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Monitoring of Adult Lost River and Shortnose Suckers in Clear Lake Reservoir, California, 2008–2010

Open-File Report 2013–1301

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	25.4	inch (in.)
centimeter (cm)	2.54	inch (in.)
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
kilometer (km)	0.6214	mile (mi)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32.$$

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Executive Summary

In collaboration with the Bureau of Reclamation, the U.S. Geological Survey began a consistent monitoring program for endangered Lost River suckers (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*) in Clear Lake Reservoir, California, in the fall of 2004. The program was intended to develop a more complete understanding of the Clear Lake Reservoir populations because they are important to the recovery efforts for these species. We report results from this ongoing program and include sampling efforts from fall 2008 to spring 2010. We summarize catches and passive integrated transponder (PIT) tagging efforts from trammel net sampling in fall 2008 and fall 2009, as well as detections of PIT-tagged suckers on remote antennas in the spawning tributary, Willow Creek, in spring 2009 and spring 2010.

Trammel net sampling resulted in a relatively low catch of suckers in fall 2008 and a high catch of suckers in fall 2009. We attribute the high catch of suckers to low lake levels in 2009, which concentrated fish. As in previous years, shortnose suckers made up the vast majority of the sucker catch and recaptures of previously PIT-tagged suckers were relatively uncommon. Across the 2 years, we captured and tagged 389 new Lost River suckers and 2,874 new shortnose suckers. Since the program began, we have tagged a total of about 1,200 Lost River suckers and 5,900 shortnose suckers that can be detected on the remote antennas in Willow Creek. Detections of tagged suckers were low in both spring 2009 and spring 2010. The magnitude of the spawning migration was presumably small in both years because of low flows in Willow Creek; detections were similar to a previous low-flow year (spring 2007) and much lower than previous years with higher flows (spring 2006 and spring 2008).

The size composition of fish captured in fall trammel net sampling over time suggests that the Lost River sucker population probably has decreased in abundance from what it was in the early 2000s. Shortnose suckers are smaller than Lost River suckers, and we are unable to infer any trend in abundance for shortnose suckers because it is impossible to separate recruitment of small fish from size selectivity of the trammel nets. Nonetheless, the substantial catch of small shortnose suckers in 2009, especially females, indicates that some new individuals recruited to the population.

Problems with inferring status and population dynamics from size composition data can be overcome by a robust capture-recapture program that follows the histories of PIT-tagged individuals. Inferences from such a program are currently hindered by poor detection rates during spawning seasons with low flows in Willow Creek, which indicate that a key assumption of capture-recapture models is violated. We suggest that the most straightforward solution to this issue would be to collect detection data during the spawning season using remote PIT tag antennas in the strait between the west and east lobes of the lake.

Introduction

Lost River suckers (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*) are federally endangered catostomids endemic to the Upper Klamath Basin of southern Oregon and northern California. Both species are long-lived; Terwilliger and others (2010) reported a Lost River sucker aged at more than 50 years old and Scoppettone and Vinyard (1991) reported shortnose suckers as old as 33 years. Historical accounts indicate that both species once were extremely abundant throughout the Upper Klamath Basin and were harvested in both a Native American subsistence fishery and a recreational snag fishery (Cope, 1884; Gilbert, 1898; Golden, 1969; Rasmussen, 2011). Evidence for decreasing population sizes and range reductions were noted as early as the mid-1960s, but the extent of the problem was not evident until the mid-1980s when recreational catch rates decreased substantially (Bienz and Ziller, 1987; Cooperman and Markle, 2003; National Research Council, 2004). The recreational snag fishery was closed in 1987, and in 1988 both species were listed as endangered by the U.S. Fish and Wildlife Service under the Endangered Species Act (USFWS, 1988).

Although the populations of Lost River and shortnose suckers in Upper Klamath Lake, Oregon, have received the most research attention, Clear Lake Reservoir in Modoc County, California (hereafter, Clear Lake) supports self-sustaining populations of each species that have been identified as critical to recovery efforts (USFWS, 2012). The life history, spawning biology, and status of Lost River and shortnose sucker populations in Upper Klamath Lake are reasonably well studied (Buettner and Scoppettone, 1990; Scoppettone and Vinyard, 1991; Perkins and others, 2000b; Cooperman and Markle, 2003; Janney and others, 2008; Hewitt and others, 2012). In contrast, the populations in Clear Lake are less well studied. Data collected by Andreasen (1975) and Koch and others (1975) more than 35 years ago indicated that the populations were in decline. In contrast, research in the last 20 years indicated that both species were abundant in Clear Lake and that the populations were characterized by diverse age structures (Buettner and Scoppettone, 1991; Scoppettone and others, 1995; USFWS, 2002).

In collaboration with the Bureau of Reclamation, the U.S. Geological Survey began a long-term study at Clear Lake in fall 2004 to monitor sucker spawning migrations and to assess the feasibility of estimating survival and related parameters with capture-recapture methods. The study consists of two types of sampling: (1) trammel net sampling in the fall to capture and tag adult suckers with passive integrated transponder (PIT) tags; and (2) sampling in the spring with remote underwater PIT tag antennas placed in Willow Creek to monitor the spawning migrations of tagged fish. In this report, we describe ongoing research efforts for endangered suckers in Clear Lake and summarize data from sampling that occurred from fall 2008 to spring 2010 in order to address four objectives: (1) describe the species composition of fall trammel net catches; (2) determine sex ratios for each population; (3) describe the timing of the spawning migrations for each species based on detections of PIT-tagged fish in Willow Creek; and (4) characterize the status of the populations to the extent possible based on the size composition of suckers captured in fall trammel net sampling.

