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Population Dynamics of Adult Lost River (*Deltistes luxatus*) and Shortnose (*Chasmistes brevirostris*) Suckers in Clear Lake Reservoir, California, 2006–08

Open-File Report 2009-1109

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

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By Patrick M. Barry, Eric C. Janney, David A. Hewitt, Brian S. Hayes, and Alta C. Scott

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Conversion Factors and Acronyms

Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
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.

Acronyms

FL fork length
PIT passive integrated transponder

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By Patrick M. Barry, Eric C. Janney, David A. Hewitt, Brian S. Hayes, and Alta C. Scott

Executive Summary

We report results from ongoing research into the population dynamics of endangered Lost River and shortnose suckers in Clear Lake Reservoir, California. Results are included for sampling that occurred from fall 2006 to spring 2008. We summarize catches and passive integrated transponder tagging efforts from trammel net sampling in fall 2006 and fall 2007, and report on detections of tagged suckers on remote antennas in the primary spawning tributary, Willow Creek, in spring 2007 and spring 2008.

Results from trammel net sampling were similar to previous years, although catches of suckers in fall 2006 were lower than in 2007 and past years. Lost River and shortnose suckers combined made up about 80 percent of the sucker catch in each year, and more than 2,000 new fish were tagged across the 2 years. Only a small number of the suckers captured in fall sampling were recaptures of previously tagged fish, reinforcing the importance of remote detections of fish for capture-recapture analysis. Detections of tagged suckers in Willow Creek were low in spring 2007, presumably because of low flows. Nonetheless, the proportions of tagged fish that were detected were reasonably high and capture-recapture analyses should be possible after another year of data collection.

Run timing for Lost River and shortnose suckers was well described by first detections of individuals by antennas in Willow Creek, although we may not have installed the antennas early enough in 2008 to monitor the earliest portion of the Lost River sucker migration. The duration and magnitude of the spawning runs for both species were influenced by flows and water temperature. Flows in Willow Creek were much higher in 2008 than in 2007, and far more detections were recorded in 2008 and the migrations were more protracted. In both years and for both species, migrations began in early March at water temperatures between 5 and 6°C and peaks were related to periods of increasing water temperature. The sex ratio of Lost River suckers detected in Willow Creek was skewed toward males, despite consistently more females having been tagged in fall sampling. This pattern indicates that some tagged female Lost River suckers may be spawning elsewhere in the system, and we intend to investigate this possibility to verify or alter the representativeness of our spring monitoring.

Length frequency analysis of fall trammel net catches showed that the populations of both species in Clear Lake Reservoir have undergone major demographic transitions during the last 15 years. In the mid-1990s, the populations were dominated by larger fish and showed little evidence of recent recruitment. These larger fish apparently disappeared in the late 1990s and early 2000s, and the populations are now dominated by fish that recruited into the adult populations in the late 1990s. The length frequencies from the last 4 years provide evidence of consistent recruitment into the Lost River sucker population, but provide no such evidence for the shortnose sucker population. Overall, annual growth rates for both species in Clear Lake were 2-4 times greater than growth rates for conspecifics in Upper Klamath Lake. However, little or no growth occurred for either species in Clear Lake between 2006 and 2007. Based on available evidence, we are unable to fully explain differences in growth rates between systems or among years within Clear Lake.

Introduction

Lost River suckers (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*) are endangered catostomids endemic to the Upper Klamath Basin of southern Oregon and northern California. Both species are long-lived; Scoppettone and Vinyard (1991) determined ages based on opercular bones and found Lost River suckers as old as 43 years and shortnose suckers as old as 33 years. Historical accounts indicate that both species once were extremely abundant throughout the Upper Klamath Basin and were taken in both a Native American subsistence fishery and a recreational snag fishery (Cope, 1884; Gilbert, 1898; Golden, 1969). 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 substantially decreased (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.

Although Upper Klamath Lake in Oregon probably supports the largest remaining populations of Lost River and shortnose suckers, Clear Lake Reservoir in California supports self-sustaining populations of each species that have been identified as refuge populations critical to recovery efforts (National Research Council, 2004). The life history, spawning biology, and status of Lost River and shortnose sucker populations in Upper Klamath Lake are reasonably well understood (Scoppettone and Vinyard, 1991; Cooperman and Markle, 2003; Janney and others, 2008), but the populations in Clear Lake Reservoir (hereafter, Clear Lake) have received far less research attention. 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; U.S. Fish and Wildlife Service, 2002).

In collaboration with the Bureau of Reclamation, the U.S. Geological Survey began a long-term tagging study at Clear Lake in fall 2005 to monitor the status of sucker spawning runs 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 by remote, underwater antennas placed in the primary spawning tributary, Willow Creek, to monitor the spawning migrations of tagged fish. Although PIT tagging has been conducted with suckers in Clear Lake by various researchers sporadically since the early 1990s, encounters with tagged suckers at the time of this report are too sparse to estimate survival and related parameters with capture-recapture models. After more encounters (either by recapture in nets or detection on remote antennas) accumulate in future years, parameter estimates will be compared with those from Upper Klamath Lake (Janney and others, 2008) to assess differences in population dynamics between the two systems. In this report, we describe ongoing research efforts for Lost River and shortnose suckers in Clear Lake and summarize data from sampling that occurred from fall 2006 to spring 2008 in order to address four objectives: (1) describe the species composition of fall trammel net catches; (2) determine sex ratios for each population based on fall sampling; (3) describe the timing of the spawning migrations for each species based on remote detections of PIT-tagged fish in Willow Creek; and (4) characterize the status of the populations based on the length composition of suckers captured in fall sampling.

