

**Surveys in 2010 only included the two stream ponds (Site IDs 13896 and 13903).

†CDFW did not conduct formal surveys in 2012 (staff only noted anecdotal observations during gill net setting).

\$ Surveys in 2013 only include Highland Lake and the two downstream ponds.

++ CDFW did not survey Site IDs 52670 and 52671 in 2019.

ΔIn 2017 and 2022, weather conditions were cold and windy in the Highland Lake drainage. See the discussion section below for details.



Figure 6. Number of larval Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2022. (See **Figure 5** for caveats about surveys.) Steady winds and occasional strong gusts during the Highland Lake survey on 10 September 2017, 7 August 2019, 11 August 2020, and 6 July 2022 made visibility into the lake difficult, which may account for the low larval SNYLF observations when compared with other recent survey years.

HIGHLAND LAKE DRAINAGE SNYLF POPULATION STATUS: DISCUSSION

As part of a larger project to inventory fish and native amphibians throughout the Sierra Nevada (CDFG 2012), fish stocking at Highland Lake ceased in 2000. The decision to manage the watershed for native species, rather than fish, occurred years before active fish removal began. Based on the small number of RT captured during active removal, the fish population had declined soon after CDFW stopped aerial plants at Highland Lake. Therefore, the SNYLF population increase may be partly attributable to the decrease in fish numbers in the absence of stocking. A decline in the RT population allowed SNYLF to begin breeding and feeding with less interference from an efficient predator. The observation of larval SNYLF in Highland Lake in 2008—four years before active fish removal began—supports this idea.

SNYLF benefitted from reduced fish densities in the watershed, but the subsequent population increase in a *Bd*-positive environment was initially uncertain, given the high variability in *Bd*-positive SNYLF population dynamics (Briggs et al. 2010). However, recent SNYLF population monitoring in other areas of the Sierra Nevada suggests that *Bd*-positive SNYLF populations can rebound in the absence of other stressors, such as trout (Knapp et al. 2016). In addition to fish removal, other environmental factors may have helped the SNYLF population rebound, including short winters, increased temperatures, and increased food availability during the 2012–2015 drought. Regardless, monitoring efforts over a 20-year period demonstrate that the SNYLF population in the Highland Lake watershed has made a dramatic comeback since management in the area switched from a focus on non-native trout stocking to a focus on restoring habitat for native amphibians.

In 2022, CDFW observed fewer SNYLF of all life stages when compared with the previous four years. However, CDFW suspects that weather conditions on the survey day were the single largest factor explaining the lower detection rates. On 6 July 2022, Highland Lake drainage and other parts of Desolation Wilderness were experiencing an atypically cool and windy period. As staff hiked into the site from the west on 5 July, the rim of Highland Lake basin was blanketed with cloud cover (**Figure 2**). This low cloud ceiling is atypical when compared with previous summer survey periods during which CDFW has been present at the site. Additionally, temperatures in the basin from 5–6 July were unseasonably cool (averaging approximately 15° C [59° F] throughout the day), whereas temperatures are typically at least 5–10° C degrees warmer during summer surveys in the Highland Lake drainage (CDFW, unpubl. data). For example, the average temperature during Highland Lake drainage VES in late June 2021 was 26° C (79° F). Finally, sustained winds during VES were moderate-to-strong, and the basin experienced frequent strong wind gusts throughout the day.

Survey conditions may be one of the most important factors explaining differences in SNYLF detections in the Highland Lake drainage. Similar to some other high alpine sites in Desolation Wilderness, numerous visits by CDFW over the past 20 years suggest that Highland Lake basin is prone to periods of strong winds. These windy conditions greatly limit visibility through the

water for observing tadpoles or detecting post-metamorphic frogs resting on lake and stream bottoms. Additionally, high winds and frequent gusts appear to reduce basking behavior of post-metamorphic SNYLF, when compared with calmer conditions (I. Chellman, pers. obs.; M. Lockhart, pers. comm.). Frogs may be more likely to seek refuge underwater and beneath lakeside cover objects during cooler and windier periods. Winds during VES in 2017, 2019, 2020, and 2022 were often high, all years during which CDFW staff observed fewer SNYLF tadpoles, when compared with years during which less wind occurred during CDFW surveys at Highland Lake (e.g., 2016, 2018, and 2021).

Another indication that environmental conditions largely explain the more limited SNYLF detections on 6 July 2022 comes from anecdotal observations by staff on the following day, 7 July 2022, during which CDFW conducted a translocation of adult SNYLF from the Highland Lake drainage to 4-Q Lakes (see below). On 7 July, although winds were still present in the basin, gusts had subsided. Additionally, the low cloud ceiling had dissipated the night before, so the sky was mostly clear while staff collected adult SNYLF at Highland Lake and the upstream section of the Highland Lake outlet stream. During those collections, staff observed high numbers of post-metamorphic SNYLF: notably higher numbers of frogs than staff observed in the same locations during the previous day. The simplest explanation for a sudden increase in post-metamorphic frogs being available for detection one day later is a change in weather to warmer, sunnier, calmer conditions that encourage frogs to be more out in the open and available for detection (**Figure 7**).



