State of California
Department of Fish and Wildlife

Memorandum

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Subject: Native amphibian restoration and monitoring in Mokelumne Wilderness; Beebe Lakes *Rana sierrae* monitoring

Beebe Lake (Sept 2019, CDFW photo)

SUMMARY

Beebe Lakes drainage is an area from which California Department of Fish and Wildlife (CDFW) and Eldorado National Forest (ENF) staff removed introduced Brook Trout (*Salvelinus fontinalis*; BK) to restore habitat for the state threatened Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF). Those interested in learning details of the Beebe Lakes drainage BK removal may consult the 2017 survey memorandum (CDFW 2018). On 10 September 2019, CDFW staff visited the Beebe Lakes drainage (**Figure 1**) to conduct visual encounter surveys (VES) for native amphibians. Amphibian monitoring data from 2012 through 2019 suggest a small SNYLF population that may be declining. CDFW will continue amphibian monitoring in the area at least biennially to document SNYLF response to fish removal.

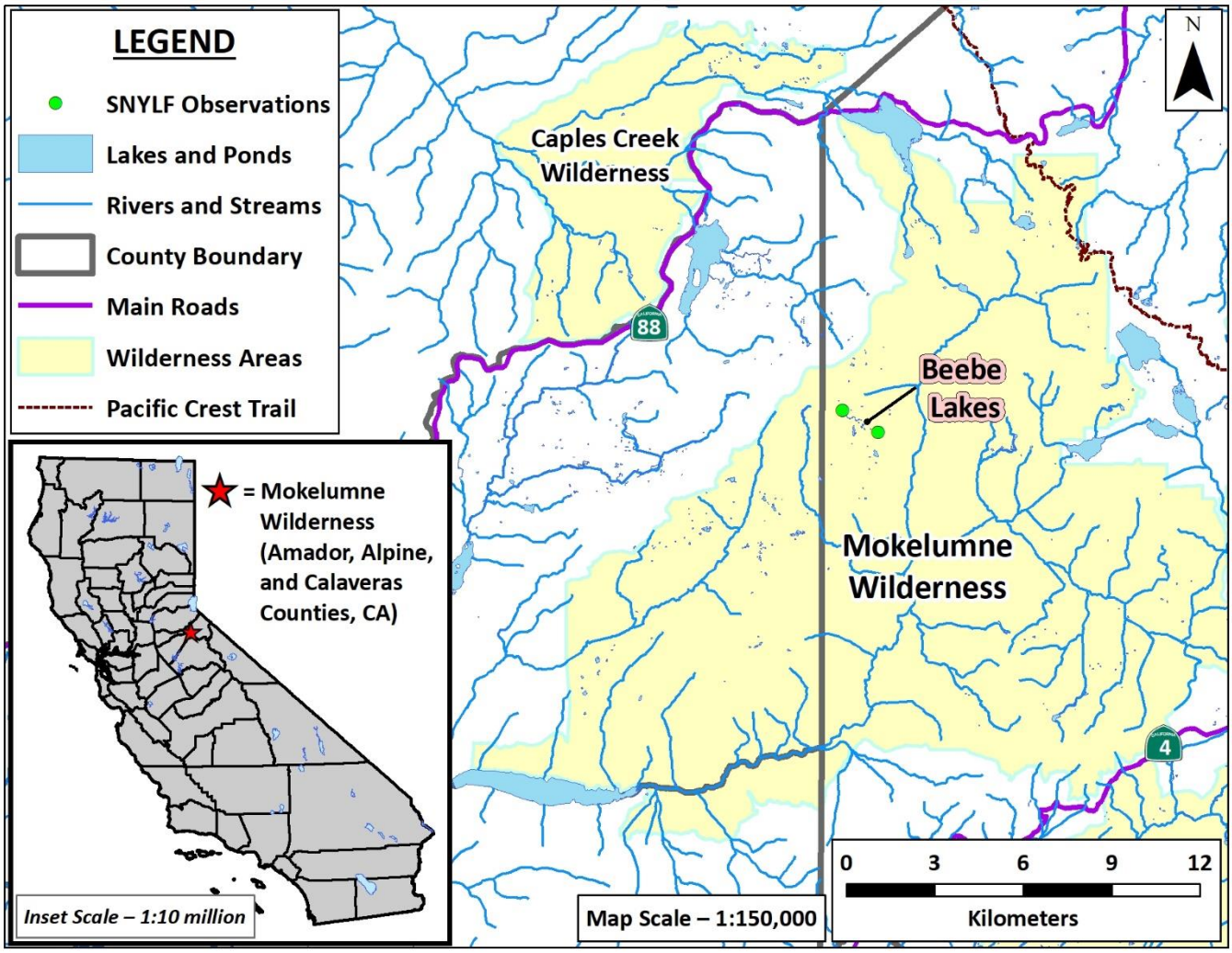


Figure 1. Mokelumne Wilderness, Amador, Alpine, and Calaveras Counties, CA. Green dots show Sierra Nevada Yellow-legged Frog (*Rana sierrae*) detections by California Department of Fish and Wildlife (CDFW) staff during 2019 visual encounter surveys (VES).

ENVIRONMENTAL SETTING

Beebe Lakes drainage is located in the Mokelumne Wilderness, just east of the Alpine County line. The basin is on the western slope of the Sierra Nevada, between 7,900' and 8,500'. Eldorado National Forest manages the land and issues grazing permits in the area. The site is accessed by driving rough 4x4 roads from the Silver Lake area off Highway 88, then hiking east into the Mokelumne Wilderness, past an old trading post, and through Ladeux Meadow before reaching Beebe Lakes basin. CDFW staff conducted baseline surveys in 2001 and 2002, during which staff captured BK in Beebe Lake