

State of California
Department of Fish and Wildlife

Memorandum

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Subject: Native amphibian restoration and monitoring in Mokelumne Wilderness;

- Updates on non-native fish removal in the Beebe Lakes drainage



CDFW staff checking gill nets in Beebe Lake, October 2020. (CDFW)

SUMMARY

Beebe Lakes drainage is an area from which California Department of Fish and Wildlife (CDFW) and Eldorado National Forest (ENF) staff had worked to remove 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 more about the previous Beebe Lakes drainage BK removal may consult the [2017 Beebe Lakes area survey memorandum](#) (CDFW 2018).

In late June 2020, CDFW staff visited the Beebe Lakes drainage to conduct visual encounter surveys (VES) for native amphibians. During the visit, CDFW staff observed small fish in the littoral zone of Beebe Lake (**Figure 1**). These observations triggered follow-up visits in 2020, during which CDFW used monofilament gill nets and backpack electrofishing units to capture 172 BK in Beebe Lake and Beebe Meadow (CDFW 2021). Staff continued fish removal efforts throughout 2021, during which CDFW caught 34 BK from gill nets set overwinter (2020–2021).

At some point between 23 June and 14 July 2021, an individual or group illegally removed 14 gill nets from Beebe Lake and Beebe Meadow. Given the net confiscation, CDFW does not know whether any fish had been captured in early summer 2021. After discovering the net theft, CDFW staff placed a new suite of gill nets into Beebe Lake and Beebe Meadow, which remained at the site for the remainder of 2021. No fish captures occurred in any of the gill nets reset between August and October 2021. CDFW will continue intensive BK removal efforts in 2022, with the goal of removing all fish from Beebe Lake, Beebe Meadow, and stream inlet to Beebe Meadow. If necessary, CDFW will continue these restoration efforts beyond 2022, particularly if additional sabotage occurs.

Amphibian monitoring data from 2012 through 2020 suggest a small SNYLF population that may be stable or declining. CDFW did not conduct amphibian surveys in 2021, due to focus on fish removal and later access issues related to the [Caldor Fire](#). However, CDFW plans to continue annual amphibian monitoring in 2022 to document SNYLF response to fish removal. Those interested in the most recent amphibian monitoring data from the Beebe Lake drainage should consult the memorandum [“Native amphibian restoration and monitoring in Mokelumne Wilderness; Beebe Lakes *Rana sierrae* monitoring and updates on non-native fish removal”](#) (CDFW 2021), which summarized results through the 2020 field season.



Figure 1. Beebe Lake in fall 2020, looking west. (CDFW)

ENVIRONMENTAL SETTING

Beebe Lakes drainage is located in the Mokelumne Wilderness, just east of the Alpine County line (**Figure 2**). The basin is on the western slope of the Sierra Nevada, between 2,408 and 2,591 meters (m; or 7,900 and 8,500 feet [ft]) in elevation. Eldorado National Forest manages the land and issues grazing permits in the area. The site is accessed by four-wheel drive roads from the Silver Lake area off State Route 88, then by hiking trail 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 at four sites in the area. All SNYLF populations in the area are small and isolated. CDFW and ENF determined that eradicating BK from Beebe Lake and Beebe Meadow area using gill nets and backpack electrofishing units would be feasible and provide SNYLF with more deep-water habitat.