Methods

Study Site

Clear Lake is located southeast of Upper Klamath Lake and forms 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 in 1910 to control water flow into the Lost River and to serve as an evaporation basin to reduce flows into Tule Lake, California. The reservoir also provides irrigation water for agricultural operations in the Lost River subbasin. The primary spawning tributary for Lost River and shortnose suckers is Willow Creek, which enters the reservoir in the northeast corner of the eastern lobe, just south of where the Lost River exits.

Fall Sampling, 2006 and 2007

Adult suckers were sampled in the western lobe of Clear Lake on 13 occasions between September 18 and October 6, 2006, and on 15 occasions between September 17 and October 11, 2007. Beginning between 08:30 and 10:00 hours (PST) at each sampling event, each of three or four boat crews deployed four large trammel nets at previously determined locations (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 trammel net sets were determined using a stratified random sampling design that placed the majority of sampling effort along the shoreline but included some sampling in open-water areas. Nets at nearshore locations were set perpendicular to shore, but the distance from shore for a given set was influenced by prevailing winds. The first four nets were 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 four nets were set a second time at new locations and the crews returned to process fish captured in the first sets. Overall, a sampling event usually resulted in 24 net sets among the three boat crews.

During processing, the gender and species of each sucker was determined based on external characteristics and each sucker 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 abdominal musculature. We used tags operating at 125 kHz prior to fall 2005, but all fish collected in 2006 and 2007 were tagged with 134 kHz full-duplex tags because of the improved read range of the higher frequency tags. Furthermore, recaptured fish that had been previously tagged with 125 kHz tags were re-tagged with 134 kHz tags because the remote antennas used in spring sampling on Willow Creek were able to detect only the higher frequency tags.

We compared length composition data from our fall 2006 and fall 2007 sampling with length composition data collected in previous years. We included data for Lost River and shortnose suckers from other researchers as far back as 1993, but only report data from fall trammel net sampling (July through November) that used methods similar to ours. We do not have information on trammel net mesh size for 1993-96, but comparisons of length frequencies combined across species indicated that the nets used in the various years captured fish over a similar size range. The area of the reservoir that was sampled also varied with time. Our sampling for 2004–07 focused entirely on the western lobe of the reservoir, but about one-half of the suckers captured in 1996 and almost all suckers captured in 2000 were from sampling in the eastern lobe of the reservoir (particularly locations near the dam and Willow Creek). Some of the suckers captured in 1993–94 were from sampling in the eastern lobe of the reservoir, the strait between the lobes, or unspecified locations. Nonetheless, despite some small sample sizes, comparisons of length frequencies divided by area of capture (eastern or western lobe) for 1993, 1994, 1996, and 2000 did not reveal geographic differences in size composition of the catches. Thus, we believe that comparisons among length frequencies between 1993 and 2007 provide a reasonable assessment of changes in size composition of Lost River and shortnose sucker populations in Clear Lake.

We calculated recent annual growth rates (fall to fall) for each sex of each species by tracking changes in the mean of the dominant modes in the length frequencies from 2004 to 2007. An average annual growth rate was calculated as the slope of a simple linear regression of the means in successive years. For years with multiple modes in the length frequency plot (Lost River suckers only), we separated the modes by assuming that the data were drawn from a mixture of two normal distributions and used maximum likelihood to determine the parameters of the component distributions. The analysis was performed using the package mixdist (see Macdonald and Green, 1988) in the R software environment (R Development Core Team, 2007).

Spring Sampling, 2007 and 2008

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 2008. 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). The antenna arrangement did not allow us to determine the direction of movement for fish that were detected. 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 February 15, 2007, and on March 10, 2008, in order to monitor the complete spawning migrations to the extent possible. Suckers that had been previously tagged with 134 kHz PIT tags were individually detected by the antennas as they ascended the creek. Remote detections of spawning fish provided additional encounters for use in capture-recapture models and also provided information about the timing of spawning runs. Because the timing of spawning runs appears to be controlled by water temperature, at least in part, we installed a HOBO Pro v2 Water Temperature Logger in the middle of the water column at the antenna site to record water temperature at hourly intervals. In 2007, the last detection of a sucker was recorded on May 7, and the antennas were removed on June 5. In 2008, the last detection was recorded on June 3 and the antennas were removed on June 17.

Results

Catch Summary

We captured a total of 881 Lost River and shortnose suckers in fall 2006 and 1,325 in fall 2007 (table 1). The total trammel net catch in 2006 was substantially lower than in 2005 or 2007 (2005 = 1,686; Barry and others, 2006). As in previous years, the two target species accounted for the vast majority of the total catch of suckers (81 percent in 2006 and 80 percent in 2007); the remainder of the catch was composed of Klamath largescale suckers (*Catostomus snyderi*) and suckers that could not be identified to species. Species composition also was similar to previous years, with shortnose suckers accounting for most of the catch (55 percent in 2006 and 62 percent in 2007). Lost River sucker catches were similar to those of Klamath largescale suckers in both years (about 20 percent each).

