Spawning and Migration of Lost River Suckers (*Deltistes luxatus*) and Shortnose Suckers (*Chasmistes brevirostris*) in the Clear Lake Drainage, Modoc County, California.

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Abstract

A study of the reproductive biology of endangered Lost River and shortnose suckers in the Clear Lake watershed was conducted from 1993 to 1995. Radio telemetry was used to determine the timing of spawning migration and the duration spawners persisted in streams before returning to Clear Lake. Transmitters were implanted in six shortnose and six Lost River suckers in the fall of 1993, and 11 shortnose and nine Lost River suckers in the fall of 1994. Areas used for spawning by Lost River and shortnose suckers were located and characterized. The emigration of young-of-year suckers into Clear Lake was monitored 1993-95. In August 1995, upper sections of the Clear Lake watershed were visually surveyed with mask and snorkel for suckers and sites with fish were characterized.

Lost River suckers started spawning in Willow Creek between the first weeks of February and March. Water temperature and flow varied dramatically within and among the spawning seasons. Spawning appeared to begin when water temperature was 4-7 ^{o}C, and ended when water temperature was about 12 ^{o}C. Radio-tagged Lost River suckers migrated 3.7 - 5.5 km upstream and stayed in the river for up to 16.4 days. Spawning sites (N=3) had the characteristics that follow: water depth, 28-128 cm; current velocity, 0.01-0.84 m/s; and rocky substrate with 66-88% of particles greater than 1.25 cm in diameter. Back-calculation of spawning dates from larvae capture dates indicated that spawning by Lost River suckers lasted for up to seven weeks. Emigration of larvae began between the end of March and mid-April, and continued for up to 50 days. Juvenile Lost River suckers were never captured emigrating down Willow Creek.

Shortnose suckers started spawning in Willow Creek between the last weeks of February and March. Spawning appeared to begin when water temperature was 7-10 ^{o}C, and fish continued to spawn when water temperature was above 20 ^{o}C. Shortnose suckers were found 4.4 - 46.7 km upstream and radio-tagged fish stayed in the river for up to 42.9 days. Spawning sites (N=3) had the characteristics that follow: water depth, 21-84 cm; current velocity,0.66-1.20 m/s; and rocky substrate with 82-91% of particles greater than 1.25 cm in diameter. Back-calculation of spawning dates from larvae capture dates indicated that spawning lasted for up to 10 weeks. Emigration of larvae began between late March and late April, and continued for up to 96 days; later emigrants were juveniles.

The number of sucker emigrants varied considerably, both among years and between species within years. The estimated numbers of emigrants are as follows: Lost River suckers - 417,248 (1993) and 1,222,175 (1994); shortnose suckers - 12,439,581 (1993) and 11,733 (1994). In 1995 an estimated 2,594,282 suckers emigrated from Willow Creek to Clear Lake (the two species were not differentiated).

A large proportion of adult, radio-tagged suckers did not migrate up Willow Creek during the spawning seasons, even during the high-flow year of 1995. Possible explanations for this absence of migrants include: 1) Lost River and shortnose suckers in Clear Lake do not spawn every year due to energy limitations, 2) creek conditions were not attractive to many of the mature fish, 3) spawning occurred in places other than the Willow Creek drainage, and 4) fish behavior was influenced by the radio transmitter.

Preface

This project was originally planned to include Tule Lake and its main tributary, the Lost River. However, our initial results from Tule Lake indicated that only a few hundred adult suckers existed in the lake and that reproduction in the Lost River was minimal. Therefore, rather than expend a large amount of effort in the Tule Lake system for minimal anticipated data, we concentrated efforts on the Clear Lake system.

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Introduction

Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers are endemic to the upper Klamath Basin in south-central Oregon and north-central California. These species were federally listed as endangered in 1988 due in large part to a decline in the populations of Upper Klamath Lake, which at the time were considered the primary populations for both species (Federal Register 1988). Subsequent studies have found that Lost River and shortnose suckers in Clear Lake are more abundant than initially thought and probably represent a large proportion of the total remaining fish of each species (unpublished data). The shortnose suckers in Clear Lake are also valuable because they are genetically distinct from those in Upper Klamath Lake (Buth et al. 1996). Clear Lake is the origin of the Lost River which historically flowed into Tule Lake, but was also connected to the Klamath River during periods of high water in spring and summer (Gilbert 1897, Snyder 1907). In 1909, a dam was built at the outlet of Clear Lake to increase water storage and evaporation in order to dewater Tule Lake so that the lake bottom could be cultivated (Strantz 1953). Since the dam construction, the Lost River has become part of an intricate canal system that provides water to and receives runoff from agricultural lands.