Figure 7. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) basking next to Site ID 13903 on 7 July 2022. (CDFW)

In discussing results from 2019, CDFW guessed that harsh winter conditions may have partially accounted for lower SNYLF observations in 2019 (CDFW 2020). However, this explanation is unlikely a factor for the comparatively lower observations during VES in 2020 and 2022. The northern Sierra Nevada experienced below average total precipitation (CDEC 2023a) and snow water content (CDEC 2023b) during winters 2019–2022. Poor SNYLF survivorship can occur during long, harsh winters (Bradford 1983). However, winter conditions cannot fully account for the between-year variability in SNYLF observations in the Highland Lake drainage. For example, if harsh winter conditions in 2016–2017 were the primary reason behind the low number of SNYLF observed in September 2017, far fewer adult SNYLF would have been available for detection during CDFW surveys in June 2018 (**Figures 5 and 6**). Although another winter with above average precipitation and snowpack in 2018–2019 correlates with lower SNYLF detections the following summer, VES results from the past several years suggest that weather conditions on the day of surveying may be the largest environmental influence on between-year differences in SNYLF detections in the Highland Lake drainage.

Overall, VES results can be difficult to compare, due to numerous factors, including weather conditions, time of year, and observer bias (Mazerolle et al. 2007). A particularly instructive example occurred in summer 2016, during which CDFW conducted three separate surveys of the Highland Lake drainage, in June, August, and September. When compared with other recent years, the June and September 2016 surveys at Highland Lake resulted in relatively few SNYLF detections (82 frogs and 13 larvae, then 130 frogs and 1 larva, respectively). These detection rates were comparable to observations at Highland Lake in September 2017 (102 frogs and 32 larvae). However, the August 2016 survey of Highland Lake resulted in dramatically higher SNYLF detections (693 frogs, 2,008 larvae). The higher SNYLF detections in August may have resulted from excellent survey conditions, coincidental timing with the height of summer SNYLF activity in the basin, more attentive surveying, or a combination of factors. These results help emphasize that VES are a helpful measure for quickly and cost-effectively determining general population status of SNYLF, but proper interpretation of the results requires consideration of the assumptions inherent with VES (Heyer et al. 1994).

In 2023, CDFW will survey the entire Highland Lake drainage (i.e., all areas within the NSR shown in **Figure 3**). Additionally, if time allows, CDFW will survey further downstream of previously monitored portions of the Highland Lake outlet stream, to determine if there may be resident SNYLF occurring farther down the drainage. CDFW plans to attempt surveying the basin during calm and warm conditions, given the better odds of such conditions allowing staff to obtain a more accurate estimate of relative SNYLF abundance in the basin.

SNYLF TRANSLOCATION

For complete details about the translocations of SNYLF from Highland Lake to 4-Q Lakes in 2018 and 2019, including background on the translocation recipient site, consult the <u>survey</u> <u>memo for the 2019 Highland-4-Q Lakes VES and translocation</u> (CDFW 2020). Additionally, further details on the 2021 translocation were included in <u>last year's update for Highland and</u> <u>4-Q Lakes</u> (CDFW 2022). Below is a brief summary of the previous translocation efforts.

Translocation Summary

CDFW has thus far conducted four translocations of adult SNYLF from Highland Lake to 4-Q Lakes (**Figure 8**). The first, which took place in July 2018, involved moving 60 adults (26 males and 34 females); the second, which took place in August 2019, involved moving 40 adults (18 males and 22 females); the third, which took place in July 2021, involved moving 51 adults (28 females and 23 males); the fourth, which occurred in July 2022, involved moving 26 adults (14 females and 12 males), and is described in detail below. In total, CDFW and ENF staff have translocated 98 females and 79 males from the Highland Lake drainage to 4-Q Lakes. During each translocation, staff intentionally collected a female-biased sample to increase the odds of successful reproduction at the recipient site.

Before each translocation, CDFW and ENF field staff conducted VES of the entire upper Highland Lake drainage to determine the current relative abundance of the SNYLF population (described in detail in the <u>HIGHLAND LAKE DRAINAGE SNYLF POPULATION STATUS: RESULTS</u> and <u>DISCUSSION</u> sections above). In general, the interagency technical team recommends removing no more than 10% of observed adults at the source population per year (MYLF ITT 2018, Attachment 3). Given high reproductive potential and the inability to detect all individuals during VES, the 10% threshold is likely highly conservative (MYLF ITT 2018, Attachment 3). Therefore, if field staff observed fewer than 200 adult SNYLF in the Highland Lake drainage, less than 20 adults could be collected for the translocation. Given the time, effort, and coordination needed to accomplish these actions, CDFW managers have decided that it may not be worthwhile to undertake a translocation with fewer than 20 adult SNYLF. Conversely, to allow for adequate time for capture, processing, and moving in the same day, CDFW decided to collect a maximum of 60 adult SNYLF per translocation action.