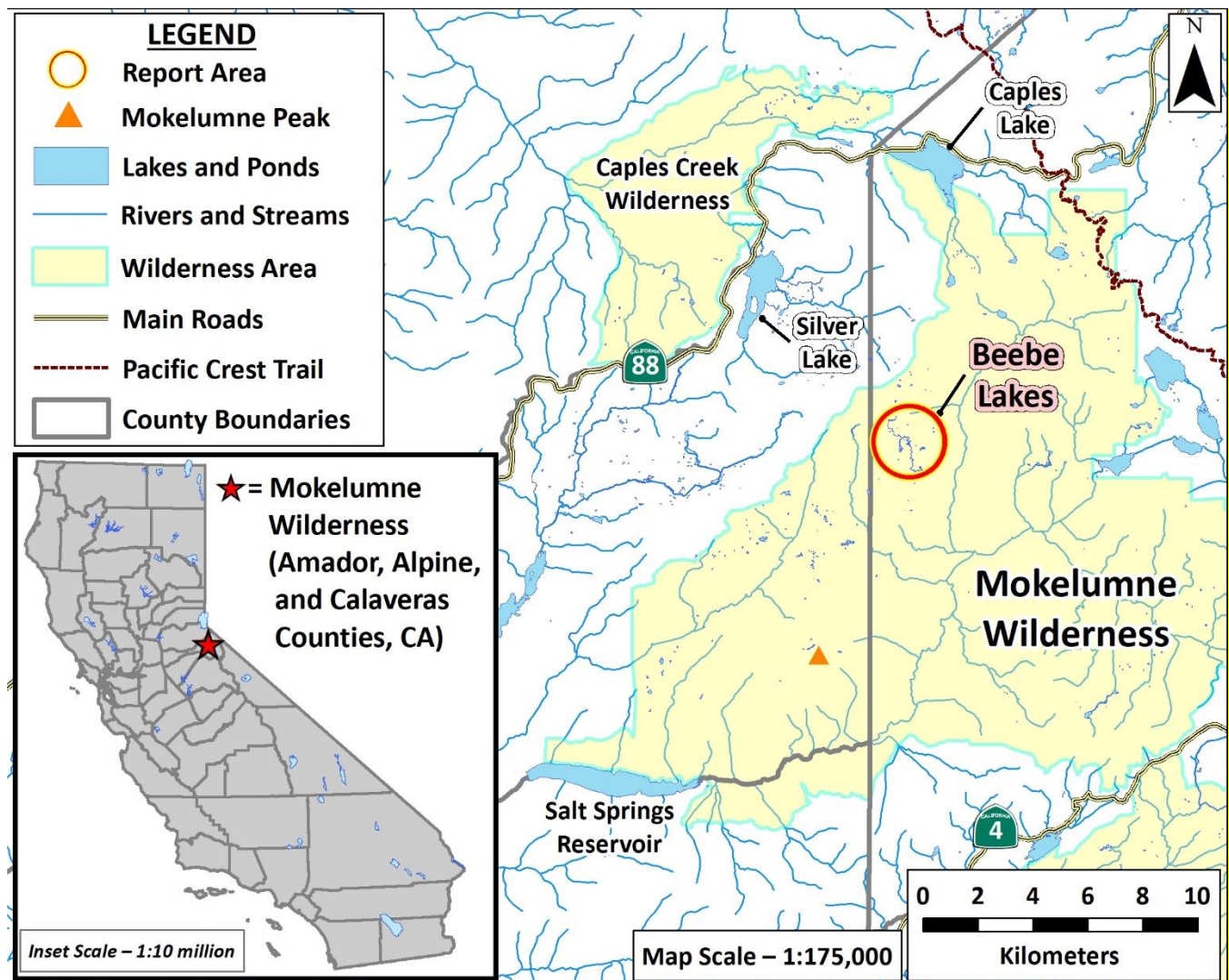


Figure 2. Mokelumne Wilderness, Amador, Alpine, and Calaveras Counties, CA. The area discussed in this memorandum is circled.