Life history studies of Lost River and shortnose suckers in Upper Klamath Lake indicated that adults typically occupied lacustrine environments and migrated up tributaries in early spring to spawn, and young-of-year returned to the lacustrine environment within several weeks after hatching (Buettner and Scoppettone 1990, Scoppettone and Vinyard 1991). Deviations from this life history pattern have also been observed, including spawning by Lost River and shortnose suckers in springs along the shore of Upper Klamath Lake and the possible stream-residence by shortnose suckers in a headwater tributary of Clear Lake (Buettner and Scoppettone 1991). Only limited information exists about the life history of Lost River and shortnose suckers in Clear Lake.

The goal of this study was to learn more about the reproduction and stream habitat requirements of the sucker populations in Clear Lake. Specifically, the objectives were to 1) determine the timing of spawning by Lost River and shortnose suckers; 2) quantify stream conditions associated with sucker spawning including substrate characteristics, water depth, flow, and temperature; 3) determine the timing of emigration by young-of-year suckers into Clear Lake; and 4) quantify characteristics of stream habitat used by young-of-year suckers.

Methods

Study Site

Clear Lake is a shallow, turbid reservoir. Lake level is regulated by a dam at the outlet and the level can fluctuate more than 5 m annually. Surface areas typically varies from 7700 to 9700 ha and the average depth is usually 2-5 m dependent upon lake level. Surrounding areas are largely volcanic in origin, which contribute fine inorganic silts. Water temperature often exceeds 25^{o}C in late summer. Clear Lake's main tributary is Willow Creek, which is joined by Boles Creek 7.9 km upstream of the lake (Figure 1).