Translocation Methods

After VES on 6 July 2022 confirmed that the SNYLF population was robust enough to support removal of 26 adult SNYLF (**Figure 5**), CDFW staff mobilized for translocation efforts. Field crews began collecting adult SNYLF (individuals >40 millimeters snout-to-urostyle length [SUL]) the morning of 7 July 2022. Field staff collected adults via hand capture or dip nets, identified sex, implanted a PIT tag to provide a unique identifier for each individual (**Figures 9a** and **9b**), measured SUL (**Figure 10a**), and recorded weight (**Figure 10b**). In total, staff collected 26 adult SNYLF (approximately 10% of the adult population observed the previous day). For the

translocation, staff collected individuals between 40 and 64 mm SUL, with an average length of 50 mm SUL for both males and females. Staff collected adults from the northern shore of Highland Lake, Site ID 52648, Site ID 53454, and the southern shore of Site ID 13903 (**Figure 4**). The 26 adult SNYLF were comprised of 14 females and 12 males.

Staff placed each frog into its own plastic container with multiple holes for ventilation (**Figure 11**) and stored the containers on snow in the shade to prevent frogs from overheating (**Figure 12**). Once staff had completed the collection, they packed the contained frogs into hard-sided plastic bear-proof canisters. Staff then placed the canisters into backpacks, along with bagged snow and foam insulating pads, to maintain cool temperatures for the frogs during transport. Staff also placed digital temperature loggers inside of the canisters to provide constant temperature read-outs. Once securely packed, the field staff hiked the frogs for approximately 2 hours to 4-Q Lakes (**Figures 8 and 13**). Once at the site, staff released frogs at three different release points along the southern shore of the middle 4-Q Lakes (Site IDs 13922 and 13932; **Figures 13–15**). All frogs appeared healthy upon release.



Figure 8. Path of travel for the Sierra Nevada Yellow-legged Frog (*Rana sierrae*) translocations from Highland Lake (donor site) to 4-Q Lakes (recipient site). Travel distance between the two sites via the route shown is approximately 6 kilometers (3.7 miles). The hike takes about two hours to complete.



Figure 9a. A CDFW staff member inserting a passive integrated transponder (PIT) tag into an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake on 7 July 2022. (CDFW)



Figure 10a. A CDFW staff member preparing to measure the snout-tourostyle (SUL) length of an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake on 6 July 2021. (CDFW)



Figure 9b. A CDFW staff member scanning the recently inserted PIT tag of an adult Sierra Nevada Yellowlegged Frog (*Rana sierrae*) at Highland Lake on 7 July 2022. (CDFW)



Figure 10b. A CDFW staff member weighing an adult Sierra Nevada Yellowlegged Frog (*Rana sierrae*) at Highland Lake on 6 July 2021. (CDFW)



Figure 11. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) inside its individual transport container, soon before making its way into new habitat at 4-Q Lakes. For the translocation, staff housed each adult SNYLF inside one of these containers, in which there were ventilation holes and a piece of wetted, unbleached paper towel to help retain moisture during transport. Lids with ventilation holes covered containers during storage and transport. In this photograph, staff have removed the lid from the frog's container so it can hop out into its new home. (CDFW)



Figure 12. Adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF), housed inside plastic containers sitting inside hard-sided plastic bear canisters, awaiting translocation to 4-Q Lakes. Field staff kept SNYLF in the shade and on snow to remain cool during captivity. (CDFW)



Figure 13. California Department of Fish and Wildlife (CDFW) and volunteer staff carrying Sierra Nevada Yellow-legged Frog (*Rana sierrae*) adults (housed individually inside bear canisters, inside backpacks) from the Highland Lake drainage to 4-Q Lakes on 7 July 2022. (CDFW)



Figure 14. California Department of Fish and Wildlife (CDFW) and volunteer staff releasing adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) at 4-Q lakes on 7 July 2022. (CDFW)



Figure 15. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) soon after being released at 4-Q Lakes on 7 July 2022.

Follow-up Surveys

During each summer from 2018–2022, CDFW staff conducted post-translocation surveys to assess if the frogs: 1) had moved from the original release sites, 2) appeared in good health, 3) were behaving normally, and 4) had successfully reproduced. In addition to the translocations, CDFW revisited 4-Q Lakes two or three times during each year, 2018–2022 (**Table 1**).

In 2022, CDFW surveyed 4-Q Lakes basin on 22–23 June (two weeks before the 2022 translocation), 26–27 July (approximately three weeks after the 2022 translocation), and 30–31 August (nearly two months after the 2022 translocation). During each visit, staff surveyed the main 4-Q Lakes, any nearby ponds that retained water (i.e., those within ~250 meters of the main lakes), and the outlet stream (**Figure 16**). In June 2022, staff visited and surveyed all waterbodies shown in **Figure 16**, plus several additional ponds at eastern end of 4-Q Lakes basin not shown in the figure (however, staff did not detect any SNYLF at those locations). Additionally, staff surveyed the entire 4-Q Lakes outlet stream (heading out of frame to the west of Site ID 13928; **Figure 16**) to the confluence with the McConnell Lake outlet stream. However, by July, many of the small ponds in 4-Q Lakes basin were dry, and the outlet stream was nearly dry. Therefore, although staff visited these locations to confirm desiccation, staff did not survey the dry locations.