during an overnight gill net survey. Staff also observed SNYLF (**Figure 2**) at four sites in the area. All SNYLF populations in the area are small and isolated. CDFW and ENF determined that eradicating BK from the Beebe Lakes area using gill nets and backpack electrofishers would be feasible and provide SNYLF with more deep-water habitat. Now fishless, CDFW manages the entire Beebe Lakes drainage as SNYLF breeding habitat (CDFW 2016).

INTRODUCTION

The Aquatic Biodiversity Management Plan for the Upper Mokelumne Management Unit (CDFW 2016) identifies Beebe Lake (Site ID 14797; **Figure 3**), Lower Beebe Lake (Site ID 2694), Beebe Meadow (Site IDs 14791, 14795, and 14799), approximately 1.5 kilometers (km) of stream (Site IDs 52651 and 52707), three small ponds with consistent SNYLF observations (Site IDs 14774, 14802 [**Figure 4**], and 14829), and several other small ponds in the basin as a Native Species Reserve (NSR; **Figure 5**) for SNYLF. Thus far, CDFW staff have not observed SNYLF in Beebe Lake. However, although only reaching a maximum depth of about 4 meters (m), Beebe Lake is the deepest wetted habitat in the basin. Additionally, Beebe Lake is located approximately halfway between Site IDs 14774 and 14802. Therefore, removing BK from Beebe Lake, Beebe Meadow, and the adjoining stream has created a series of interconnected fishless aquatic habitats for SNYLF.

Beebe Lake was stocked with BK from 1930 until 2000. Gill net sampling conducted by CDFW staff in 2001 and 2010 revealed that the BK population in Beebe Lake was self-sustaining. Beginning in 2011, CDFW, with assistance from ENF personnel, began removing BK from Beebe Lake and the surrounding area to benefit SNYLF. As of 2018, after three years of monitoring without detecting BK, the basin is fishless. The most recent BK capture was in 2015. However, CDFW staff will continue to regularly survey the Beebe Lakes basin SNYLF population and monitor for presence of any latent BK.