Methods

Study Site

Clear Lake is part of the Lost River subbasin that spans the Oregon-California border (fig. 1). Clear Lake is a natural lake that was enlarged by the Bureau of Reclamation with a dam completed in 1910. The dam was built to control water flows in the Lost River and reduce flows into the reclaimed portions of Tule Lake. The reservoir also provides irrigation water for agricultural operations in the Lost River subbasin. Clear Lake has distinct east and west lobes that are connected in the north through a shallow strait with a narrow channel. Water is deeper in the west lobe (up to 4 m) than in the east lobe (less than 2 m), and the east lobe typically is low enough in the late summer and fall to make boat travel difficult. The spawning tributary for Lost River and shortnose suckers is Willow Creek, which enters the reservoir in the northeastern corner of the east lobe near Clear Lake Dam.

Fall Sampling, 2008 and 2009

Adult suckers were sampled in the west lobe of Clear Lake on 12 days between September 15 and October 2, 2008, and on 14 days between September 23 and October 15, 2009. Beginning between 0730 and 0900 hours on each day, each of two boat crews deployed four to six large trammel nets (net dimensions: 91.4 m long × 1.8 m deep; two 30.5-cm bar mesh outer panels and one 3.8-cm bar mesh inner panel). Locations for net sets were chosen to focus sampling effort along the shoreline in the southern one-half to two-thirds of the west lobe, where sucker catches are consistently highest. Nets were occasionally set in the northern part of the west lobe as well. Nets were set perpendicular to shore beginning as close to shore as possible; distance from shore for a given set was influenced to some extent by prevailing winds. The first set of nets was allowed to soak for about 2 hours before being retrieved, at which time captured suckers were removed from the nets and transferred to floating net pens. After all suckers were transferred to net pens, the nets were set a second time at new locations and the crews returned to process fish captured in the first sets. Overall, a sampling day resulted in 16–24 net sets, and we set a total of 264 and 297 nets in 2008 and 2009, respectively.

During processing, the species and sex of each sucker was determined based on external characteristics (Markle and others, 2005) and each fish was measured to the nearest millimeter fork length (FL). Suckers were scanned for the presence of a PIT tag and untagged fish were injected with a tag in the ventral abdominal musculature anterior to the pelvic girdle. We used tags operating at 125 kilohertz (kHz) prior to fall 2005, but all fish collected in 2005 through 2009 were tagged with 134 kHz full-duplex tags because of the improved read range of the higher frequency tags. Recaptured fish that had been previously tagged with 125 kHz tags were re-tagged with 134 kHz tags because the remote antennas in Willow Creek were only able to detect the higher frequency tags.

We compared length composition data from our fall 2008 and fall 2009 sampling with length composition data collected in previous years. A previous report included length composition data as far back as 1993 (Barry and others, 2009). In this report, we include data since 2004, following the demographic transition that apparently occurred in the late 1990s and early 2000s.

Spring Sampling, 2009 and 2010

The operation of remote PIT tag antennas in Willow Creek was incorporated into the study beginning in spring 2006, and these efforts were continued through spring 2010. As in previous years, antennas were installed in Willow Creek about 3 km upstream of where it enters Clear Lake. Six large rectangular antennas were placed in an upright, pass-through orientation and located end to end to cover the entire width of the channel (antenna dimensions: 3 m long × 0.75 m tall). Antennas were connected to a transceiver (Digital Angel model FS1001M) located on shore with water-tight cables. The transceiver recorded the date, time, and identification code of PIT-tagged suckers that swam through the antennas.

Antennas were installed on January 22, 2009, and on January 28, 2010, early enough to monitor the complete spawning migrations. Suckers that had been previously tagged with 134 kHz PIT tags were detected by the antennas as they ascended the creek, providing information about the timing of spawning runs. Because the timing of spawning runs appears to be controlled in part by water temperature, we installed temperature loggers in the middle of the water column at the antenna site to record water temperature at hourly intervals. We were not able to recover the temperature loggers in 2010, so we do not have data for that spawning season. In 2009, the last detection of a sucker was recorded on May 9, and the antennas were removed on May 29. In 2010, the last detection was recorded on June 13 and the antennas were removed on June 30.

Results

Catch Summary

We captured a total of 926 endangered suckers in fall 2008 and 2,531 in fall 2009 (table 1). The vast majority of suckers captured in 2008 and 2009 were shortnose suckers (73 percent in 2008; 86 percent in 2009). Lost River suckers made up about 11 percent of the catch in both years and the remainder of the catch was composed of Klamath largescale suckers (*Catostomus snyderi*) and suckers that could not be identified to species. We captured more suckers in 2009 than in any previous year, which we attribute in part to the low water levels in the west lobe that fall. Water surface elevation was nearly 0.6 m lower during sampling in fall 2009 than during sampling in any other year since 2006, and our impression is that the low water level concentrated fish.

For all species in all years since 2006, only a small percentage of captured suckers had been previously tagged (table 1). Shortnose suckers have consistently had the highest percentage of recaptures, and recaptures made up 6 percent of the shortnose sucker catch in both 2008 and 2009. No more than 1 percent of Lost River suckers had been recaptures prior to 2009, but 3.6 percent were recaptures in that year.

Detections Summary

The remote antennas in Willow Creek detected 146 PIT-tagged Lost River and shortnose suckers in spring 2009 and 286 PIT-tagged individuals in spring 2010 (table 2). The total number of individuals detected on the remote antennas in both years was similar to 2007 and was much lower than in 2006 or 2008, despite more fish being tagged (Barry and others, 2009). Although Willow Creek does not have a flow gage, snowpack in the watershed was minimal in both 2009 and 2010 and we observed that flows were low during both spawning seasons. The low flows in the spawning tributary explain the overall low number of fish detected by the remote antennas, a

pattern we have observed since 2006. An isolated precipitation event occurred in late April 2010, which apparently increased flows for a short time and led to a late pulse of migrating fish, particularly shortnose suckers (figs. 2 and 4).

Suckers PIT-tagged in 2005 continued to be detected in numbers comparable to fish tagged in later years (table 2). For example, the number of shortnose suckers from the 2005 tagging cohort that were detected in spring 2009 was nearly the same as the number of shortnose suckers detected from the 2007 and 2008 tagging cohorts. The only exception was shortnose sucker detections in 2010, which were dominated by fish newly tagged in the large catches during fall 2009 trammel net sampling. Lost River sucker detections are consistently low, but represent generally similar proportions of the tagging cohorts when compared to shortnose suckers. Although the detections in Willow Creek are strongly influenced by flows, the pattern of detections indicates that many PIT-tagged fish remain at large and a future year with high flows like 2008 could generate a substantial number of detections.