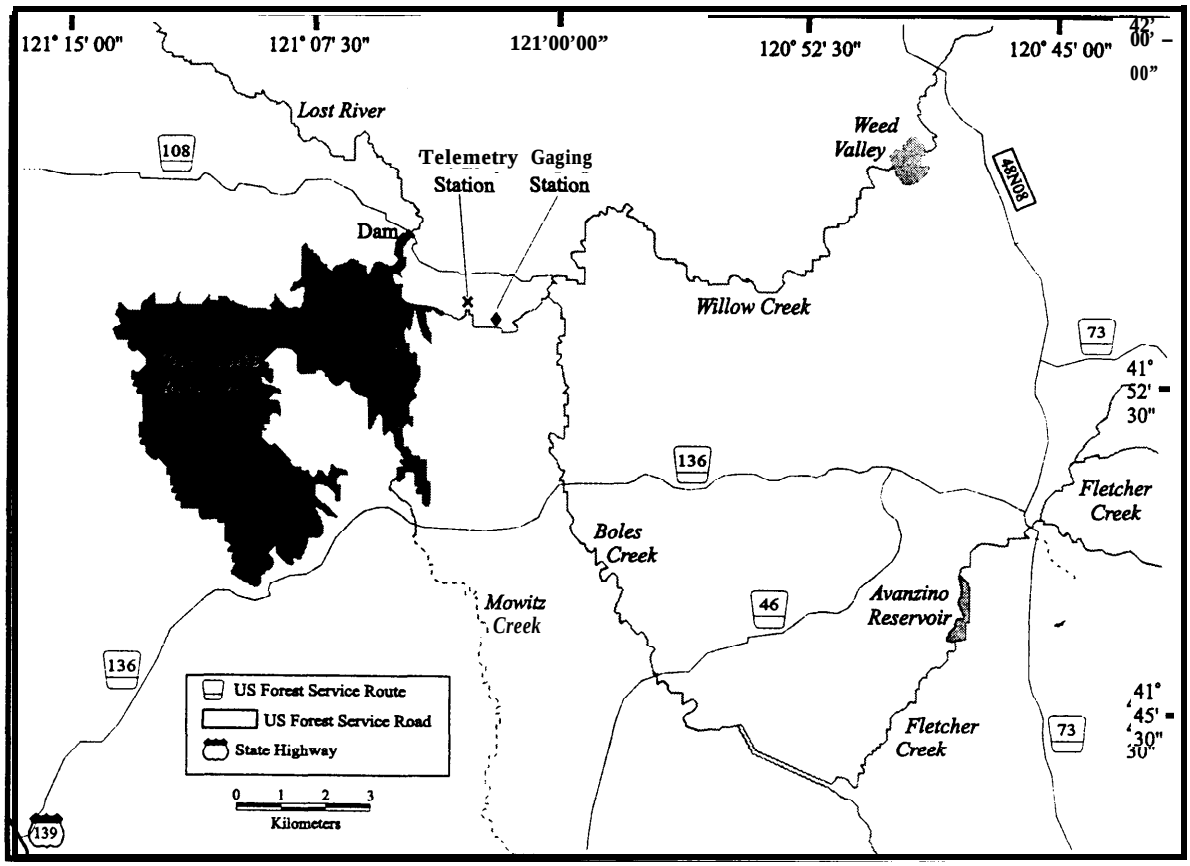

FIGURE 1. Map of Clear Lake Reservoir watershed, Modoc county, CA.

The lower sections of Willow and Boles creeks often become disjunct pools during summer months. Stream flows into Clear Lake are largely unregulated, but numerous small reservoirs and water diverted by the U.S. Forest Service to create wetlands have an unknown impact on the intensity and duration of stream flows.

Spawning Migration

Radio telemetry was used to determine the timing of spawning migration and the duration spawners persisted in streams before returning to Clear Lake. Transmitters were implanted in six shortnose and six Lost River suckers in the fall of 1993, and 11 shortnose and nine Lost River suckers in the fall of 1994 (Table 1). Two different transmitters were used dependent on fish size (FRT-2, 25.8 g and FRT-4, 16.3 g by Lotek Engineering, Inc. Aurora, Ontario).

Suckers that received transmitters were captured with trammel nets and seines and then held in the lake in mesh cages for 6-18 hours until the desired number were captured. Fish ranged from 403 - 695 mm fork length and 952-3698 g. They were anesthetized with MS-222 (75 mg/L) which immobilized Lost River suckers after six minutes and shortnose suckers after 7-10 minutes (ambient water temperature was 4-6^{o}C). After immobilization, fish were transferred to a container with a 25 mg/L-solution of MS-222 and held in a cradle that kept the fish's head underwater and the abdomen out of water. The incision area was scrubbed with betadine and removed of scales. A 5-cm longitudinal incision was made with a scalpel along the abdomen, posterior to the pectoral fins and offset from the ventral midline. A hollow, stainless steel needle (18 cm long, 1.5 mm diameter) was inserted through the incision and pushed out of the body cavity 8 cm posterior to the incision. The transmitter's whip antenna was threaded through the needle and out the body cavity, after which the needle was removed. The emergent antenna was then pulled as the transmitter was inserted in the body cavity and moved posteriorly such that the transmitter would not put pressure on the incision once sutured. A polydioxanone monofilament (PDS) with a curved needle (3.0 metric, taper CT-2) was used to close the incision with 2-4 sutures. Penicillin G was injected in the incision and the musculature below the dorsal fin. Surgical procedures for each fish were completed in 9-15 minutes. All surgical equipment was boiled prior to use and then held in absolute alcohol. After surgery, fish were put back in mesh cages and held 18-36 hours for observation before release.

Aerial surveys of Clear Lake and the upstream watershed were conducted about once per week from mid-January through the end of April to locate fish with transmitters. When a radio signal was received, the pilot would circle the area while the signal strengths of the right and left antennae of the receiver were compared and the signal position marked on a map. When aerial surveys located fish in the Willow Creek system, we tried to pinpoint the instream location of the fish by ground tracking.