For all species in all years, only a small percentage of captured suckers had been previously tagged (table 1). The highest percentage of recaptures was for shortnose suckers (3–6 percent), and in both years only 1 percent of Lost River suckers were recaptures. Notably more recaptures of shortnose suckers occurred in 2007, but the increase from 2006 appears to be attributable to the increase in overall catches for that species in 2007. All Lost River and shortnose suckers that were not recaptures, as well as those captured with an old 125 kHz tag, were given a 134 kHz PIT tag (864 in 2006 and 1,268 in 2007).

Detections Summary

The remote antennas in Willow Creek detected 121 tagged Lost River and shortnose suckers in spring 2007 and 1,154 tagged individuals in spring 2008 (table 2). The total number of individuals detected on the remote antennas in 2007 was much lower than in 2006 or 2008 (2006 = 856; Barry and others, 2006). In 2008, suckers tagged in 2005 were still being detected in numbers comparable to fish tagged in later years. The overall percentage of tagged Lost River and shortnose suckers potentially at large (assuming no mortality of tagged fish since 2005) that were detected in Willow Creek was 5 percent in spring 2007 and 30 percent in spring 2008; the percentage for spring 2008 is similar to results from spring 2006.

Lost River Suckers

The sex ratio of Lost River suckers captured in fall trammel net sampling was skewed to males in 2006 and skewed to females in 2007 (table 1). The sex ratio skewed to females in 2007 is similar to results from other recent years (Barry and others, 2006). Although most tagged Lost River suckers are females, consistently more males are detected on the remote antennas in Willow Creek (table 2).

The number of remote detections of Lost River suckers in Willow Creek was low in 2007, but there appeared to be a single, well-defined peak in the migration in mid-March (fig. 2). The first detections occurred on March 8, well after the antennas were installed, indicating that the entire spawning run was monitored. Detections first occurred when water temperatures had increased to about 6°C and decreased once water temperatures exceeded 10°C.

The number of detections was much greater in 2008 and the spawning migration was far more protracted, with new detections occurring over a 2-month time period (fig. 2). In addition, a number of detections were recorded on the day that the antennas were installed (March 10), indicating that an early portion of the spawning run was not monitored. Water temperatures were about 5°C when the antennas were installed and detections stopped when water temperatures consistently exceeded 10°C. Five evident peaks in the migration appeared to be coupled to periods when water temperatures were increasing (fig. 2). However, because an early portion of the run was missed, first detections of early run fish that are returning downstream to the lake are mixed with first detections of fish beginning their migrations.

Length frequencies of Lost River suckers captured in fall trammel net sampling indicate that the vast majority of large adult fish present in 1993–96 had disappeared by 2000, and the remainder disappeared by 2004 (fig. 3). Whereas very few small fish were present in the population in the mid-1990s, the length frequency plot for 2000 shows the addition of a cohort of small fish, presumably due to recruitment. Between 2004 and 2007, this cohort continued to grow and small numbers of recruits appeared to be added to the population in each year. By 2007, the cohort of large fish, presumably now the adult spawners, had grown to about 500 mm FL, but was still 75–100 mm FL smaller than the cohort that was evident in sampling from 1993 to 1996. A particularly large cohort of small fish was captured in 2007.

The dominant group of male Lost River suckers grew about 17 mm FL per year between 2004 and 2007, and females grew about 29 mm FL per year. However, growth between 2006 and 2007 for both sexes was much reduced from the previous years and almost nonexistent, decreasing the overall growth rate. Average growth of males between 2004 and 2006 was 23 mm FL per year and average growth of females was 38 mm FL per year.

Shortnose Suckers

As in previous years, the sex ratio of shortnose suckers captured in fall trammel net sampling was strongly skewed to females in 2006 and 2007. Catches of female shortnose suckers have consistently been as much as double the catches of males since 2004 (Barry and others, 2006). Sex ratios for the detections of shortnose suckers on the remote antennas in Willow Creek have reflected the sex ratio of the tagged population more so than for Lost River suckers (table 2).

Similar to results for Lost River suckers, the number of remote detections of shortnose suckers in Willow Creek was low in 2007. The duration of the spawning run was short and occurred almost entirely in the first half of March (fig. 4). The first detections occurred on March 8, well after the antennas were installed, indicating that the entire spawning run was monitored. Detections first occurred when water temperatures had increased to about 6°C and decreased once water temperatures exceeded 10°C.

The number of detections was much greater in 2008 and the spawning migration was far more protracted, with new detections occurring over 2½ months (fig. 4). A few detections were recorded on the day that the antennas were installed (10 March), but it appears that most of the spawning run was monitored. Three primary peaks in migration occurred in late March and early and mid-April. Similar to Lost River suckers, the peaks appeared to be related to periods when water temperatures were increasing, and the vast majority of first detections occurred when water temperatures were greater than 5°C (fig. 4). In contrast to results for Lost River suckers, new detections continued into May when water temperatures were as high as 15°C. Some of these new detections may have been fish that had ascended the creek before the antennas were installed and were returning to the lake.

Similar to Lost River suckers, the length frequencies of shortnose suckers captured in fall trammel net sampling indicate that the population was composed of mostly large fish in 1993–96, and that this group of fish mostly disappeared by 2004 (fig. 5). In addition, recruitment of small fish is evident in the length frequency plots for 2000 and 2004, and this cohort dominated the population through 2007 and presumably makes up the current spawning stock. However, in contrast to Lost River suckers, sampling from 2005 to 2007 did not reveal evidence of further recruitment. Rather, the single dominant group of fish appears to be growing but new individuals are not being added, producing a current situation similar to what was observed in 1993–96. By 2007, most of this group had grown to between 350 and 400 mm FL (with females substantially larger than males), but still was somewhat smaller than the group observed in 1993–96.