Figure 2. Adult Sierra Nevada yellow-legged Frog (*Rana sierrae*) near Site ID 14785 in September 2017. (CDFW)

Figure 3. Beebe Lake in September 2019, looking north. (CDFW)

Figure 4. Site ID 14802 in September 2019, looking east. This pond is one of the locations in Beebe Lakes basin where California Department of Fish and Wildlife staff (CDFW) have consistently observed a small SNYLF population. (CDFW)

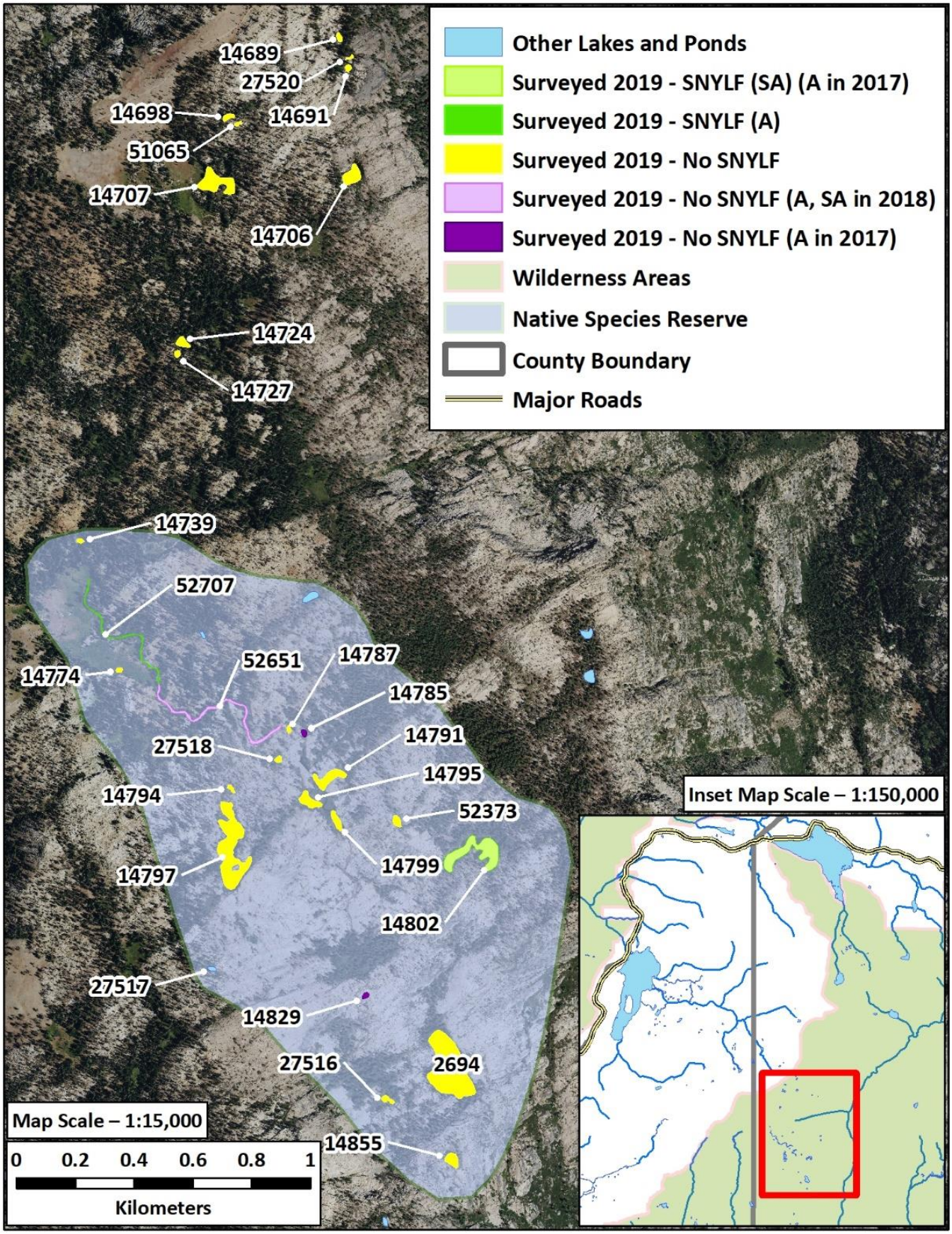


Figure 5. [See figure caption at the beginning of the next page.]