CDFW staff observed 15 adult SNYLF individuals in late June (four males and 10 females, plus one additional frog of unknown sex that escaped capture), 17 SNYLF individuals in July (nine males and eight females), and 25 SNYLF individuals in August (12 males and 12 females, plus one dead SNYLF of unknown sex due to decomposition; Table 1). Of the SNYLF adults observed in June, five were also captured in July and three others were also captured in August. One other individual captured in June was also caught in both July and August. Finally, two individuals newly recaptured for the season in July were recaptured in August. Additionally, in 2022, CDFW staff PIT-tagged seven new adults originally born at 4-Q Lakes (one tagged in June, two tagged in July, and four tagged in August). Therefore, combining all three surveys in 2022, CDFW observed 45 SNYLF individuals (21 males and 23 females, and one of unknown sex). Of those 45 frogs, three were found dead during surveys (one male, one female, and one of unknown sex). Subtracting the seven newly marked adults, which were born at 4-Q Lakes, CDFW observed 37 of the 177 translocated SNYLF in 2022 (21%; Table 1). Given its large size, the dead SNYLF found in August was very likely also a translocated frog. However, due to decomposition and the lack of PIT tag detected, CDFW excluded that frog from the total number of known translocated frogs recaptured by staff in 2022. Of the known 37 translocated adult recaptures, five were translocated to 4-Q in 2018, nine were translocated to 4-Q in 2019, seven were translocated to 4-Q in 2021, and 15 were translocated to 4-Q in 2022. One final frog had an unknown translocation year due to PIT tag malfunction. When combining data for all follow-up surveys at 4-Q Lakes from 2018–2022, CDFW has observed 86 of the 177 released adult SNYLF individuals at least once (49%; Table 1).

In keeping with the female-skewed sex ratios for the releases, sex ratios among recaptures during follow-up surveys have been dominated by females. During post-translocation surveys from 2018–2022, CDFW has recaptured 52 of the females and 34 of the males that were translocated. These ratios among overall recaptures (1.53 females:1 male) correspond roughly with the sex ratios of total released frogs (1.27 females:1 male). However, among recaptures in 2022, staff detected a more equal number of males and females, with a sex ratio of 0.91 females:1 male (one SNYLF was excluded from the ratio total due to sex not being determined).

Most frogs detected during follow-up surveys at 4-Q Lakes have appeared to be in good condition. However, in 2022, staff observed three adult SNYLF that had died prior to detection. Staff also detected another large, dead anuran in July 2022. However, the carcass was highly degraded, so species could not be determined. That dead individual may have been a Western Toad (*Anaxyrus* [*Bufo*] *boreas*) or large SNYLF. Two of the known adult SNYLF (one female and one of unknown sex) died of unknown causes. For the other SNYLF mortality, staff used a PIT tag reader to detect the frog, a male originally translocated to 4-Q Lakes in 2021, inside a large adult Sierra Gartersnake (*Thamnophis couchii*). CDFW staff often observe gartersnakes during VES in the Sierra Nevada, including Mountain Gartersnakes (*Thamnophis elegans elegans*), Sierra Gartersnakes, and Valley Gartersnakes (*Thamnophis sirtalis fitchi*). Gartersnakes are known to prey on SNYLF and Sierran Chorus Frogs (*Hyliola* [*Pseudacris*] *sierra*) (Jennings et al. 1992, Matthews et al. 2002); therefore, gartersnake predation on Sierra Nevada amphibians is a natural and expected event (CDFW staff, pers. obs.; T.C. Smith, unpubl. data).

Staff have often observed gartersnakes at 4-Q Lakes: for example, staff observed 11 gartersnakes in June 2022 and 12 gartersnakes in August 2022. In 2021, CDFW staff observed two separate instances of gartersnakes attempting to prey on SNYLF at 4-Q Lakes (CDFW 2022). Additionally, CDFW staff and researchers have seen gartersnakes preying on SNYLF at other locations in Desolation Wilderness, including at another translocation site on Lake Tahoe Basin Management Unit land (I. Chellman, S. DeCurtis, J. Imperato, R. Knapp, and T.C. Smith; pers. obs.). In one notable example from that area, CDFW staff observed an adult Sierra Gartersnake preying on a young adult SNYLF on 1 September 2020. Staff extracted the frog, which was still alive, to collect PIT tag data and morphological measurements. Staff released the frog at the point of capture, at which time the gartersnake was no longer visible. During the next circumnavigation of the lake that same afternoon, staff observed an adult Mountain Gartersnake consuming the same frog, which was by that time deceased.

All live recaptured SNYLF had grown substantially since their initial translocation, suggesting that the SNYLF are healthy and feeding well in their new habitat. Growth, in terms of increased SUL and mass, was particularly pronounced in females, which grew approximately twice as much as males (**Table 2**). These trends in growth patterns between the sexes were consistent

in individuals with data available for timespans of one-month, one-year, and three-years between release and most recent capture (**Table 2**).