Lost River Suckers

Since our contemporary monitoring program began in fall 2004, we have PIT-tagged approximately 1,360 Lost River suckers. Although we have recaptured and re-tagged some of the fish tagged with 125 kHz PIT tags in 2004, about 160 fish from that cohort potentially remain at large with 125 kHz tags and can not be detected on the remote antennas in Willow Creek. In addition to the fish we have tagged since 2004, a substantial number of juveniles and adults were tagged with 125 kHz PIT tags in 1993–1996 and 2000. We suspect that few of those fish remain at large in the population, and we did not recapture any of them in our fall trammel net sampling between 2004 and 2009.

The sex ratio of Lost River suckers captured in fall trammel net sampling was skewed to females in 2008 and nearly even in 2009 (table 1). With the exception of 2006 and 2009, the sex ratio in trammel net sampling has been skewed to females (see also Barry and others, 2006). Although most of the PIT-tagged Lost River suckers are females, the detections on the remote antennas in Willow Creek tend to favor males (table 2).

The number of remote detections of Lost River suckers in Willow Creek was low in both 2009 and 2010. The seasonal pattern of detections in 2009 was similar to the pattern in earlier years, with most detections occurring in March (fig. 2). The water temperature records show that, similar to past years, detections in 2009 increased when water temperatures increased to greater than 6°C. In 2010, nearly all of the 28 Lost River suckers that were detected in Willow Creek migrated past the antennas with the short-term increase in flows that occurred in late April and early May.

In a previous report, we presented length composition data from trammel net catches dating back to 1993 (Barry and others, 2009). That data showed that the spawning population of Lost River suckers "turned over," transitioning from a relatively homogeneous population of larger, presumably older individuals to one comprised of smaller, presumably younger individuals. The transition occurred over a relatively short time frame between 1996 and the early 2000s, suggesting that the older individuals spawned the newer individuals not long before they died off. A similar transition occurred in the mid-1990s for the endangered sucker populations in Upper Klamath Lake (Janney and others, 2008). Whereas the changes in Upper Klamath Lake were due at least in part to extensive fish die-offs in 1995, 1996, and 1997 (Perkins and others, 2000a), no conclusions have been drawn about the cause(s) for the transition in Clear Lake. The updated series of length frequencies for Lost River suckers from Clear Lake

indicates that the new cohort of small individuals that were first captured in 2000 have remained the dominant cohort of spawners through 2009 (fig. 3). By 2009, the median FL of males was 504 mm and the median FL of females was 528 mm, still substantially smaller than the fish that were present in the mid-1990s (Barry and others, 2009). A large cohort of new individuals were apparent in our sampling in 2007, but the vast majority of these individuals apparently died in the last couple of years and are no longer a substantial part of the population. Lost River suckers do not grow fast enough in Clear Lake (Barry and others, 2009) to allow the smaller fish from 2007 to have grown into the dominant cohort of larger fish in 2008 and 2009.

Shortnose Suckers

We have PIT-tagged approximately 6,240 shortnose suckers since fall 2004. Although we have recaptured and re-tagged some of the fish tagged with 125 kHz PIT tags in 2004, about 330 fish from that cohort potentially remain at large with 125 kHz. In addition to the fish we have tagged since 2004, a substantial number of juveniles and adults were tagged with 125 kHz PIT tags in 1992–1996 and 2000. We suspect that few of those fish remain at large in the population, but we did recapture (and re-tag) 16 of them in our fall trammel net sampling between 2004 and 2009. Eight of those individuals were at large for 10 or more years before being recaptured. Four individuals were measured at between 100 and 150 mm in length when they were first PIT-tagged in 1995 and 1996, and had grown to be 310 to 430 mm FL by the time they were recaptured.

As in previous years, the sex ratio of shortnose suckers captured in fall trammel net sampling was strongly skewed to females in 2008 and 2009. Catches of female shortnose suckers have consistently been as much as two or three times the catches of males since 2004 (see also Barry and others, 2006). In contrast to results for Lost River suckers, sex ratios for the detections of shortnose suckers on the remote antennas in Willow Creek have reflected the sex ratio of the tagged population (table 2).

The number of remote detections of shortnose suckers in Willow Creek was low in 2009, but detections occurred through March and April as in past years (fig. 4). In 2010, few detections occurred during the low flows in March and April, but a surge in detections occurred in late April and early May, coinciding with the increased flows from an isolated precipitation event. More than one-half of the shortnose suckers detected in 2010 migrated past the antennas in the first 3 days of May. Similar to Lost River suckers and the data from previous years, detections in 2009 first occurred when water temperatures reached about 6°C.

Similar to Lost River suckers, the long-term series of length composition data showed that the shortnose sucker population in Clear Lake transitioned from a rather homogeneous population of large, old individuals to one comprised of small, young individuals between 1996 and the early 2000s (Barry and others, 2009). The updated series of length frequencies for shortnose suckers captured in fall trammel net sampling shows that the cohort of small fish present in 2004 has remained the dominant cohort through 2009 (fig. 5). By 2009, the median FL of males was 350 mm and the median FL of females was 375 mm, still somewhat smaller than the fish that were present in the mid-1990s (Barry and others, 2009). However, interpretation of length data for shortnose suckers is complicated by the selectivity of our trammel nets. Experience has shown that the effectiveness of our nets decreases for smaller fish approaching 300 mm FL. Because of their smaller size, a larger proportion of the shortnose sucker population coincides with the size range where trammel net effectiveness decreases, particularly if new individuals are recruiting to the population. As a cautionary example, we note the apparent

"bulges" on the left side of the length frequencies from fall 2009 sampling; the bulge is particularly obvious for females (fig. 5). For shortnose suckers, it is impossible to determine based on length data alone the extent to which new individuals are contributing to fall trammel net catches.