The dominant group of male shortnose suckers grew about 10 mm FL per year between 2004 and 2007, and females grew about 15 mm FL per year. However, as with Lost River suckers, growth between 2006 and 2007 for both sexes was minimal. The mean size of males in 2007 actually was smaller than in 2006, and the mean sizes of females in 2006–07 were about the same. Limiting the regression to 2004–06 resulted in an average growth of males of 15 mm FL per year and an average growth of females of 22 mm FL per year.

Discussion

Trammel net sampling in Clear Lake during fall 2006 and fall 2007 was successful in capturing large numbers of Lost River and shortnose suckers. The species composition of the sucker catch in both years was similar to previous years and the two target species made up the vast majority of the catch (about 80 percent). Catches in 2006 were lower than in 2007 and previous years, and we speculate that sampling was less effective because the increased volume of water in the reservoir in 2006 caused fish to be more dispersed. Nonetheless, across both years, we were able to tag 586 new Lost River suckers and 1,546 new shortnose suckers that can contribute to future inferences based on capture-recapture models.

The numbers of tagged suckers physically recaptured in fall trammel net sampling were very low, despite more than 10,000 Lost River and shortnose suckers having been tagged in Clear Lake since 1993. Such low recapture rates are similar to our previous results for Clear Lake and Upper Klamath Lake (Janney and others, 2008). Remote detections of suckers tagged with 134 kHz PIT tags on the antennas in Willow Creek were much higher, reinforcing the value of this strategy for collecting information on tagged suckers. The number of individuals detected in 2007 was lower than in 2006 and 2008, apparently because spawning runs in 2007 decreased in magnitude and duration (lasting only about 2 weeks). Based on our experience with these species in Upper Klamath Lake (Janney and others, 2006), we presume that the low flows in Willow Creek during spring 2007 were a primary cause of the small, short spawning runs in that year.

In combination, the numbers of physical recaptures of tagged suckers in the fall and remote detections in the spring should be sufficient for capture-recapture modeling after another year of sampling, but some concerns about the application of these methods in Clear Lake remain. First, if low flows in Willow Creek substantially reduce spawning runs in some years and thus limit the number of detections we can obtain, we may need other approaches to obtain detections in those years. Second, it appears that our spring monitoring missed a portion of the Lost River sucker spawning run in 2006 and 2008. We make every effort to begin monitoring in Willow Creek as early as possible, but in some years weather and other logistical issues make it impossible to install the antennas early enough to capture the entire spawning migrations. Finally, we question whether spring monitoring in Willow Creek is sufficient as a source of encounters with spawning suckers. The sex ratio of Lost River suckers detected in Willow Creek has been consistently skewed towards males, despite far more females having been tagged in fall trammel net sampling. If female Lost River suckers are spawning elsewhere, we need to investigate other areas of the reservoir for spawning activity in order to improve the representativeness of our spring monitoring. The consistent evidence of recruitment in the length composition of Lost River suckers in recent years also indicates that spawning may be occurring elsewhere, given the relatively small number of individuals being detected in Willow Creek. Other possible explanations for the disproportionate lack of female detections 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. Some of these possibilities can be investigated through capture-recapture modeling after another year of sampling.

Detections by the antennas in Willow Creek provided information about run timing and the effects of flow and temperature on spawning run size and duration. For Lost River and shortnose suckers, the magnitude and duration of the spawning runs increased in years with higher flows, and peaks in the runs corresponded with periods of increasing water temperature. These results are similar to what we have observed in the Williamson and Sprague Rivers for sucker populations in Upper Klamath Lake, although suckers in Clear Lake initiate migration at colder water temperatures.

Length composition of the fall trammel net catches provided evidence that the Lost River and shortnose sucker populations in Clear Lake have undergone a major demographic shift over the last 15 years, similar to what we observed in Upper Klamath Lake (Janney and others, 2008). Both populations are now dominated by a cohort of fish that apparently were recruited into the adult population in the late 1990s. However, our sampling indicates that some recruitment has consistently occurred for Lost River suckers, and a particularly large number of smaller fish were observed in 2007. In contrast, we have observed little evidence of recruitment into the adult shortnose sucker population in recent years, and although "recruitment droughts" are common among western lakesuckers (Scoppettone and Vinyard, 1991), this pattern is of concern.

Based on length frequency analysis, annual growth rates for adult Lost River and shortnose suckers in Clear Lake are greater than those for the same species in Upper Klamath Lake (Janney and others, 2009). Growth rates of adult males of both species are 2-3 times faster in Clear Lake (LRS: 17-23 mm/yr vs. 8-10 mm/yr; SNS: 10-15 mm/yr vs. 5 mm/yr) and growth rates of adult females are 3-4 times faster (LRS: 29-38 mm/yr vs. 11-12 mm/yr; SNS: 15-22 mm/yr vs. 5 mm/yr). In particular, adult female Lost River suckers grew at exceptionally fast rates in Clear Lake between 2004 and 2006, averaging nearly 40 mm/yr. We are unable to explain the nearly complete lack of growth observed for both species in Clear Lake between fall 2006 and fall 2007. We suspect that the generally faster growth rates in Clear Lake are at least partly due to the populations in Clear Lake being younger, such that individuals are not as close to their asymptotic size. The cohorts that dominate Clear Lake populations recruited in the late 1990s whereas the cohorts that dominate the Upper Klamath Lake populations recruited in the early to middle 1990s (Janney and others, 2008).