Figure 5 (continued). Recent (2017–2019) Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) detections in Beebe Lakes Native Species Reserve (NSR) by California Department of Fish and Wildlife (CDFW) field staff. In prior surveys, CDFW staff have observed all SNYLF life stages in four ponds within the drainage (Site IDs 14774, 14802, 14829, and 14706). CDFW has not observed SNYLF at Site ID 14774 since 2014 or at Site ID 14706 since 2010. Since fish removal began, CDFW staff have observed SNYLF adults and/or subadults in several other parts of the basin, including Site IDs 52651, 52707, 14785, and 14799. SNYLF letter codes in the legend, which indicate the life stage(s) observed during recent surveys, are as follows: "A" = adults and "SA" = subadults. Number labels shown are unique site identification codes that CDFW uses for data collection. All flowing waters in the basin drain south, through Lower Beebe Lake, east into Summit City Creek, and eventually into the North Fork Mokelumne River.

THREATS

Disease

All known SNYLF populations in the Mokelumne Wilderness are positive for chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*). In 2008 and 2010, CDFW collected epithelial swabs from SNYLF populations in the Beebe Lakes and had the samples screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. Staff collected eleven swabs from sites 14774, 14802, and 14829, and results from both years detected very light to moderate zoospore loads.

Marginal Habitats

SNYLF populations in the surrounding area are persisting at small, isolated ponds and their seasonally flowing tributaries (**Figure 5**). Any disturbance, natural or otherwise, that threatens overwintering habitats presents a potential extirpation risk. Potential risks include severe winter conditions, extended drought, or anthropogenic habitat disturbances.

Introduced Fish

All sites supporting SNYLF in the Beebe Lakes area are fishless. However, prior to recent fish removal activities, BK were persisting in much of the available aquatic habitat, including Beebe Lake and the nearby meadow/stream complex. The stream that connects Pond 14787 to Lower Beebe Lake flows seasonally and dries to a series of deep tannin pools by late summer. The stream and pool complexes are not ideal trout habitat, yet BK were persisting in the absence of stocking. The formerly fish-containing habitats may have been acting as population sinks for migrating SNYLF. Additionally, BK likely precluded any successful SNYLF breeding and recruitment in Beebe Lake, which supplies the only deep water habitat in the basin.

Cattle Grazing

Studies investigating direct interactions between cattle and SNYLF populations have not been conducted. However, the U.S. Forest Service (USFS) acknowledges cattle effects to aquatic resources in the Mokelumne Wilderness Management Guidelines (USFS 1995). Additionally, potential negative effects of livestock grazing on SNYLF habitat are discussed in the U.S. Fish and Wildlife Service (USFWS) final rule for listing SNYLF as a federally endangered species (USFWS

2014, pg. 24628–24630). USFWS concluded: "*Current livestock grazing activities may present an ongoing, localized threat to individual populations in locations where the populations occur in stream riparian zones and in small waters within meadow systems, where active grazing co-occurs with extant frog populations."* The USFWS concluded that livestock grazing that complies with USFS grazing guidelines is not expected to negatively affect most SNYLF populations (USFWS 2014).