Discussion

Fall trammel net sampling has been an effective strategy for capturing and PIT-tagging Lost River and shortnose suckers in Clear Lake. Through 2009, we have tagged more than 1,300 Lost River suckers and more than 6,200 shortnose suckers. Although we are cautious about drawing inferences from raw catch rates, the consistent difference in catches between the two species indicates that the population of shortnose suckers is substantially larger than the population of Lost River suckers. Despite the large number of tagged fish at large in the populations, physical recaptures of previously tagged individuals of either species have been relatively uncommon in fall trammel net sampling. In contrast, we have collected large numbers of detections of suckers tagged with 134 kHz tags on the remote antennas in Willow Creek in years with adequate flows during the spawning season (for example, 2008). Flows in Willow Creek were low in both 2009 and 2010 and detections on the remote antennas were low in both years.

Based on the size composition of fish captured in fall trammel net sampling over time, we conclude that the Lost River sucker population probably has decreased in abundance from what it was in the early 2000s. Since 2000, we have not observed any substantial number of new individuals surviving to contribute to the spawning population. The new cohort of small fish that was seen in 2007 apparently died off for unknown reasons before many of the individuals reached 400 mm FL. As a result, recruitment of new spawners probably has not balanced natural mortality. For shortnose suckers, we are unable to infer population trends based on size composition data alone because it is impossible to disentangle recruitment of small fish from size selectivity of the trammel nets. The catch of small shortnose suckers in 2009, especially females, suggests that new individuals were recruiting to the population, but the magnitude of that recruitment is unknown. We note that our conclusion in Barry and others (2009) that shortnose suckers were experiencing an ongoing lack of recruitment, based on length data from trammel net sampling through fall 2007, was likely incorrect. Such issues of interpretation related to size composition data emphasize the benefits of a capture-recapture program that follows the histories of individual fish.

The main objective of our adult sucker research in Clear Lake has been to establish a capture-recapture program that can generate information on the status and dynamics of the sucker spawning populations, similar to that in Upper Klamath Lake (Janney and others, 2008; Hewitt and others, 2010, 2012). The primary impediment to inferences based on capture-recapture is that detection rates of PIT-tagged fish during spawning seasons with low flows in Willow Creek are much reduced compared to years when flows are higher. The poor detection rates are themselves a problem because they reduce the amount of data collected for capture-recapture, but they are even more troublesome because they indicate that a critical assumption of capture-recapture models is being violated—that each fish alive in the population has a chance of being reencountered in each sampling occasion. A key implication of this assumption violation is that any estimates of survival probabilities produced by the models will be negatively biased. However, relatively minor changes to the sampling program could lead to substantial gains in our ability to make inferences about population dynamics through capture-recapture.

The most straightforward solution to the detections issue would be to collect detection data during the spawning season somewhere outside of Willow Creek. The obvious location for an array would be the strait between the west and east lobes of the lake. We expect that nearly all suckers return to the west lobe at some point during the summer or fall because of the low water levels in the east lobe at those times. Thus, fish migrating to spawn would have to pass through the strait to access spawning habitat in Willow Creek. Furthermore, even in years with high flows in Willow Creek, fish that do not migrate upstream as far as the antennas in Willow Creek would have an opportunity to be detected during the spawning season. A radio telemetry study would be one way to confirm the seasonal movements of suckers and understand the likely success of such an approach. Results from radio telemetry could determine whether some fish skip spawning in some years and how far upstream fish migrate during a season in which they do spawn.

Another possible change would be to shift trammel net sampling to coincide with the spawning season, such that all sampling for a year occurs in one time period as it does for sucker monitoring in Upper Klamath Lake (Hewitt and others, 2012). Such a change would only benefit capture-recapture inferences if it allowed us to recapture substantially more previously tagged fish by targeting areas where they concentrate before, during, or after spawning. An additional benefit would be that sampling during the spawning season would make it easier to determine the sex of captured fish, particularly for shortnose suckers and Klamath largescale suckers, for which sex can be more difficult to ascertain. Nonetheless, sampling in Clear Lake in late winter and early spring can be especially challenging because of winter weather, road conditions, and the remoteness of the area. Indeed, these factors often create difficulties for installing the remote PIT tag antennas in Willow Creek early enough to be sure that we capture the entire time period of the sucker spawning migrations, which can begin in February. We suspect that shifting trammel net sampling to occur during the spawning season would not in itself provide sufficient data to support strong inferences from capture-recapture models.

Radio telemetry might also help explain the apparent discrepancy in sex ratios for Lost River suckers captured in fall trammel net sampling and those detected in Willow Creek during the spawning season. The sex ratio of Lost River suckers captured in fall trammel net sampling since 2004, with the exception of 2006 and 2009, has favored females, similar to catches for the river-spawning subpopulation of this species in Upper Klamath Lake (Hewitt and others, 2012). As a result, more females than males have been tagged with 134 kHz PIT tags. However, the sex ratio of Lost River suckers detected on antennas in Willow Creek, with the exception of 2010 when few fish were detected, has consistently favored males. This result contrasts with results for shortnose suckers, where catches and detections in both Upper Klamath Lake and Clear Lake are dominated by female fish. Possible explanations for the reduced detections of female Lost River suckers in Willow Creek include (1) lower detection probabilities compared to males; (2) lower survival compared to males; and (3) females skipping years between spawning events but males spawning every year.