As of 2022, CDFW has data on 16 females that were released at 4-Q Lakes in 2021 or 2022 (or newly marked at 4-Q Lakes during that period) and for which the most recent subsequent recapture event was approximately one month later (range 20–54 days between capture events). In that brief period, these females had increased in weight an average of 9 g and grown an average of 6 mm SUL. This average three- to seven-week weight increase (9 g) is remarkably similar to the average one-year weight gain of 11 different females for which the most recent recapture event was one year following translocation or marking at 4-Q Lakes (10 g; **Table 2**). Among males for which the most recent recapture event was approximately one month post-release or marking at 4-Q Lakes, the average growth rates were lower. Of seven males translocated (or newly marked at 4-Q Lakes) in 2021 and 2022 for which the most recent subsequent recapture event was approximately one month later (range 19–54 days between capture events), the average weight increase was 5 g and the average SUL increase was 4 mm (**Table 2**).

Looking at longer periods of growth, female growth rates were strikingly higher than males. CDFW collected data from six females for which the most recent recapture event was three years following translocation to 4-Q Lakes. Average growth for these six females was 41 g and 26 mm SUL (**Table 2**). Meanwhile, average growth for eight males most recently recaptured three years post-translocation was 11 g and 9 mm SUL. Although the eight males averaged somewhat larger than the six females when translocated (the eight males averaged 19 g and 53 mm SUL when translocated, whereas the six females averaged 17 g and 49 g when translocated), the females exhibited much larger growth rates (**Table 2**). Like many explosive breeding anuran species (Wells 2007, pg. 389), SNYLF females are on average much larger than males, and the data presented in **Table 2** demonstrates that females can achieve these larger sizes in relatively short timeframes.

SNYLF released at 4-Q Lakes have continue to disperse from their original release points and now occupy many areas in 4-Q Lakes basin (**Figure 16**). In 2022, CDFW staff observed SNYLF occupying numerous areas in the basin, in most of which staff have previously detected SNYLF. Exceptions included Site IDs 52800 and 52805, in which CDFW had not previously detected SNYLF (**Figure 16**). For further details on early life stage SNYLF detections and locations, see the *Reproduction* section below.



Figure 16. [See figure caption on the next page.]

Figure 16 (continued). Map showing locations of all adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) individuals detected by California Department of Fish and Wildlife (CDFW) field staff during visual encounter surveys (VES) in 2022. Number labels shown are unique site identification codes for locations where CDFW staff detected adult SNYLF in 2022. The map also shows locations where adult SNYLF translocated from Highland Lake were released in 2018 (n = 60; 26 males, 34 females), 2019 (n = 40; 18 males, 22 females), 2021 (n = 51; 23 males, 28 females), and 2022 (n = 26; 12 males, 14 females; green triangles).

In 2022, CDFW conducted surveys at 4-Q Lakes on 22–23 June (two weeks before the fourth translocation, which CDFW conducted on 7 July), 26–27 July, and 30–31 August. During each survey at 4-Q Lakes, CDFW staff visited every pond shown in this map that still contained surface water, plus additional sites to the east that are not visible (however, staff detected no SNYLF at those sites in 2022). Additionally, CDFW staff surveyed down the basin outlet stream (exiting the figure to the west), to the confluence with the outlet of McConnell Lake. In 2022, staff did not detect any SNYLF in most of the outlet stream, so the downstream section is excluded from the map.

Most of the small ponds shown in this map dry by late summer. Summer 2022 was drier than average, so many of the small ponds shown were completely dry during the site visits in July and August. CDFW suspects these dry conditions are the primary reason most August SNYLF detections occurred at the main lakes.

CDFW staff observed 15 SNYLF individuals in June (grey circles indicate frogs released in 2018, grey squares indicate frogs released in 2019, grey crosses indicate frogs released in 2021, and the purple star indicates one young adult that was born at 4-Q Lakes and newly tagged in June). Additionally, CDFW observed two adult mortalities (one translocated in 2018 and one translocated in 2021; staff scanned the passive integrated transponder [PIT] tag of the latter frog from within the body of a captured *Thamnophis couchii*), and recaptured one adult with a faulty PIT tag into which staff implanted a new, functional tag. Staff also observed one additional adult SNYLF that escaped capture. However, based on size, location, and survey coverage, staff know that this individual was not one of the other captured SNYLF.

In July 2022, staff observed 17 individuals (white circles with "x's" in the center indicate frogs released in 2018, white squares with "x's" in the center indicate frogs released in 2019, white crosses indicate frogs released in 2021, and white diamonds indicate frogs released on 7 July 2022). Additionally, the blue star indicates the recapture location of the SNYLF newly tagged in June, and light green stars indicate frogs born at 4-Q Lakes and newly tagged in July. Staff also observed a large dead anuran of unknown species in July, which is indicated by a red "?".

In August 2022, staff observed 25 individuals (black circles indicate frogs released in 2018, black squares indicate frogs released in 2019, black crosses indicate frogs released in 2021, and black diamonds indicate frogs released on 7 July 2022). Additionally, the yellow star indicates the recapture location of a SNYLF newly tagged in July, and orange stars indicate frogs born at 4-Q Lakes and newly tagged in August. Finally, CDFW observed one adult SNYLF mortality. The adult was large, but staff did not detect a PIT tag when scanning the frog.