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Table 1. Catches of Lost River and shortnose suckers in fall trammel net sampling, 2006–07.

[Catches of Klamath largescale suckers and suckers that could not be identified to species are included for completeness. Individuals of unknown gender were excluded from species-specific sex ratio calculations. 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			
	♂	♀	Unknown	Sex ratio (♂:♀)	♂	♀	Unknown	Sex ratio (♂:♀)	♂	♀	Unknown	Sex ratio (♂:♀)	♂	♀	Unknown	Total
2006	148	132	8	1.12	176	313	104	0.56	68	91	22	0.75	10	5	4	1,081
Recaptures	0	2	0		2	15	2		0	4	0		0	0	0	
2007	121	178	3	0.68	261	755	7	0.35	99	213	3	0.46	3	6	3	1,652
Recaptures	0	3	0		10	46	5		0	5	1		0	0	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, 2006–08.

[Detections are shown by year of tagging (tag cohort). 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 antennas in 2006 or 2007, and those fish are excluded from this summary unless they were recaptured and tagged with a 134 kHz tag]

Tag cohort	Year detected	Lost River suckers				Shortnose suckers			
		♂	♀	Unknown	Total	♂	♀	Unknown	Total
2005		105	120	1	226	415	1,095	17	1,527
	2006	55	32	0	87	216	500	5	721
	2007	15	7	0	22	8	39	0	47
	2008	49	46	0	95	65	192	4	261
2006		148	130	8	286	174	300	104	578
	2007	22	4	0	26	12	9	5	26
	2008	79	45	4	128	46	88	37	171
2007		121	176	3	300	253	711	4	968
	2008	65	60	0	125	100	274	0	374

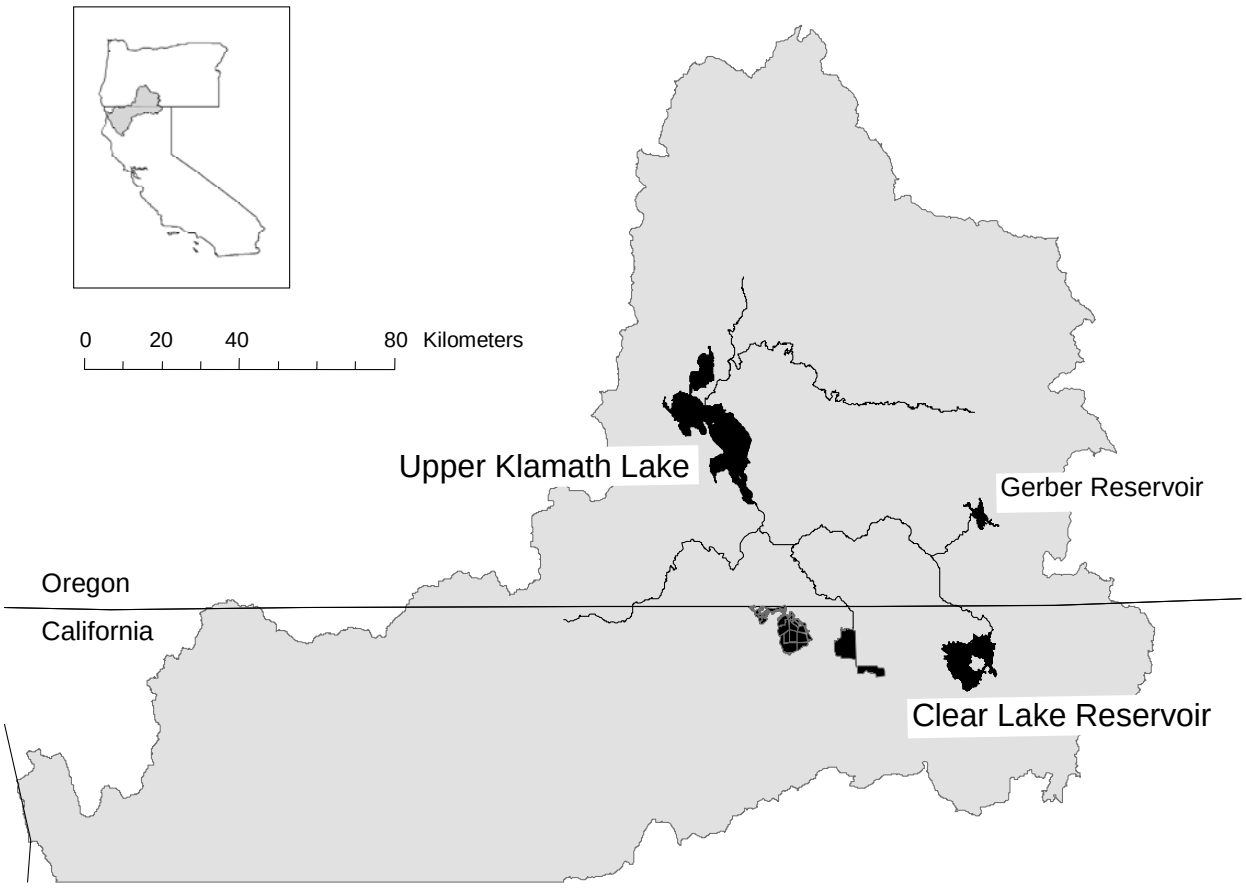

Figure 1. Map showing location of Clear Lake Reservoir in the Upper Klamath Basin, Oregon and California. Inset shows the entire Klamath River watershed.