INTRODUCTION

The Aquatic Biodiversity Management Plan for the Upper Mokelumne Management Unit (CDFW 2016) identifies Beebe Lake (Site ID 14797; **Figure 1**), Lower Beebe Lake (Site ID 2694; which is filling in with sediment and is no longer a lake, but rather an occasionally flooded meadow with stream channels), Beebe Meadow (Site IDs 14791, 14795, and 14799), approximately 1.5 kilometers (km) of stream (Site IDs 52651, 52707, and 52783), three small ponds with consistent SNYLF observations (Site IDs 14774 [**Figure 3**], 14802, and 14829), and several other small ponds in the basin as a Native Species Reserve (NSR; **Figure 4**) for SNYLF. Thus far, CDFW staff have not observed SNYLF in Beebe Lake, which is the deepest wetted habitat in the basin, with a maximum depth of about 4 m. 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 is required to create 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, CDFW had determined the basin was fishless. Prior to 2020, the most recent BK capture was in 2015. However, in 2020, CDFW discovered that BK had reemerged in the basin. Therefore, CDFW reinstated fish removal efforts. Additionally, staff will continue to regularly survey the Beebe Lakes basin SNYLF population and increase monitoring for presence of any latent BK.



Figure 3. Site ID 14774 in June 2020, looking southeast. This spring-fed meadow pool is one of the few locations in Beebe Lakes basin where California Department of Fish and Wildlife staff (CDFW) have observed evidence of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) breeding, including egg masses and tadpoles. (CDFW)