[End of figure caption.]

Table 1 (see next page). Dates of adult Sierra Nevada Yellow-legged Frog (Rana sierrae; SNYLF) translocations and follow-up surveys at 4-Q Lakes, Desolation Wilderness, between 2018 and 2022; and number of SNYLF translocated, recaptured, or newly captured during each event. SNYLF numbers shown in each row (females, males, and total) are the number of unique individuals recaptured or newly marked during that site visit (i.e., not capture events, since some SNYLF individuals were caught more than once during each visit). The grand total rows display the following: 1) the sum of SNYLF individuals originally translocated from the Highland Lake drainage that have been recaptured at least once since the first follow-up survey in July 2018 (in yellow). In total, CDFW has moved 177 adult SNYLF from the Highland Lake drainage to 4-Q Lakes between 2018 and 2022. Of those 177 translocated frogs, CDFW has recaptured at least* 86 individuals (49% of all translocated adults) at least once during post-translocation follow-up surveys at 4-Q Lakes. 2) The sum of all unique adult SNYLF individuals that have been observed at 4-Q Lakes at least once since 2018, including frogs translocated from the Highland Lake drainage and new adults that were born at 4-Q Lakes (in pink). (*See below for why the total number of recaptured individuals is not known precisely, given a few recaptured frogs with PIT tag issues.)

⁺For tallies showing the original year of translocation (in grey), CDFW does not know the release year of three SNYLF individuals. There is a chance that two of these unknown individuals are in fact the same frog. Staff captured the first SNYLF with an unknown release year in August 2020. This frog had a passive integrated transponder (PIT) tag, but the tag was unreadable (i.e., the Biomark 601 PIT tag reader displayed "AVID tag detected," although no AVID tags have been inserted into frogs during this project). The frog was a male with snout-tourostyle (SUL) length of 57 mm and a weight of 22 g. Staff captured the second SNYLF with an unknown release year in June 2022. This frog contained a PIT tag, but the tag would not read (staff could clearly see a PIT tag underneath the skin above the frog's urostyle, but the Biomark HPR Lite PIT tag reader did not detect the tag and nothing was displayed on the reader). Therefore, staff retagged the frog with a new PIT tag that was readable. The frog was a male with 59 mm SUL and a weight of 26 g. Given the PIT tag malfunctions and sizes of these two male frogs, there is a chance that the frog with an unreadable tag caught in August 2020 is the same individual as the frog caught in June 2022. However, since that possibility cannot be known definitively, the tallies below record these two frogs as separate individuals. Staff captured the third SNYLF with an unknown release year in August 2022. Staff found this frog dead and highly decomposed, so they could not determine the frog's sex. Additionally, staff did not detect a PIT tag in this dead SNYLF. Give this dead individual's large size, the frog had likely been translocated from Highland Lake. However, since staff did not detect a PIT tag in this individual, CDFW was unable to determine the potential translocation year.

Table 1. (continued).

Year	Dates	Females	Males	Total	Notes
2018	3 July	34	26	60	Translocation #1
2018	17–18 July	5	7	12	
2018	21 Aug	13	2	15	
2018		14	8	22	Total individuals observed in 2018
2019	6 Aug	5	4	9	
2019	8 Aug	22	18	40	Translocation #2
2019	4 Sept	10	9	19	
2019	4 Sept	2	2	4	Frogs released in 2018; all 4 also seen on 6 Aug 2019
		8	7	15	Frogs released in 2019
2019		13	11	24	Total individuals observed in 2019
2020	16–17 June	14	6	20	
2020	11–12 Aug	10	6	16	
2020	Trips	4	2	6	Frogs released in 2018
	Combined-	16	7	23	Frogs released in 2019
	Unique	0	1	1	Frog with unknown release year;
	individuals	0	1	1	(see table heading on previous page for details).
2020		20	10	30	Total individuals observed in 2020
2021	30 June	10	5	15	
2021	6 July	28	23	51	Translocation #3
2021	11 Aug	18	3	21	
2021	Trips	5	3	8	Frogs released in 2018
	Combined-	7	3	10	Frogs released in 2019
	Unique individuals	6	1	7	Frogs released in 2021
		4	1	5	Newly tagged at 4-Q Lakes
2021		22	8	30	Total individuals observed in 2021
2022	22–23 June	*4	+10	‡15	*One female SNYLF found dead. †One male SNYLF detected inside a Sierra Gartersnake (<i>Thamnophis couchii</i>). ‡One additional adult, which was not one of the other 14 individuals tallied, escaped capture.
2022	7 July	14	12	26	Translocation #4
					One dead adult anuran also found; not included in tally.
2022	26–27 July	9	8	17	(Species unknown due to decomposition—Large SNYLF or Anaxyrus
					[Bufo] boreas; no PIT tag detected.)
2022	30–31 August	12	12	*25	*One additional SNYLF found dead and included in total;
					(no PIT tag, sex unknown due to decomposition).
2022	Trips	*2	3	5	Frogs released in 2018; *one of the females was found dead.
	Combined–	2	7	9	Frogs released in 2019
	Unique	3	*4	7	Frogs released in 2021; *one of the males was eaten by a gartersnake.
	individuals	10	5	15	Frogs released in 2022
		0	1	*2	Frogs w/ unknown release year (*Includes one adult SNYLF of unknown
		1	*3	sex found dead with no PIT tag detected).	
		1	1	*3	Adult SNYLF mortalities seen in 2022 (*sex of one individual unknown).
		4	5	/	Tetal individuale a harmond in 2022 (*traductor and at CNN// E of
2022		21	23	*45	Iotal Individuals observed in 2022 (*Includes one adult SNYLF of unknown say found dead with no DIT tag detected)
	2019 2022	17	11	20	Erons released in 2019
	2018-2022	16	12	20	Frogs released in 2010
	From released in 2013				
		9	5	14	