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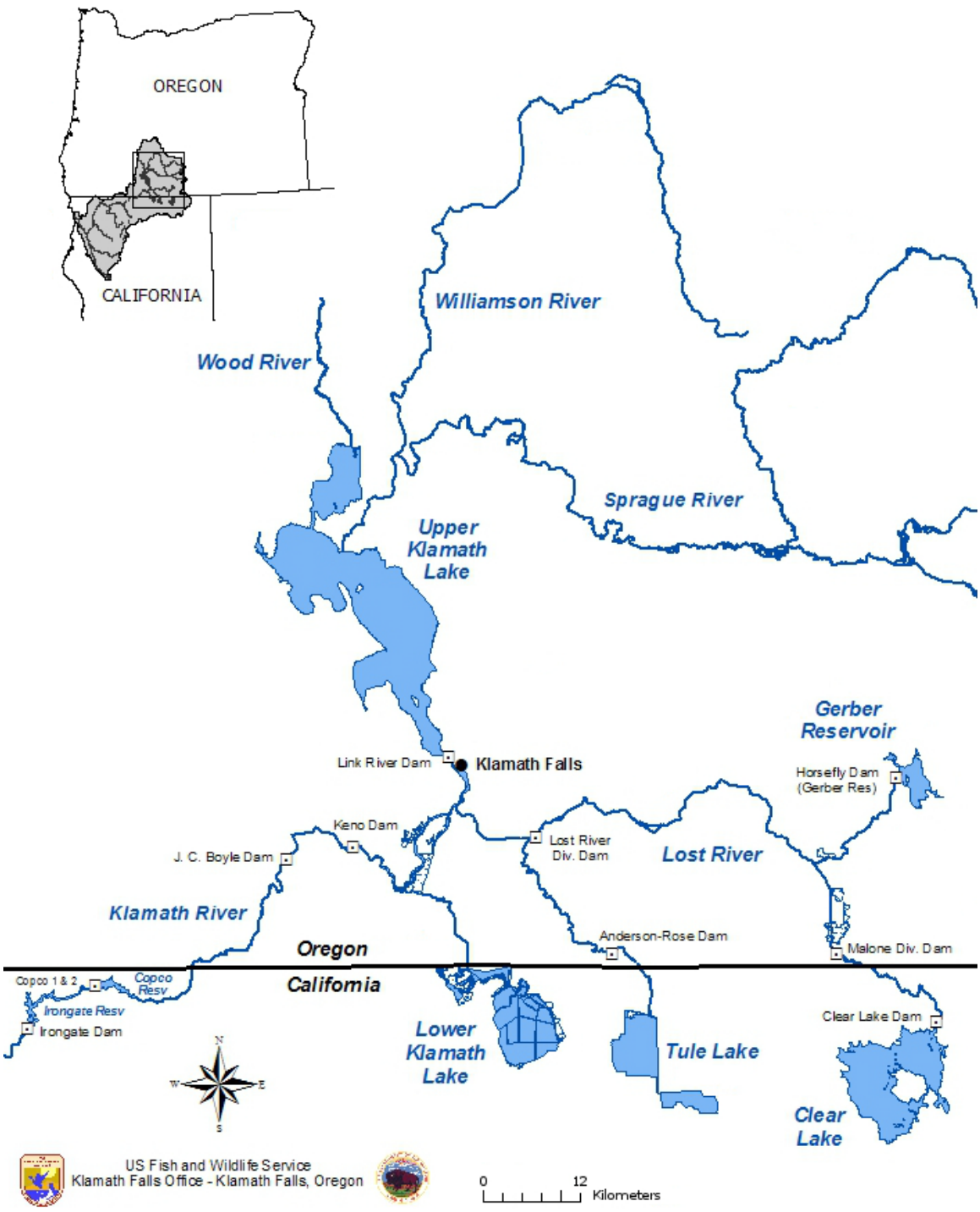

Figure 1. Map showing location of Clear Lake Reservoir (Clear Lake) in the Upper Klamath River Basin of southern Oregon and northern California. Willow Creek, the spawning tributary for Lost River and shortnose suckers, flows into Clear Lake from the east near the dam. Inset shows the area of the Klamath River watershed. Map modified and reprinted from National Marine Fisheries Service and U.S. Fish and Wildlife Service (2013), with permission.