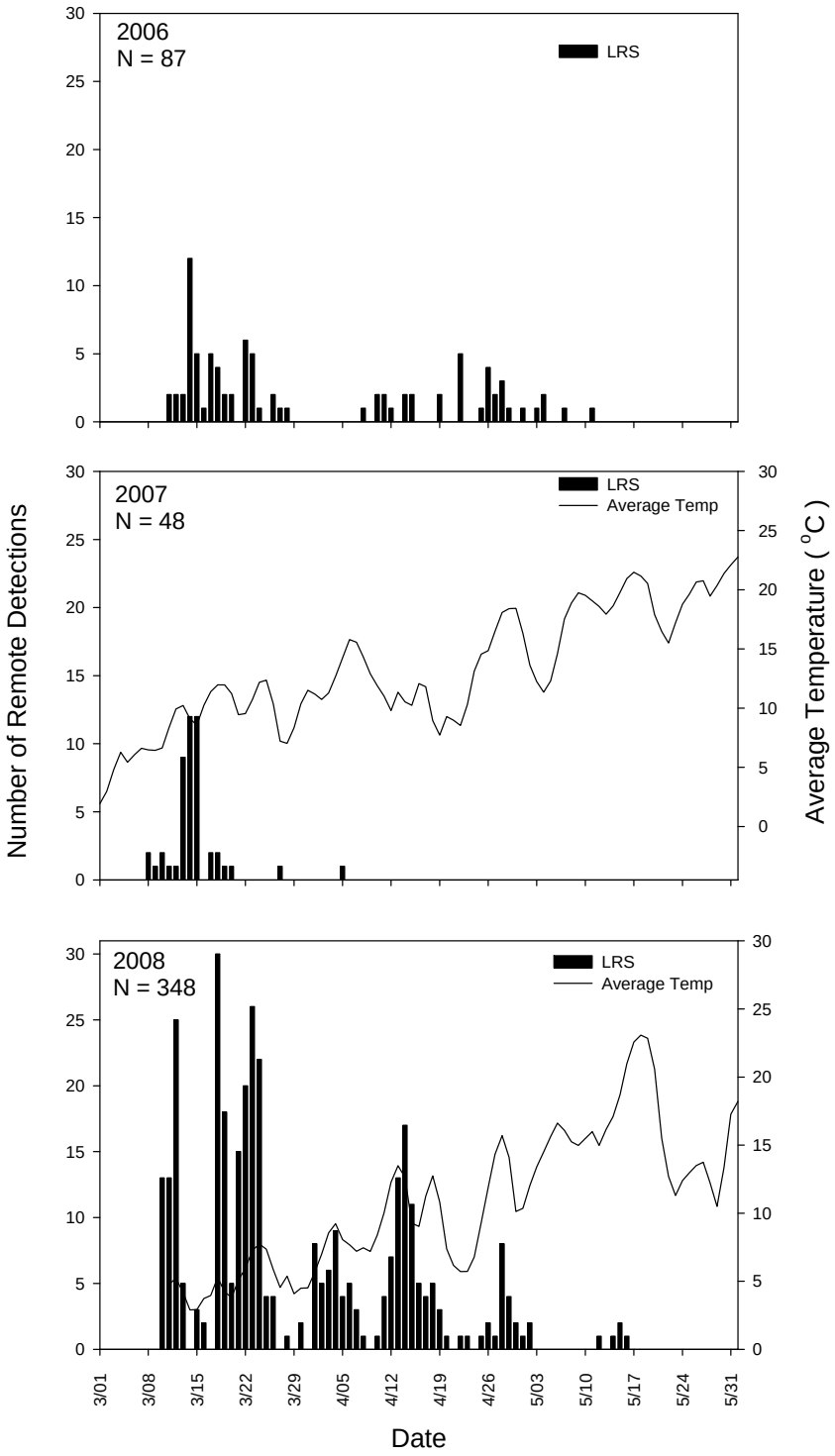

Figure 2. Summary of detections of individual Lost River suckers on remote antennas in Willow Creek during spring spawning migrations, 2006–08. Only the first detection of an individual in a given year is included. Water temperature was recorded at the antenna site in 2007–08.