An automated telemetry receiving station was positioned 1.2 km upstream of the mouth of Willow Creek and monitored fish movement continually from 23 February to 25 April 1995 (Figure 1). A Lotek SRX 400 receiver and two directional Yagi antennas were positioned on a cliff 10 m above the creek. One antenna pointed downstream and the other upstream. The receiver was programmed to scan through all transmitter frequencies on one antenna and then switch to the other antenna and scan all frequencies. The

TABLE 1. Lost River and shortnose suckers in Clear Lake that were implanted with radio transmitters.

Fish'	Fork Length (mm)	Weight (g)	Transmitter frequency	Date tagged
LRF	689	4493	164.665	11/03/93
LRF	610	3028	164.465	11/03/93
LRF	559	2372	164.564	11/03/93
LRF	635	---	164.475	12/08/93
LRM	558	2406	164.615	11/03/93
LRM	508	---	164.523	12/08/93
SNF	422	—	164.685	12/08/93
SNF	447	- -	164.643	12/08/93
SNF	447	---	164.425	12/09/93
SNF	448	---	164.445	12/09/93
SNF	391	---	164.487	12/09/93
SNM	435	---	164.636	12/08/93
LRF	635	2913	165.265	11/09/94
LRF	—	---	165.005	11/09/94
LRF	593	2269	165.3 14	11/09/94
LRF	695	3698	165.274	11/09/94
LRF	554	1941	165.104	11/10/94
LRF	625	2771	165.215	11/10/94
LRM	565	2140	165.225	11/09/94
LRM	---	---	165.205	11/09/94
LRM	554	2295	165.304	11/09/94
SNF	458	1501	165.065	11/07/94
SNF	421	1033	165.035	11/07/94
SNF	463	1389	165.074	11/07/94
SNF	476	1538	165.015	11/09/94
SNF	447	1417	165.114	11/09/94
SNF	442	1282	165.125	11/09/94
SNF	442	1301	165.025	11/10/94
SNF	423	1169	165.045	11/10/94
SNM	422	1132	165.054	11/09/94
SNM	430	1153	165.134	11/09/94
SNM	403	952	165.145	11/10/94
LRF	595	2507	165.195	10/17/95
LRF	691	3250	165.234	10/17/95
LRF	565	1965	165.274	10/17/95
LRM	570	2356	165.164	10/17/95
LRM	570	2366	165.174	10/17/95
LRM	584	2538	165.184	10/17/95
LRM	557	2070	165.244	10/17/95
LRM	634	3161	165.254	10/17/95
LRM	568	2306	165.285	10/17/95
SNF	414	1149	165.085	10/17/95
SNM	429	1119	165.094	10/17/95

'The first two letters indicate species (LR = Lost River, SN = shortnose) and the third letter indicates gender (M = male; F = female).

receiver recorded transmitter frequency, signal strength, and the antenna through which the signal was received. Cycling through all frequencies took 2-3 minutes per antenna. Data were downloaded from the receiver to a portable computer weekly.

Spawning dates were also estimated by back-calculating from the dates of larvae captures. Although formal studies have not been conducted, data from the Braymill Hatchery indicated that Lost River suckers incubated at a mean temperature of 14.4°C required an average of 135.7 thermal units (TU, i.e., temperature x days) to hatch and 278.4 TU to swim-up. Shortnose suckers incubated at 15.3 °C (mean) required 88.6 TU to hatch and 249.8 TU to swim-up (L. Dunsmoor, Klamath Tribes, Klamath Falls, OR, personal communication, 1996). These data were combined with larvae capture and temperature data for Willow Creek and used to back-calculate the time of spawning.

Location and Description of Spawning Sites

Areas used for spawning by Lost River and shortnose suckers were located by direct observation of spawning fish and collection of eggs in areas occupied by radio-tagged fish. Water depth and velocity were recorded at areas where spawning was observed or suspected (based on the presence of eggs). Velocity was recorded with a Marsh-McBirney Flo-Mate flow meter (model 2000). Substrate was characterized several months after spawning when water levels were low. At each spawning site, substrate was removed from several 0.5 m x 0.5 m areas to the depth at which interstices were filled with silt and sand. Substrate was measured by washing the material through a series of sieves (2.5, 1.25, 0.63, 0.17, and 0.0425 cm). Substrate larger than 2.5 cm was measured across the longest axis. The volume of each size class was measured by displacement of water in containers of known volume.