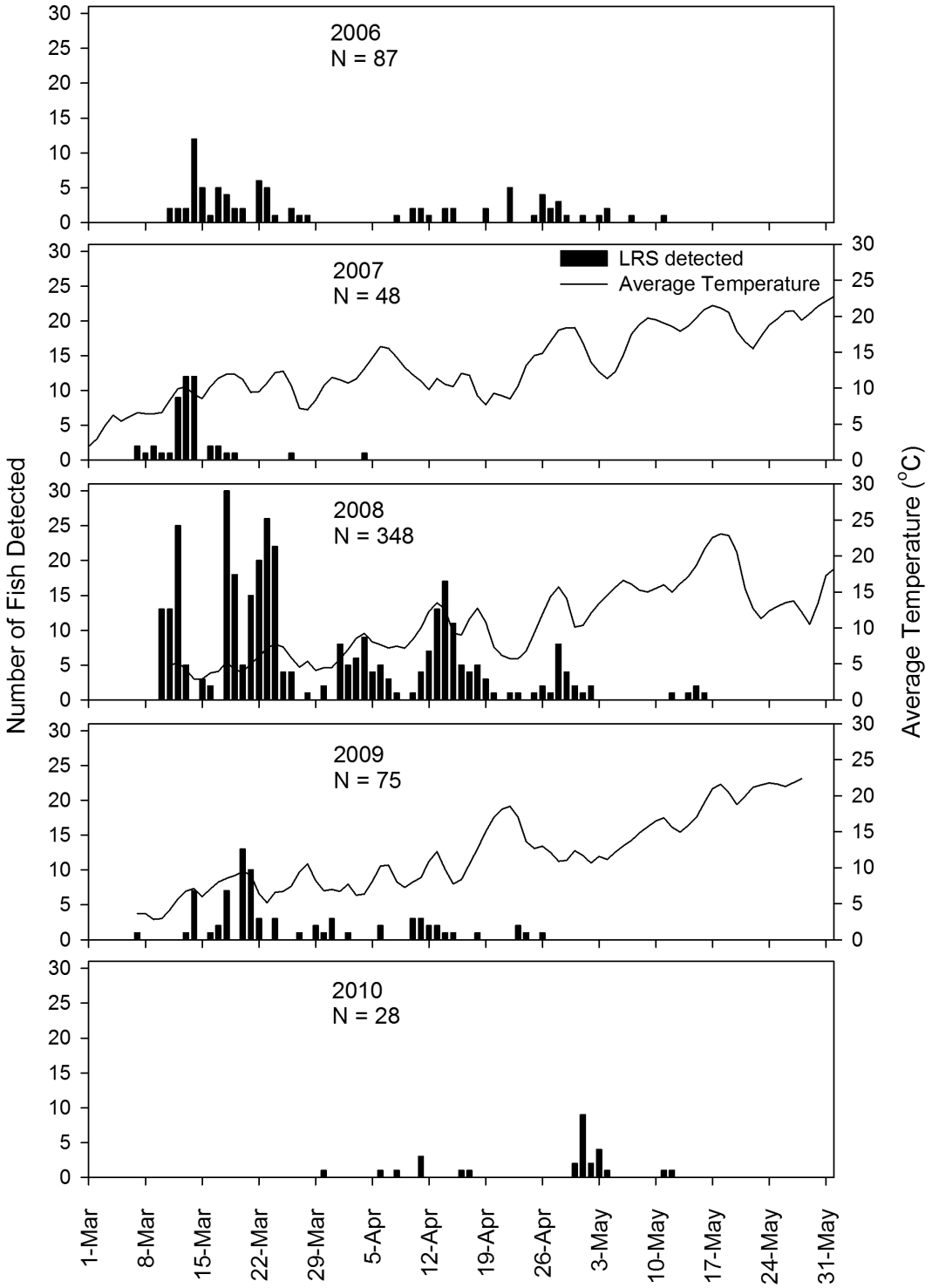

Figure 2. Detections of Lost River suckers on the remote passive integrated transponder (PIT) tag antennas in Willow Creek during the spring spawning seasons in 2006–2010. If an individual fish was detected more than once in a given season, only the first detection is included. Average daily water temperature (°C) was taken from in-stream loggers at the antenna site in 2007, 2008, and 2009.

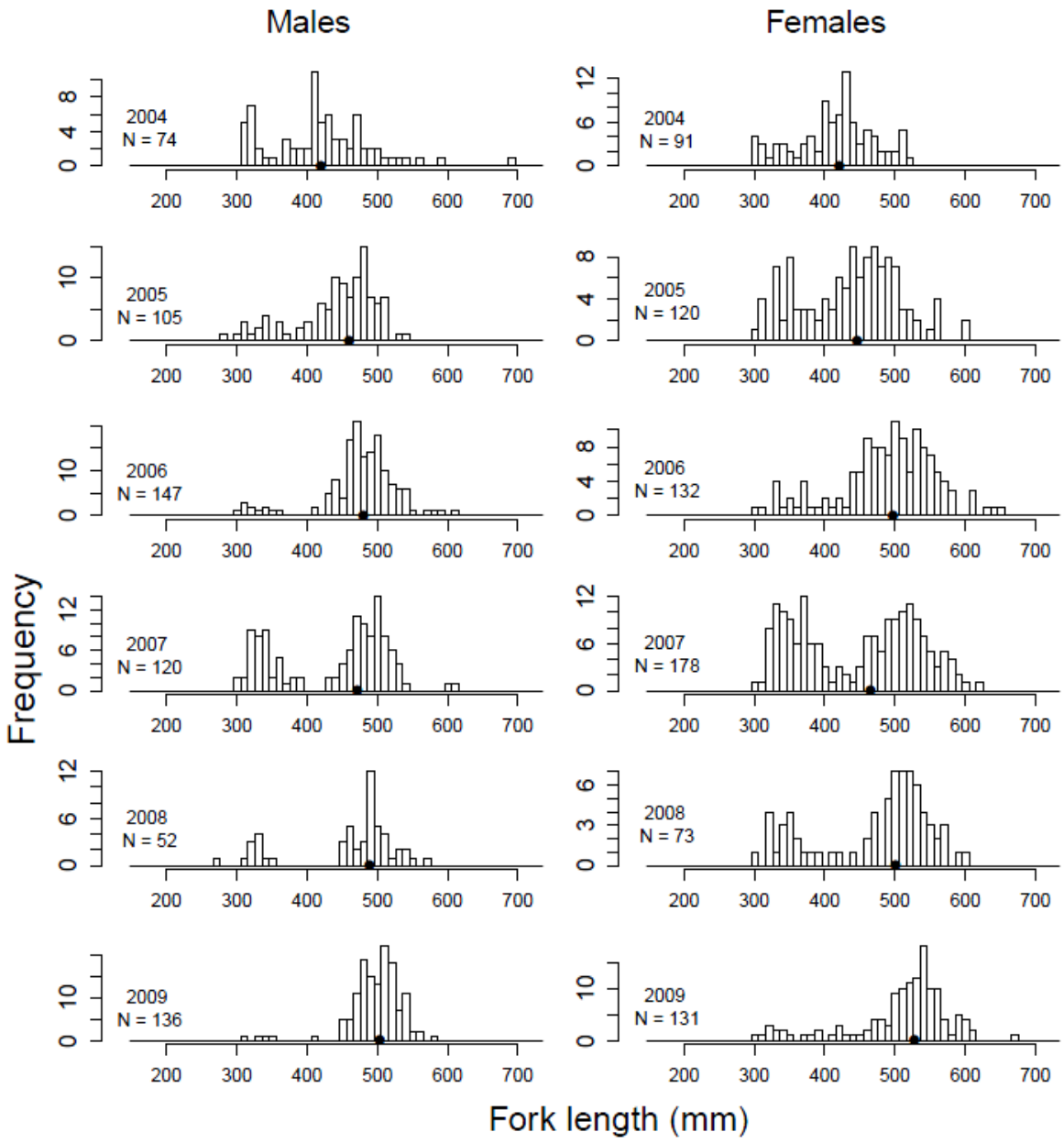

Figure 3. Length frequencies of male and female Lost River suckers captured with trammel nets in Clear Lake Reservoir during fall sampling, 2004–2009. Dots on the *x*-axis in each panel show the median fork length for fish collected in that year.