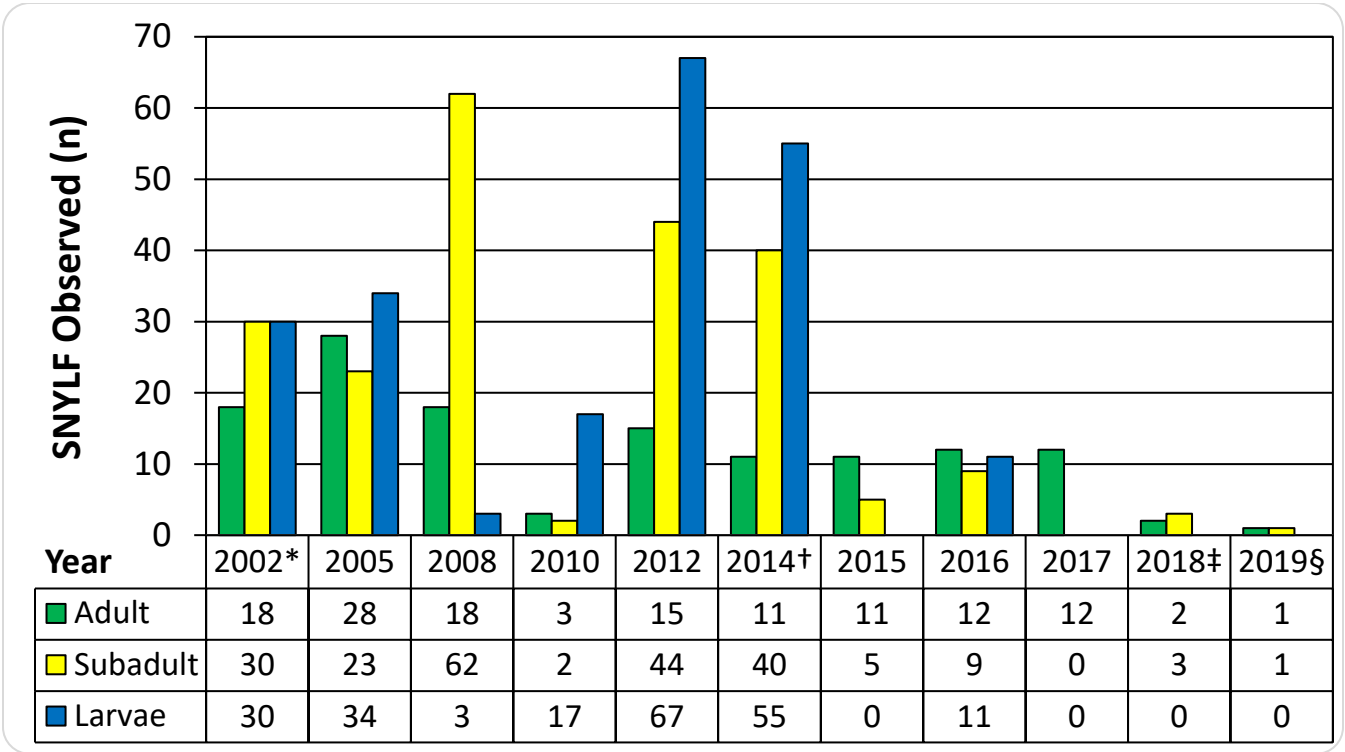
Loss of Genetic Diversity

Like many SNYLF populations in the northern Sierra Nevada, the population in Beebe Lakes is small and isolated. Although there are small populations in relatively close proximity (e.g., Ladeux Meadow, Devils Hole Lake, Bear River, and Deadwood Canyon; CDFW 2016), the rugged landscape of the Upper Mokelumne results in the Ladeux population being the only realistic source for gene flow from a source outside Beebe Lakes. The nearest location with fairly widespread SNYLF occupancy is the Jeff Davis Creek area, which is about 14 km east of Beebe Lakes (CDFW 2014). In addition to the threats presented by stochastic environmental events (e.g., drought or especially harsh winter), genetic isolation can lead to factors such as inbreeding depression, genetic drift, fixation of deleterious alleles, and loss of genetic diversity, all of which are population genetic factors exacerbated in small populations like those in Beebe Lakes (Frankham et al. 2009).