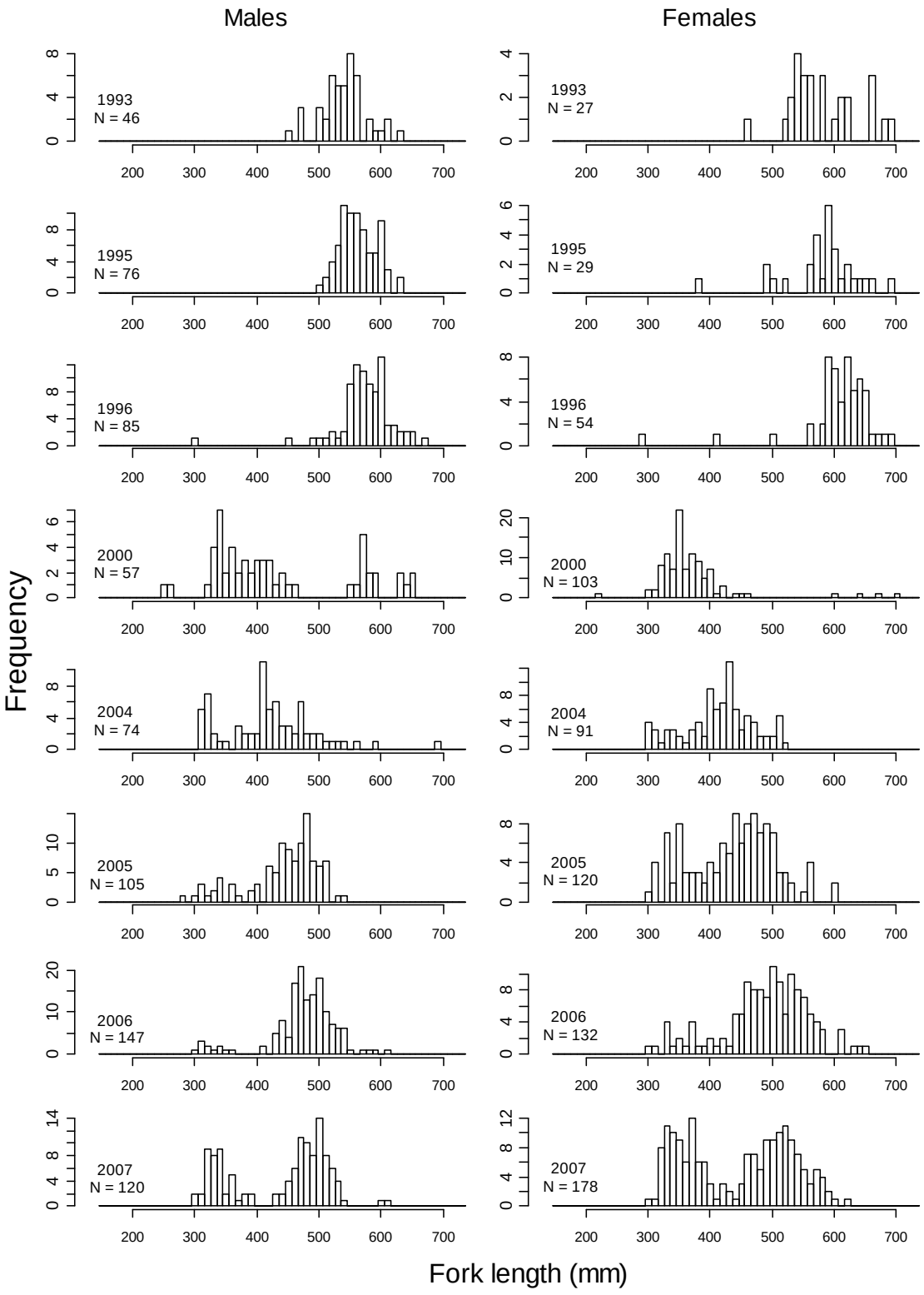

Figure 3. Length frequencies of male and female Lost River suckers captured in fall trammel net sampling, 1993–2007.