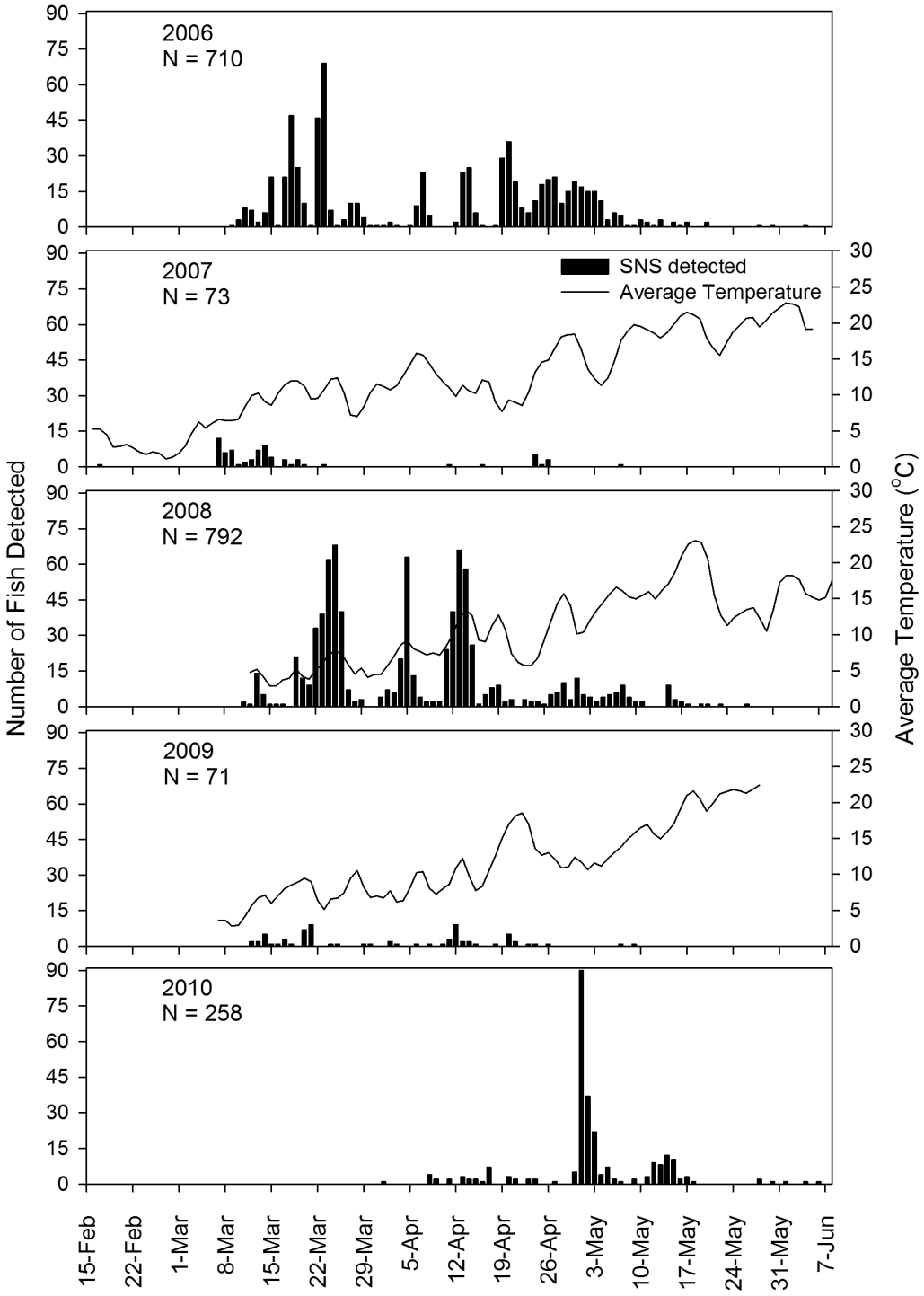

Figure 4. Detections of shortnose suckers on the remote passive integrated transponder (PIT) tag antennas in Willow Creek during the spring spawning seasons in 2006–2010. If an individual fish was detected more than once in a given season, only the first detection is included. Average daily water temperature (°C) was taken from in-stream loggers at the antenna site in 2007, 2008, and 2009.