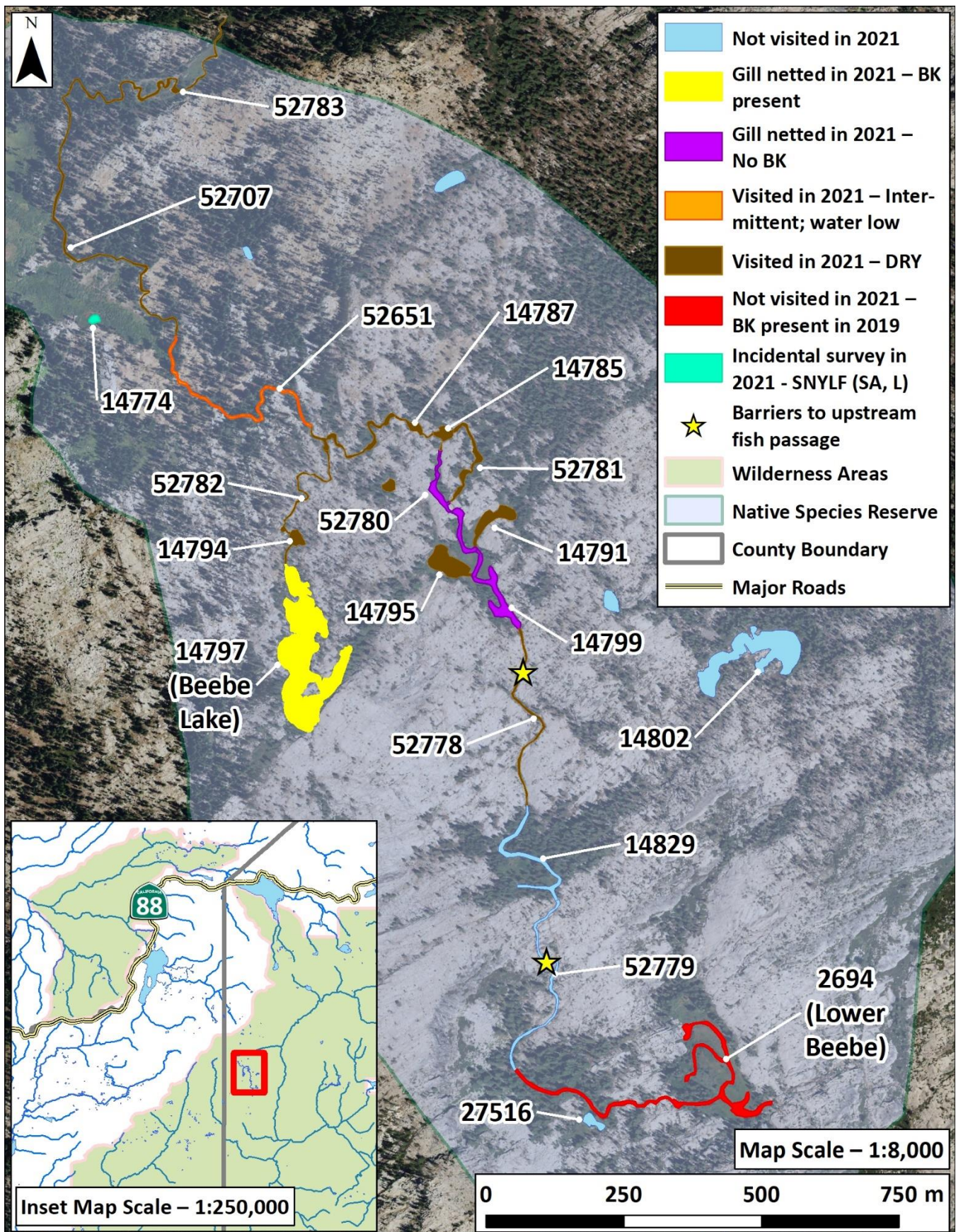


Figure 4. [See figure caption at the beginning of the next page.]

Figure 4 (continued). Hydrologic status and Brook Trout (*Salvelinus fontinalis*; BK) detections observed by California Department of Fish and Wildlife (CDFW) staff in Beebe Lakes Native Species Reserve (NSR) in 2021. CDFW staff captured 34 BK in gill nets set overwinter (fall 2020 to early summer 2021) in Beebe Lake. Staff did not capture any additional trout in the Beebe Lake or Beebe Meadow in 2021. However, between 23 June and 14 July 2021, unknown individuals removed 14 gill nets from Beebe Lake (area displayed in yellow) and Beebe Meadow (area displayed in purple). Therefore, CDFW cannot confirm if any trout were captured during early summer. Staff reset gill nets into Beebe Lake and Beebe Meadow on 3 August 2021. On 19 October 2021, CDFW staff removed gill nets from Beebe Meadow and took out four gill nets from Beebe Lake. Staff will check the overwinter gill nets that remain in Beebe Lake (n = 6) when the site is accessible following spring snowmelt. Areas shown as “DRY” are those that no longer contained visible surface water in mid-October 2021. All flowing waters in the basin drain south, then east into Summit City Creek, and eventually into the North Fork Mokelumne River. In prior surveys, CDFW staff have observed SNYLF at multiple locations in the Beebe Lakes drainage, including Site IDs 14774, 14785, 14799, 14802, 14829, 52651, 52707, 52778, and 52781.

BROOK TROUT REMOVAL:

Background

CDFW and ENF staff originally began removing introduced BK from Beebe Lake in 2011. Before 2020, the last BK captures in Beebe Lake occurred during summer 2012. Subsequent gill net sets from fall 2012 until early summer 2015 yielded no BK captures. Therefore, CDFW removed gill nets from Beebe Lake in July 2015, after more than two years of constant gill net sets with no BK captured. One notable event during the latter period of fish removal occurred in summer 2014, during which one or more people removed most of the nets from the lake. The looters damaged several nets, including somehow stringing several into the canopies of dead trees adjacent to Beebe Lake (**Figure 5**). Between July 2015 and August 2020, CDFW set no gill nets in Beebe Lake. Those interested in a detailed accounting of Beebe Lakes drainage BK removal from 2011–2017 may consult the [2017 Beebe Lakes area survey memorandum](#) (CDFW 2018).