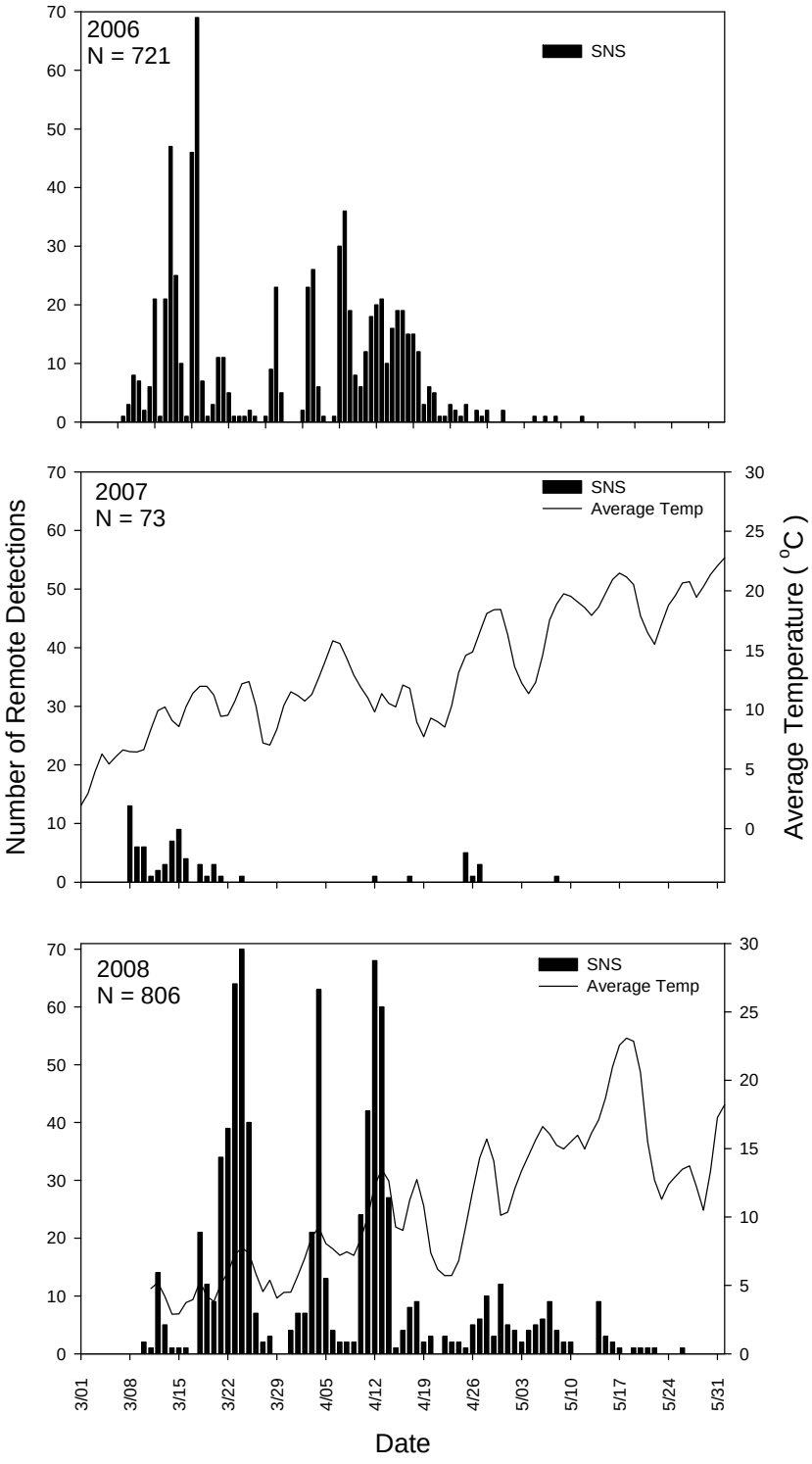

Figure 4. Summary of detections of individual shortnose suckers on remote antennas in Willow Creek during spring spawning migrations, 2006–08. Only the first detection of an individual in a given year is included. Water temperature was recorded at the antenna site in 2007–08.

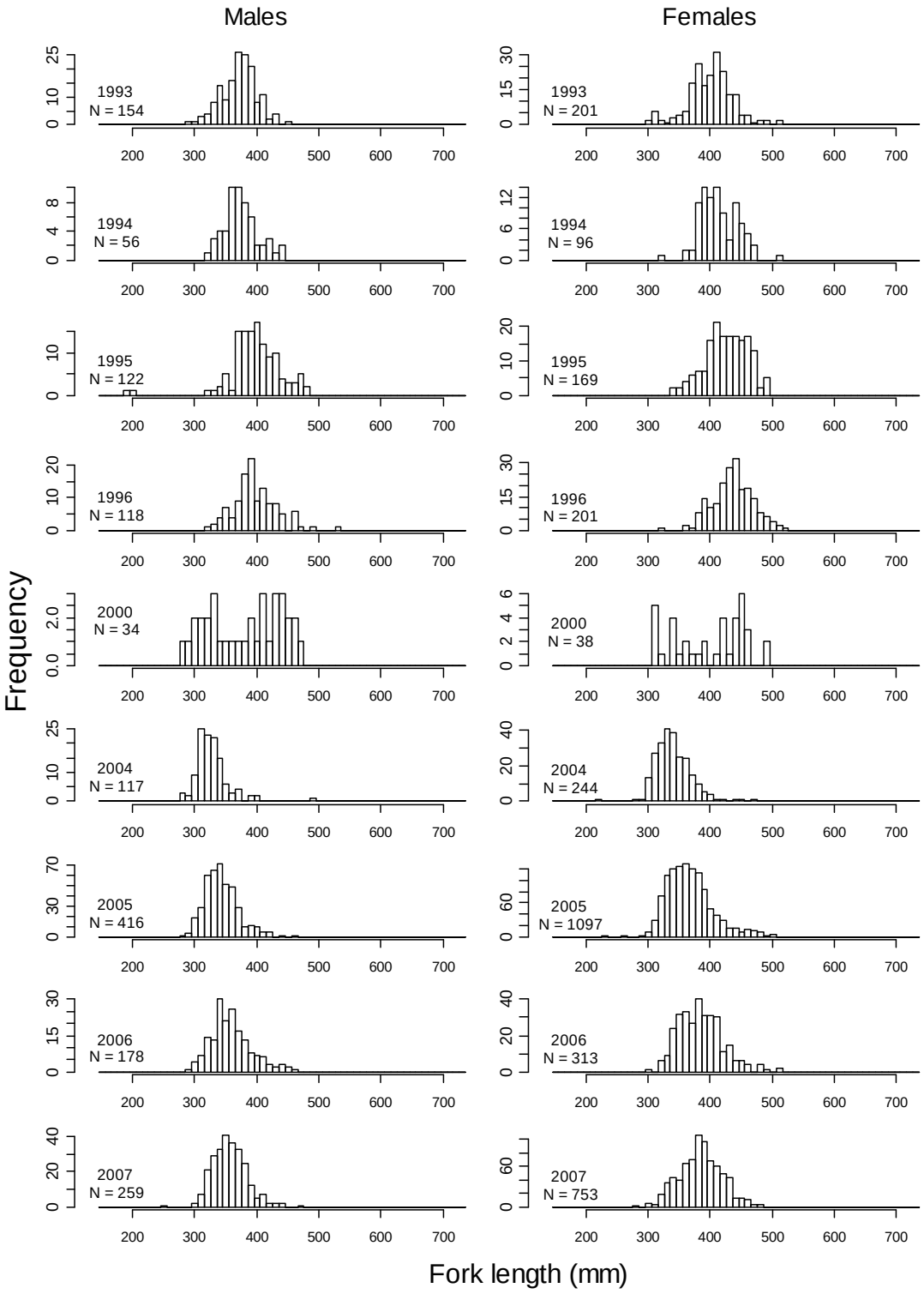

Figure 5. Length frequencies of male and female shortnose suckers captured in fall trammel net sampling, 1993–2007.

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