Water temperature in Willow Creek was measured hourly from 8 January 1995 to 8 August 1995 at the telemetry station with StowAway™ dataloggers (Onset Instruments). Turbidity was measured at the station with a DRT-15C portable turbidimeter (HF Scientific, Inc.).

Adult Fish Capture During the Spawning Period

In 1993 and 1994, trap and trammel nets were fished at the mouth of Willow Creek during the spawning season to capture migrating adults. In 1995, netting at the creek mouth was largely replaced by seining fish from spawning areas in the creeks of the Clear Lake watershed.

Emigration of Larvae and Juvenile

The emigration of larval and juvenile Lost River and shortnose suckers into Clear Lake was monitored in 1993, 1994, and 1995. Conical nets were used to collect fish as they drifted downstream. Each net was 2.5 m long, with a circular mouth 50 cm in diameter and 0.75-mm mesh. At the mouth of each net was a General Oceanics model 2030R mechanical flowmeter and at each end was a plastic canister with two 0.5-mm mesh windows. Nets were held in position by attachment to either stakes or a fixed line that spanned the stream. Sampling usually took place between 2000 and 0300 hours. Nets were set at 30-60 minute intervals; each set lasted 5-60 minutes dependent on larvae

abundance. Larvae were preserved in 10% formalin and later identified by myomere counts and pigmentation patterns (Buettner and Scoppettone 1990; D. Markle, Oregon State University, Corvallis, Oregon personal communication).

In 1993, sampling was conducted twice weekly (Tuesday and Thursday) from 13 April through 17 June and then weekly until 27 July. Sampling first occurred at a site about 1.5 km upstream of the mouth of Willow Creek, but was later moved upstream twice (6 May and 3 June) as the discharge of Willow Creek decreased. Most water flowing past these sites was naturally funneled through a channel 1.5-3.0 m wide and 1 m deep. In 1994, sampling was conducted at the uppermost 1993 site every other week from 27 March to 25 April. In 1995, sampling occurred every week from 12 April to 12 June. The sample site in 1995 (41^{o} 54.196', 121^{o} 03.057') was upstream of sites used in previous years, all of which were inundated by high lake level. The 1995 site was 15 m wide and 1.5 m deep.

To quantify total larvae emigration past the drift net sites, the mean number of larvae per unit volume of water screened by the nets was extrapolated to the entire creek discharge. Larvae were assumed to be uniformly distributed in the water column. In 1993 and 1994, discharge was estimated from monthly changes in the surface elevation of Clear Lake (lake levels and the water capacity at different levels were provided by the Bureau of Reclamation, Klamath Falls, OR). Willow Creek was assumed to contribute 90% of the total inflow. In 1995, discharge was measured at a gaging station 4.9 km upstream of Clear Lake.

Summer Occupation of Stream Habitat by Suckers

In August 1995, upper sections of the Clear Lake watershed were visually surveyed with mask and snorkel for suckers. Areas surveyed included: Boles Creek downstream of the road crossings of Routes 136 and 46, Willow Creek near the crossing of USFS road 48N70, Willow Creek downstream of the crossing of USFS road 48N08, and Fletcher Creek upstream of the crossing of USFS Route 73. When fish were observed, data were recorded for the parameters that follow: fish behavior, water depth, focal depth (i.e., at the location of the fish) , mean flow (i.e., at 60% total depth), focal flow, dissolved oxygen, temperature, and pH.

Results

Spawning migration

Fish capture at the mouth of Willow Creek was not successful in determining the time of spawning migration. In 1993, boat access to Willow Creek was not possible until late March because of ice cover. Once accessed, high flows severely affected fish capture because trap nets were continually rolled and twisted. No more than five Lost River suckers were captured near the mouth of Willow Creek in any single week. Less than 10 shortnose suckers were captured per week between 22 March and 17 May; however, a peak of 25 were captured the week of 12 April. In 1994, low water flow in Willow Creek did not appear to attract many spawners. As no suckers were caught near the creek mouth, trap netting was stopped in early April.