POPULATION STATUS: RESULTS

In the past, the sites in which a majority of SNYLF have been observed during VES in the Beebe Lakes drainage are Site IDs 14774, 14802, and 14829 (**Figure 5**). During backpack electrofishing on 26 September 2018, CDFW staff observed two adult and three subadult SNYLF in the Beebe Lake meadow inlet stream (Site ID 52651; **Figures 5 and 6**). CDFW field staff did not conduct any additional VES during summer 2018.

CDFW field staff returned for VES in the Beebe Lake area in September 2019. Staff surveyed 27 water bodies in the area (**Figure 5**), the most ponds surveyed since 2012 (during which CDFW and ENF surveyed 31 water bodies). Despite the expanded survey area, staff only observed two live SNYLF (staff also observed two dead subadults at Site ID 14802; **Figure 4**). CDFW observed one adult in a previously unmapped stream segment upstream of Site ID 52651 (Site ID 52707), and one live subadult in pond 14802. However, despite the low number of SNYLF observations in recent years, comparison to past surveys (during which SNYLF detections were higher) is confounded by several factors, including weather conditions, time of year, and observer bias (Mazerolle et al. 2007; See POPULATION STATUS: DISCUSSION section).



Year	2002*	2005	2008	2010	2012	2014†	2015	2016	2017	2018‡	2019§
Adult	18	28	18	3	15	11	11	12	12	2	1
Subadult	30	23	62	2	44	40	5	9	0	3	1
Larvae	30	34	3	17	67	55	0	11	0	0	0

Figure 6. Total number of Sierra Nevada Yellow-legged Frogs (SNYLF) of each life stage observed in the Beebe Lakes area by California Department of Fish and Wildlife (CDFW) staff between 2002 and 2019. Yearly totals primarily include observations from Site IDs 14774, 14802, and 14829. The chart also includes one adult observed in Site ID 14785 in 2017, one adult observed in Site ID 14799 in 2015, and one adult observed in Site ID 52707 in 2019. This chart does not include observations from Site ID 14706.

*CDFW staff did not survey Site ID 14829 in 2002.

†CDFW staff began surveying Site ID 52651 in 2014. Staff have only observed post-metamorphic SNYLF in Site ID 52651 (one in 2014, one in 2015, five in 2016, one in 2017, and five in 2018).

‡In 2018, CDFW staff did not conduct visual encounter surveys (VES) for SNYLF in the Beebe Lakes basin. Staff only incidentally surveyed Site ID 52651 during three passes of backpack electrofishing on 26 September 2018.

§CDFW staff began surveying Site ID 52707 in 2019.

POPULATION STATUS: DISCUSSION

Seventeen years of monitoring data suggest the Beebe Lakes SNYLF population is declining (**Figure 6**). However, observer bias, variation in survey conditions, and relatively low number of detections all make deriving trends difficult. Additionally, 2015 was the first season that SNYLF did not have to share high quality stream and meadow habitat with introduced BK. Another confounding factor is recent drastic changes in winter conditions between years. These seasonal fluctuations increase the difficulty of interpreting population trends. For example, since 2012, winter precipitation in the northern Sierra Nevada has alternated from far below average during an extended drought (2012–early 2016), to record-setting (2016–2017), to well below average (2017–2018), to well above average (2018–2019). SNYLF mortality can increase during long winters with deep snowpack (Bradford 1983). Contrarily, drought conditions can dry up many areas normally occupied by SNYLF, especially in places like Beebe Lakes, where much of the available aquatic habitat is small shallow ponds and ephemeral streams.

Two other important environmental considerations are survey timing and weather during the survey. CDFW amphibian VES at Beebe Lakes in 2017 and 2019 occurred during the first and second weeks of September, respectively. Although these dates are within the window of time that survey conditions are generally favorable for SNYLF detectability, weather becomes less predictable during September, and cooler evening temperatures become more common. The Beebe Lake area is one of the higher elevation SNYLF sites in the northern Sierra Nevada (2,560 m [~8,400 feet]), so temperatures at Beebe Lakes during any given time tend to be cooler when compared with many other sites.