10	10 5 15 Frogs released in 2022		Frogs released in 2022	
8	4	12	Newly tagged at 4-Q Lakes	
0	2	†3	<i>Frogs with unknown release year;</i> (<i>†see table heading on previous page</i>).	
52	34	86	Grand total of translocated individuals recaptured at 4-Q Lakes at least once during the period 2018–2022.	
60	40	†101	Grand total of all unique adult SNYLF observed at 4-Q Lakes at least once during the period 2018–2022. (†see table heading on previous page for details regarding SNYLF with unknown release year).	

Table 2. Average one, two, three, and four-year growth summary statistics—partitioned by sex (F = female, M = male)—for adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) translocated from Highland Lake to 4-Q Lakes‡. Measurements displayed are original ("trans." = measurement on translocation day) and most recent ("latest" = measurement from most recent recapture event) average snout-to-urostyle length (SUL, in millimeters [mm]) and average weight (mass, in grams [g]) of unique individuals recaptured in 2020, 2021, and 2022 for which California Department of Fish and Wildlife (CDFW) had original measurements*. Both SUL and mass have a column showing the average difference between the original and most recent measurements of each row ("diff."). The first column displays the number of individual SNYLF measurements incorporated in each average value within a row. All adult SNYLF measured had grown substantially since being translocated. On average, for any given period of growth, females grew approximately twice as much as males in mass. The final two rows display the average difference in measurements for 16 females and seven males during a one-month period between capture events. In that one-month interval, on average, females grew 6 mm SUL and gained 9 g, and males grew 4 mm SUL and gained 5 g.[†]

sex (years of growth); sample size	SUL (trans.)	SUL (latest)	SUL (diff.)	Mass (trans.)	Mass (latest)	Mass (diff.)
M (4); n = 3	50 mm	66 mm	+16 mm	13 g	37 g	+24 g
F (3); n = 6	49 mm	75 mm	+26 mm	17 g	58 g	+41 g
M (3); n = 8	53 mm	63 mm	+9 mm	19 g	30 g	+11 g
F (2); n = 9	54 mm	72 mm	+18 mm	20 g	45 g	+25 g
F (1); n = 11	54 mm	64 mm	+10 mm	19 g	30 g	+10 g
M (1); n = 7	49 mm	57 mm	+7 mm	16 g	21 g	+6 g
F (<i>1 month</i>); n = 16†	53 mm	59 mm	+6 mm	18 g	28 g	+9 g
M (<i>1 month</i>); n = 7†	49 mm	53 mm	+4 mm	13 g	18 g	+5 g

‡In 2022, CDFW was only able to obtain measurements on one female originally translocated to 4-Q Lakes in 2018. Therefore, the table does not include an average four-year growth for females. That one female increased 26.4 mm in SUL and 38.0 g in mass between 3 July 2018 and 27 July 2022. No growth statistics were available for the two-year growth interval in males (i.e., the most recent capture event for all recaptured males was either one month, one year, three years, or four years removed from the original capture event), so the table omits that category.

*CDFW staff did not record morphological data during recapture trips at 4-Q Lakes in 2018 and 2019.

[†]One male and one female included in the one-month growth categories were frogs born at 4-Q Lakes, not translocated frogs (i.e., each of these two individuals was originally collected and measured at 4-Q Lakes in 2022 and recaptured one month later).

Reproduction

Detecting SNYLF reproduction at 4-Q Lakes is one of CDFW's principal goals of this translocation project. Fortunately, in June 2020, field staff observed a recently hatched SNYLF egg mass at Site ID 13922 and one large tadpole, which evaded follow-up detection. During the second visit in August, CDFW staff observed more early life stage SNYLF, including at least five tadpoles and 14 subadults. The total number of tadpoles and subadults is not known because these life stages are unmarked. However, when totaling counts of early life stage SNYLF detections from one pass of each waterbody during the same survey day, the total was 5 larvae and 14 subadults. In 2021, staff detected at least 12 subadults in June, and at least 27 subadults in August (**Figures 17a–c**). Staff did not detect SNYLF tadpoles in 2021.