Figure 5. Gill net sabotage at Beebe Lake in September 2014. (CDFW)

CDFW also used gill nets and backpack electrofishing units to remove BK from Beebe Meadow (Site IDs 14785, 14787, 14791, 14795, 14799, 52780, and 52781; **Figure 4**) and the inlet stream (i.e., Site IDs 52707 and 52651; **Figure 4**). Staff had gill nets set in the meadow pools from July 2014 to August 2017. Late September 2015 was the last time CDFW or ENF captured any BK in Beebe Meadow or the inlet stream. The final confirmation rounds of electrofishing for the BK removal project occurred in late September 2018, during which CDFW staff completed three full passes of the Beebe Meadow inlet stream with no BK detected. In all, between 2016 and 2018, CDFW and ENF staff completed 14 electrofishing passes of the Beebe Meadow inlet stream (areas holding water in Site IDs 52707 and 52651; **Figure 4**) with no BK detected. In 2018, after eight consecutive years of fish removal efforts, CDFW declared Beebe Lake and Beebe Meadow area fishless.

Following fish removal efforts, CDFW staff returned to the Beebe Lake drainage annually to conduct VES for native amphibians. During VES in late June 2020, CDFW staff observed small fish in the littoral zone of Beebe Lake. These observations triggered a follow-up visit in mid-September, during which CDFW set two gill nets in Beebe Lake to attempt capturing and identifying the fish present. The gill nets captured 63 BK during a two-week set. CDFW staff returned to the site from 30 September to 1 October 2020 and deployed twelve 30-m (100-ft) monofilament gill nets into Beebe Lake and three gill nets in Beebe Meadow. Additionally, staff used a backpack electrofishing unit to capture fish in areas with shallow water in Beebe Meadow, nearby connected ponds, and the wetted stream segments (**Figure 4**). During these efforts in 2020, staff removed 172 BK from the Beebe Lake NSR. Before leaving the site on 20 October, CDFW staff removed all gill nets from the meadow (in which nets tend to get damaged and/or buried by early season high flows) and half the gill nets from Beebe Lake, leaving six gill nets to capture fish overwinter. For further details on these fish removal efforts, please consult the memorandum "[Native amphibian restoration and monitoring in Mokelumne Wilderness; Beebe Lakes *Rana sierrae* monitoring and updates on non-native fish removal](#)" (CDFW 2021).

2021 Updates

When Beebe Lakes drainage became accessible in early summer 2021, CDFW staff returned to check the six overwinter gill nets in Beebe Lake. On 22 June, staff removed approximately 34 trout from the overwinter gill nets (**Table 1**). All overwinter fish captures were likely BK, but staff could not definitively identify many captures to species due to decomposition of the carcasses. Following net checks, staff removed and repaired all overwinter gill nets. On 23 June, staff reset Beebe Lake with 10 summer gill nets. Additionally, staff set five gill nets into Beebe Meadow (**Figure 4**, area shown in purple).

Staff next visited Beebe Lake on 14 July 2021. Upon arriving at the site, staff discovered that an individual or group had stolen all gill nets from Beebe Lake and most gill nets from Beebe Meadow. In the Beebe Meadow area, one net had been removed from the water, crumpled up, and stashed inside a downed tree hollow (**Figure 6**). Only one net was found undisturbed in

Beebe Meadow. Staff cleaned and reset this single gill net. After discovering the sabotage, staff searched around the meadow and the lake extensively, and were unable to locate any other nets or net fragments.



Figure 6. A gill net, as found by California Department of Fish and Wildlife (CDFW) staff on 14 July 2021. Individual(s) had illegally removed the net from Beebe Meadow. (CDFW)

In response to the net theft, CDFW returned to Beebe Lakes drainage on 3 August 2021 and reset new nets into the same areas. Staff set 10 nets into Beebe Lake and three nets into Beebe Meadow. While setting new gill nets, staff checked the one gill net that had remained in Beebe Meadow following the previous check on 14 July. That gill net contained no fish captures. Staff next returned to the Beebe Lakes area on 9 August to check all gill nets, which did not contain any fish. Following this visit, access to the Beebe Lakes area was prevented until October due to the [Caldor Fire](#). CDFW staff returned to the Beebe Lakes area on 19 October for the final visit of the season. During this visit, staff checked all gill nets, removed the gill nets from Beebe Meadow, and removed four of the 10 gill nets from Beebe Lake. Staff left six nets in Beebe Lake to capture fish overwinter. CDFW plans to check these overwinter gill nets in late spring or early summer 2022, when the site becomes accessible.