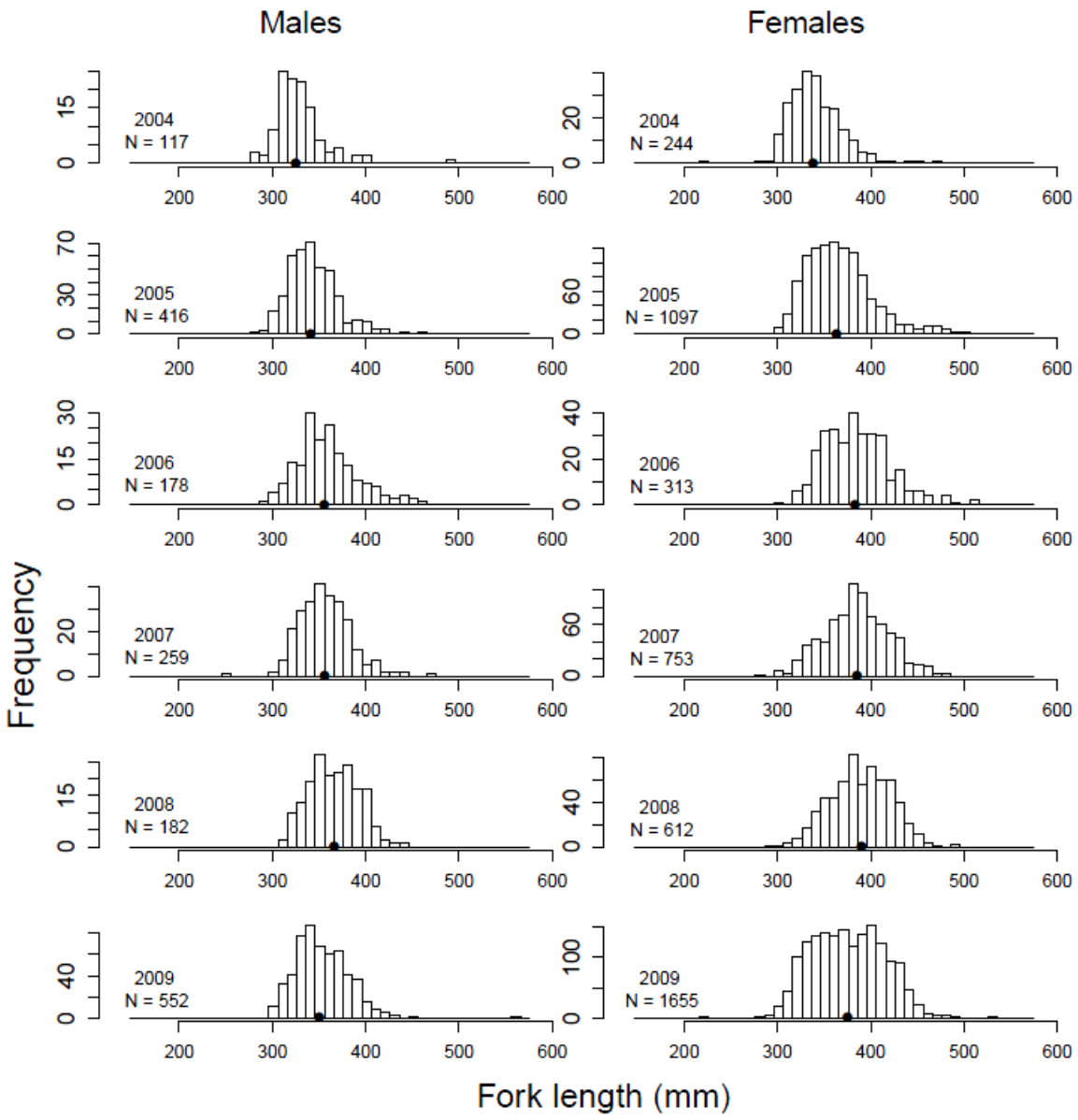

Figure 5. Length frequencies of male and female shortnose suckers captured with trammel nets in Clear Lake Reservoir during fall sampling, 2004–2009. Dots on the *x*-axis in each panel show the median fork length for fish collected in that year.

Table 1. Catches of Lost River and shortnose suckers in fall trammel net sampling in Clear Lake Reservoir, California, 2006–2009.

[Catches of Klamath largescale suckers and suckers that could not be identified to species are included for completeness. Individuals of unknown sex (Unk) were excluded from sex ratio calculations (male to female; ♂:♀). The numbers of captured individuals that were tagged in a previous year are given under the year in which they were recaptured. Recaptures are a subset of the catches in each year, and include fish tagged in any previous year with any tag type, but exclude within-year recaptures]

Year	Lost River suckers				Shortnose suckers				Klamath largescale suckers				Unidentified suckers			Total
	♂	♀	Unk	Sex ratio	♂	♀	Unk	Sex ratio	♂	♀	Unk	Sex ratio	♂	♀	Unk	
2006	148	131	9	1.13	173	318	99	0.54	67	90	22	0.74	11	14	3	1,085
Recaptures	0	1	0		2	15	2		0	2	0		0	3	0	
2007	120	175	3	0.69	254	744	6	0.34	97	193	3	0.50	12	45	1	1,653
Recaptures	0	2	0		6	37	3		0	2	1		4	17	0	
2008	52	73	0	0.71	182	616	3	0.30	37	97	0	0.38	4	24	2	1,090
Recaptures	1	0	0		10	36	1		0	2	0		1	14	0	
2009	136	132	7	1.03	556	1668	32	0.33	15	32	0	0.47	11	24	4	2,617
Recaptures	6	4	0		18	111	5		0	3	0		7	16	1	

Table 2. Number of Lost River and shortnose suckers PIT-tagged in fall trammel net sampling and the number of individuals detected on remote antennas in Willow Creek during spring spawning migrations, 2006–2010.

[Detections are shown by year of tagging (tag cohort). Individual fish can be included in detection counts in multiple years. Fish tagged in fall 2005 and fish detected in spring 2006 are included for completeness. Individuals tagged prior to fall 2005 with 125 kHz PIT tags could not be detected on the remote antennas in Willow Creek, and those fish are excluded from this summary unless they were recaptured and re-tagged with a 134 kHz PIT tag]

Tag cohort		Lost River suckers				Shortnose suckers			
	Year detected	♂	♀	Unk	Total	♂	♀	Unk	Total
2005		**105**	**116**	**1**	**222**	**411**	**1,076**	**25**	**1,512**
	2006	55	32	0	87	214	487	9	710
	2007	15	7	0	22	8	38	0	46
	2008	49	46	0	95	62	186	5	253
	2009	15	3	0	18	5	16	0	21
	2010	2	2	1	5	4	18	0	22
2006		**148**	**130**	**8**	**286**	**169**	**307**	**96**	**572**
	2007	22	4	0	26	12	10	5	27
	2008	79	45	4	128	42	93	34	169
	2009	15	9	2	26	2	12	0	14
	2010	2	1	0	3	3	4	2	9
2007		**120**	**174**	**3**	**297**	**249**	**708**	**4**	**961**
	2008	65	60	0	125	97	272	1	370
	2009	6	10	0	16	3	19	0	22
	2010	3	3	0	6	3	19	0	22
2008		**52**	**72**	**0**	**124**	**169**	**583**	**2**	**754**
	2009	8	7	-	15	4	10	0	14
	2010	0	0	-	0	6	24	0	30
2009		**130**	**128**	**7**	**265**	**538**	**1,555**	**27**	**2,120**
	2010	6	8	0	14	50	122	0	172

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