During both survey occasions in 2017 and 2019, weather conditions were less than ideal. For example, in 2017, VES followed an afternoon of heavy thunderstorms and cool temperatures. Weather conditions were overcast and relatively cool (~17° C [62° F] for a mid-day high) during the survey. In 2019, it was even cooler on the day of surveying, with a recorded mid-day high air temperature of 14° C [57° C] in the NSR. During both years, CDFW surveyed several sites in the basin in the morning, during which air temperatures were even cooler (≤10° C [≤50° F]). SNYLF activity in both years may have been reduced during these relatively cold late summer temperatures.

The habitat composition of Beebe Lakes drainage is another reason that estimating SNYLF abundance is difficult. Available habitat consists of Beebe Lake, numerous small tannin ponds (into which visibility can be highly limited), multiple springs, a long stream channel, and a large meadow complex with dozens of isolated depressions that occasionally hold water. Dense vegetation surrounds many of these aquatic areas. This habitat variety is likely beneficial for SNYLF. However, the habitat complexity and thick vegetation also reduces visibility and maneuverability for surveyors. Therefore, SNYLF detectability during VES in the Beebe Lakes drainage is likely very limited.

Despite these challenges, CDFW will continue to monitor the Beebe Lake SNYLF population regularly to assess the population status over time. Long-term monitoring will be required to derive population trends and quantify the SNYLF population in the Beebe Lakes area.

Additionally, in 2020, CDFW will attempt to survey the Beebe Lakes area during more ideal survey conditions in mid-summer. If VES during better weather conditions result in low SNYLF detections, similar to observations in 2017 and 2019, CDFW will have better evidence for SNYLF population decline in the Beebe Lakes area.

Finally, given the low detectability and downward trend in detections, CDFW may begin marking adult SNYLF in the Beebe Lakes area with passive integrated transponder (PIT) tags. Over time, marking adult SNYLF in this manner would allow capture-mark-recapture analysis, which can provide a more accurate estimation of population size, especially for a relatively small population occupying habitat that is challenging to survey (Mazerolle et al. 2007). However, CDFW will only begin marking SNYLF if field staff detect more individuals during VES in 2020. If VES during better survey conditions result in highly limited detections (e.g., <10 post-metamorphic SNYLF observed), CDFW will likely forego marking any individuals, to limit additional stress to an imperiled SNYLF population.

LITERATURE CITED

Bradford, D.F. 1983. Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*. Ecology 64:1171–1183.

California Department of Fish and Wildlife (CDFW). 2014. Aquatic Biodiversity Management Plan for the Jeff Davis Creek Management Unit. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84128

CDFW. 2016. Aquatic Biodiversity Management Plan for the Upper Mokelumne Management Unit. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=127574

CDFW. 2018. Native amphibian restoration and monitoring in Mokelumne Wilderness: Beebe Lakes fish removal and *Rana sierrae* monitoring. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=156671

Frankham, R., J.D. Ballou, and D.A. Briscoe. 2009. Introduction to Conservation Genetics. Cambridge University Press, New York, NY, USA.

Mazerolle, M.J., L.L. Bailey, W.L. Kendall, J.A. Royle, S.J. Converse, and J.D. Nichols. 2007. Making great leaps forward: accounting for detectability in herpetological field studies. Journal of Herpetology 41:672–689.

U.S. Fish and Wildlife Service (USFWS). 2014. Endangered and threatened wildlife and plants; endangered species status for Sierra Nevada Yellow-legged Frog and northern distinct population segment of the mountain yellow-legged frog, and threatened species status for Yosemite toad. Federal Register 79:24256–24310.

U.S. Forest Service (USFS). 1995. Toiyabe National Forests. Mokelumne Wilderness Management Guidelines – Environmental Assessment #EO95-01.