In total, CDFW captured 34 fish from Beebe Lake and zero fish from Beebe Meadow in 2021. All fish captures were from the 2020–2021 overwinter gill nets in Beebe Lake (**Table 1**). CDFW staff did not undertake any electrofishing in the Beebe Lake area in 2021 because the Caldor Fire prevented site access during the period when staff had planned to conduct electrofishing in Beebe Meadow and the meadow inlet stream during late summer and fall 2021.

Table 1. Locations (Site IDs), effort (number of gill nets and net check events), and total number of Brook Trout (*Salvelinus fontinalis*; BK) removed from the Beebe Lakes area by California Department of Fish and Wildlife (CDFW) staff in 2021. Staff estimated that all adult BK were ≥ 300 mm total length (TL), while juveniles were approximately age 1 fish (~ 100 – 150 mm TL). However, staff could not definitively determine most fish lengths due to overwinter decomposition of fish carcasses. The gill net set at Site ID 14795 does not have a pull date because it was stolen, and staff did not reset a net at that location due to low water levels. CDFW will check all overwinter nets in 2022. See **Figure 4** for locations of all Site IDs listed below.

Site ID	Name	Summer nets (n)	Date of first net check	Date of last net pull	Net check events	Trout total		Over-winter nets (n)
						Adults	Juveniles	
14797	Beebe Lake	10	22 June	19 Oct	4	2	32	6
52780	---	1	23 June	19 Oct	4	0	0	0
52651	---	1	23 June	8 Aug	4	0	0	0
14791	---	1	23 June	Stolen	1	0	0	0
14795	---	1	23 June	19 Oct	4	0	0	0
14799	---	1	23 June	19 Oct	4	0	0	0

Discussion

The reemergence of BK is an unfortunate setback to SNYLF conservation in Beebe Lakes basin. CDFW will not be able to conclusively determine whether BK remained in the basin following eradicated work from 2011 to 2018, or if someone illegally replanted BK. Both scenarios are plausible. A small number of BK may have remained following initial fish removal efforts; the habitat in Beebe Meadow is complex, and few BK may have remained undetected, despite gillnetting and electrofishing work resulting in zero BK detections from 2015 to 2018. Alternatively, two known instances of project sabotage (2014 and 2021) lend circumstantial evidence to illegal BK reintroduction. Lower Beebe and the connected stream (below barriers to upstream fish movement; **Figure 4**) contain BK and provide a potential source for illegal reintroduction into Beebe Lake. Whether failed initial eradication or illegal fish planting, CDFW's response—reinstating fish removal—is the same. However, the explanation for BK reemergence is important for long-term management and potential for project success. Therefore, the topic is considered in more detail here.

The presence of two discrete BK size classes captured in Beebe Lake in fall 2020, with no fish captured in the ~ 150 – 300 mm (6–12 inch) TL range, is an indication that BK recently reinvaded Beebe Lake. Five years passed between CDFW removing gill nets from Beebe Lake and redetecting BK in 2020. If BK had remained in Beebe Lake after CDFW removed gill nets in 2015,

or if fish had somehow reinvaded the lake several years ago, it is reasonable to assume that a wider range of size classes—and a much larger BK population—would be present in 2020. There were three above average precipitation years in the northern Sierra Nevada between 2015 and 2020 (2015–2016, 2016–2017, and 2018–2019; CDEC 2022a), during which more ideal fall spawning conditions may have been available for BK in the Beebe Lake drainage. Water years 2016–2017 (two years post-fish removal) and 2018–2019 (four years post-fish removal) were well above the 1966–2015 precipitation average (136% and 183%, respectively; CDEC 2022a). However, the snowpack during both the 2016–2017 and 2018–2019 water years was similar, particularly in the late spring and early summer (CDEC 2022b). These conditions may have been sufficient to allow BK spawning in fall 2017 and fall 2019. However, based on presence of only a single juvenile size class during gillnetting in 2020, it appears that BK only successfully spawned once, which most likely occurred in 2019. Therefore, the BK reinvasion likely occurred in early 2019 and the single spawning event would have occurred in fall 2019.