Observations of early SNYLF life stages continued in 2022. In June, two weeks prior to the fourth translocation, staff detected one SNYLF egg mass, two tadpoles, and two subadults. In July, staff detected at least 21 subadults. However, in late August, staff detected the largest number of early life stage SNYLF observed at 4-Q Lakes since the inception of translocations. Staff detected at least 82 subadults and 8 tadpoles in the basin (**Figure 18**). Staff detected most subadults at the three largest lakes (48 subadults at Site ID 13932, 18 subadults at Site ID 13922, and 12 subadults at Site ID 13928), but staff also detected a few subadults at Site IDs 13926, 52692, and 52818 (**Figure 18**).

These early life stage observations are particularly exciting because they provide definitive evidence that the newly established SNYLF population at 4-Q Lakes is continuing to successfully reproduce. Additionally, the presence of subadults in 2020 strongly suggests that reproduction first occurred at 4-Q Lakes in early 2019 (given that SNYLF often require at least one winter before metamorphosis), which was the first opportunity that newly translocated SNYLF would have been able to breed. The SNYLF breeding season typically occurs in late spring/early summer (depending on conditions at the site). Therefore, SNYLF translocated in summer 2018 would not have first bred until late spring 2019 at the earliest.



Figure 17a-c. Three subadult Rana sierrae observed at 4-Q Lakes on 11 August 2021. (CDFW)



Figure 18. Locations of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) subadult, tadpole, and egg mass detections by California Department of Fish and Wildlife (CDFW) staff in summer 2022. Symbology is divided up by survey period (June, July, and August 2022), and number of early life stage SNYLF detected within 5 meters of each location. Symbols are sized in general proportion to the number of individuals detected, where the smallest symbols indicate one individual, and larger symbols indicate more individuals, up to n = 7. All Site IDs at which CDFW staff detected early life stage SNYLF during summer 2022 are labeled.

Looking ahead: 2023

In 2023, CDFW staff plan to visit Highland Lake to survey the drainage and obtain current information on the relative abundance of SNYLF in the basin. The current Section 6 grant provides funding for consistent follow-up surveys annually through 2023 to maintain detailed demographic information on 4-Q Lakes populations. CDFW also has a State Wildlife Grant (SWG; Federal Grant Award #F22AF01541), which will provide CDFW with the resources to continue monitoring at Highland and 4-Q Lakes in 2024 and 2025. CDFW plans to seek additional funding to continue consistent monitoring at the Highland and 4-Q Lakes sites beyond 2025.

For each adult captured during subsequent monitoring visits to 4-Q Lakes, staff will record PIT tag, sex, location coordinates, weight, and length measurements (staff will only record weight and length measurements once per site visit for each individual). Now that new SNYLF recruitment is occurring, CDFW will continue PIT-tagging any new adults observed at 4-Q Lakes. These data will be used for capture-mark-recapture (CMR) analysis to determine abundance and survivorship in the SNYLF population more accurately (Mazerolle et al. 2007). Given the conservation importance of this population, CDFW needs current information obtained through annual monitoring.

Other notable observations

CDFW documented one additional noteworthy observation during site visits to 4-Q Lakes in 2022.

On 27 July 2022, staff detected a large adult Sierra Gartersnake at Site ID 13932 that was lethargic, and portions of its body were swollen and contained skin lesions (**Figures 19–21**). Staff suspected this snake may have been infected with snake fungal disease (SFD), which is caused by the fungal pathogen *Ophidiomyces ophiodiicola*. SFD was first discovered in California in 2019, when the CDFW Wildlife Health Lab (WHL), in collaboration with the University of Illinois, confirmed the pathogen present on a California Kingsnake (*Lampropeltis californiae*) found in Amador County (CDFW 2019). Subsequently, <u>CDFW has begun SFD</u> monitoring efforts throughout the state. In 2022, CDFW high mountain lakes monitoring staff collected SFD samples from gartersnakes at various field sites in the northern Sierra Nevada, particularly focusing on any individuals that exhibited potential clinical symptoms of SFD.

Staff collected skin swab samples from this sick Sierra Gartersnake and submitted the samples to WHL staff. Results from the swabs came back negative for presence of SFD. However, sample preservation methods were still being refined at the time staff collected these samples, so swabs from this snake were not stored using preferred methods (R. Elander, WHL, pers. comm.). Therefore, SFD screening tests of the swabs collected from this snake may have returned false negative test results. In 2023, CDFW plans to continue collaborating with WHL staff in monitoring for SFD during high mountain lake amphibian and reptile surveys.



Figure 19. An adult Sierra Gartersnake (*Thamnophis couchii*) found at 4-Q Lakes (Site ID 13932) on 27 July 2022. This snake was lethargic, bloated in several locations, and had several lesions on its body. The snake's tail appeared to be the worst affected area on its body. Staff suspected this snake may have been infected with snake fungal disease (SFD), which is caused by the fungal pathogen *Ophidiomyces ophiodiicola*. (CDFW)



Figure 20. A close-up photograph of the tail of the Sierra Gartersnake (*Thamnophis couchii*) shown in Figure 19. The tail of this snake appeared to be necrotic and had several areas with sloughing skin, lesions, and other damage of unknown cause. (CDFW)



Figure 21. One of several body lesions found on the Sierra Gartersnake (*Thamnophis couchii*) shown in Figure 19.

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