One potential explanation for the BK reemergence is that fish were fully eradicated from Beebe Lake, but some BK remained in Beebe Meadow and/or the inlet stream to Beebe Meadow. Even during exceptionally dry years (e.g., 2021), portions of the main channel flowing through Beebe Meadow remain over 1 m deep and hold enough water to sustain fish (e.g., portions of Site IDs 52780, 14791, 14795, and 14799; **Figure 4**, area shown in purple). Additionally, the stream that flows into Beebe Meadow is spring fed via the meadow west of Site ID 52707, which prevents a section of Site ID 52651 from going completely dry (**Figure 4**). In late winter and spring, there is an ephemeral outlet (Site ID 52782; **Figure 4**) flowing from the north end of Beebe Lake into the stream segment flowing into Beebe Meadow. During the right flow conditions (e.g., high flows during snowmelt, particularly during big water years like 2017 and 2019), BK may be able to ascend Site ID 52782 to enter Beebe Lake from Site ID 52651. The outlet of Beebe Lake is steep and contains several drops over bedrock. However, the channel may not contain a barrier to upstream fish movement under all flow conditions. If so, Site ID 52782 provides a seasonal connection between Site ID 52651 and Beebe Lake that can occasionally be exploited by BK.

Given the greater difficulty of removing BK from the more complex meadow and stream habitat, this scenario is more plausible than BK having remained in Beebe Lake. However, a few assumptions are required: 1) there is no definitive barrier to upstream fish movement between Site ID 52651 and Beebe Lake, 2) despite the results of electrofishing and gillnetting efforts in the stream and meadow, BK were still present, and 3) many ~6–9-inch TL stream form adult BK (i.e., at least the number of large adults captured in gill nets during fall 2020) were able to ascend the stream and enter Beebe Lake. Given the similar size of the adults captured in 2020, and the presence of only one juvenile cohort in Beebe Lake, the reinvading BK would have most likely entered Beebe Lake from Site ID 52651 via Site ID 52782 (**Figure 4**) in early 2019.

Before 2020, the last BK detections in the meadow inlet stream (Site IDs 52707 and 52651) were during electrofishing in September 2015. The 2012–early 2016 drought likely helped CDFW

greatly reduce or eradicate BK from the stream channel via electrofishing. However, the deep channel running through Beebe Meadow (**Figure 4**, area shown in purple) is perennial, and holds enough water, even during dry years, to retain fish. This channel is relatively wide and deep, darkly stained with tannins, and contains submerged large woody debris in some locations: all conditions that lead to ineffective backpack electrofishing, particularly with only a single electrofisher. However, the water is also shallow enough during dry years, and contains enough emergent vegetation during low water, that gillnetting can be inhibited in some areas. CDFW suspects that these conditions in the main meadow channel may have resulted in a portion of the BK population evading capture during the meadow eradication efforts from 2014–2017.

In addition to the scenario discussed above, there are other circumstances that could have resulted in reemergence of BK. One possibility is that BK remained in Beebe Lake after eradication efforts were completed. However, if BK had still been present when CDFW removed gill nets in 2015, a much wider range of BK size classes would have likely been present. Additionally, mechanical trout removal has been achieved successfully at many sites over more than two decades of work across the Sierra Nevada. Failure to capture a single BK following two years of constant gillnetting seems extremely implausible if fish were still present. The possibility of BK having remained under these circumstances is especially unlikely given that Beebe Lake is relatively small, and the habitat is not complex.

A more likely alternative explanation for the reemergence of BK in the basin is that someone illegally replanted Beebe Lake. This assumption is given more credence based on two separate instances of net vandalism and theft in 2014 and 2021 (**Figures 5 and 6**), and an incident in 2017 where a district fisheries biologist received public comments threatening to plant fish back into Beebe Lake. If illegal planting was the cause of BK reinvasion, the event(s) likely occurred between summer 2017 and summer 2019. These BK were either of reproductive age when planted, or they became reproductively mature by fall 2019. In 2020, CDFW only caught 30 total adult BK in the basin, and CDFW has subsequently captured only two additional BK adults, both from the 2020–2021 overwinter gill nets (**Table 1**). Therefore, capture rates of large adults were rapidly declining after only a few weeks of gill net sets in 2020 (e.g., only four adults were caught from 15 gill nets set between 1 and 19 October 2020). These capture results suggest that fewer than 40 BK could have been planted into Beebe Lake (which would have then grown rapidly in a fishless environment with an abundant food source of aquatic macroinvertebrates, which rebounded in the years after eradication in 2015). Such an effort could be achievable, particularly on horseback. These fish were then able to spawn in fall 2019. In this scenario, a few of these fish flushed down the outlet stream of Beebe Lake into Beebe Meadow in 2019 and/or early 2020. The fact that CDFW staff were able to catch a couple BK during one electrofishing pass of Site ID 52651 in fall 2020, after zero BK captured during numerous electrofishing passes during the same time of year in 2018 (another low water year; CDEC 2022a), is another line of evidence suggesting that BK did not reenter the stream until 2019 at the earliest.

In 2020, CDFW suspected that among all of these potential scenarios, the most likely explanation is that BK endured in Beebe Meadow through the attempted eradication efforts in 2014–2017, due to complex habitat and insufficient gillnetting effort (CDFW 2021). This possibility is still likely in the absence of other direct evidence. However, there is now more indirect evidence for illegal planting, given two separate instances of elaborate efforts to stop fish removal in the Beebe Lake area.

Irrespective of the true explanation for BK reemergence in the Beebe Lake area, these results provide an opportunity to adapt eradication techniques to focus more effort on fish removal in the meadow, including setting more nets in the main meadow channel and checking those nets more frequently, which will improve capture success. CDFW's increased focus on gillnetting in the meadow will be in tandem with continued electrofishing in the meadow inlet stream and gillnetting in Beebe Lake. Additionally, although BK may have not been completely removed during initial efforts, electrofishing and gillnetting from fall 2020 through 2021 suggest that the BK population is very small, which will help expedite eradication efforts. Gillnetting in 2020 and 2021, both extremely low water years, likely helped prevent another spawning event, which will improve the chances of restoring the basin to its natural fishless condition. Years with dry conditions limit the available aquatic habitat for BK, reduce fall spawning potential, and consolidate fish into smaller areas for more targeted eradication. Although winter 2021–2022 was initially on a trajectory to be a larger water year than 2020 and 2021, precipitation has ceased nearly completely in January and early February 2022, and daytime high temperatures have often been above average (CDEC 2022a,b). However, at the time this memorandum was being finalized, it was still too early to know if these conditions would persist through spring. As of this writing, the 2020–2021 water year is on a very similar trajectory as the 2012–2013 water year (at the beginning of the 2012–2016 drought). Both water years began with large amounts of snow accumulation in December, but precipitation tapered off by early the following calendar year (CDEC 2022a,b).

The reemergence of BK in Beebe Lake basin emphasizes the importance for regular follow-up monitoring at fish removal sites. Periodic gill net sets will help detect any incipient non-native trout reinvasion. Catching these events early will likely make removing fish easier to achieve. Once BK are removed, SNYLF will finally have the chance to reclaim the larger, more perennial waterbodies in the basin. In summer and fall 2022, CDFW will continue *Rana sierrae* population monitoring and BK removal in the Beebe Lake NSR.

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