In 1994, five of six Lost River and all six shortnose suckers with radio transmitters were in the east lobe of Clear Lake throughout January, February, and March, but were never found close to the mouth of Willow Creek. The sixth Lost River sucker (female, 164.475 MHz) was found in Willow Creek 2.0 km upstream of Clear Lake on 2 March. On 9 March, this fish was 3.5 km further upstream, past the gaging station. On 16 March, the fish was back in Clear Lake.

In 1995, two of eight[1] Lost River and seven of 13[1] shortnose suckers with transmitters were recorded at the automated telemetry station on Willow Creek (Tables 2 and 3). Lost River suckers entered the creek in mid-February. One of the Lost River suckers remained near the telemetry station for 2.3 days and then returned to the lake. The other Lost River sucker migrated to a spawning site 3.7 km upstream and then returned to the lake on 7 March after 16.4 days in the creek. Shortnose suckers entered the creek between late February and early April, and remained in the river 0.3-42.9 days; the last fish left on 24 April. Three shortnose suckers did not move past the telemetry station and the other four migrated 4.4, 9.6, 12.9, and 13.2 km upstream.

In 1995, groups of spawning Lost River and shortnose suckers were observed on several occasions. On 13 March 1995, 12 Lost River suckers were observed spawning 3.8 km upstream of Clear Lake (Willow Creek site 2, Table 4). On 14 March a larger group of Lost River suckers was observed spawning 3.7 km upstream of Clear Lake and 21 were captured in a seine (Willow Creek site 1, Table 4). The next day, 12 additional Lost River suckers were captured from the same site. Also, eggs were collected from rocky substrate 15 m upstream of site 1 (Willow Creek site 1b, Table 4). Fish ranged from 530 - 724 mm fork length with a male to female ratio of 25:8. On 30 March shortnose suckers were observed spawning in Fletcher Creek and Bayley Creek (a tributary to Fletcher Creek). Both spawning sites were located 46.7 km upstream of Clear Lake where the creeks cross USFS Route 73 within 250 m of each other. An estimated 150 shortnose suckers were spawning at the Fletcher Creek site, 13 of which were captured. Fish captured were 350 - 422 mm fork length with a male to female ratio of 6:7; however, most fish were less than 350 mm and escaped through the 5-cm-mesh seine.

Back-calculation from the dates that recently-emerged larvae were captured provided the most detailed information about the start and end of spawning (Table 5). Lost River suckers started spawning between the first weeks of February and March, and ended in April. Shortnose suckers started spawning between the last weeks of February and March, and ended as late as the first week of June.

Water conditions during the period of upstream migration and spawning by Lost River and shortnose suckers varied considerably within and among years (Tables A1 and A2, Figures 2 and 3); however, some general associations were apparent. Both species usually entered Willow Creek immediately after or during a period of rising water temperature. Lost River suckers began migration when water temperature was 4-8 ^{o}C, whereas shortnose suckers typically began migration at 7-10 ^{o}C. Spawning by Lost River suckers ended when water temperature was about 12 ^{o}C, whereas shortnose suckers continued to spawn at temperatures above 20 ^{o}C.

[1] Although more fish had transmitters implanted, some fish were known or suspected to be dead.

TABLE 2. Lost River (LR) and shortnose (SN) suckers located by aerial and ground telemetry or recorded at the telemetry reception station on Willow Creek, 1.2 km upstream from Clear Lake, 1995. A series was defined as a group of consecutive records (transmitter receptions) which were separated by less than one hour. For telemetry station data, italicized dates indicate the reception was from the upstream antenna, otherwise the reception was from the downstream antenna. Comparison of antennae between the first and last record in a series often indicates the direction of fish movement.

				Summary		
Trasmitter frequency and fish'	Date of first record	Date of last record in series	Location \2	Entry to Willow Creek	Departure from Willow Creek	No. days in watershed
164.636	2/24 14:00	w-m	Willow Crk. 50 m downstream of flow gage	2/24 14:00	4/8 11:43	42.90
SNM	2/25 12:30	e-e	Willow Crk. 500 m upstream of flow gage			
	3/7 14:00	eee	Willow Crk 450 m upstream of flow gage			
	3/8 11:51	——	Willow Crk 300 m downstream of Site 1			
	3/8 15:00	-sw	fish could not be located			
	3/20 13:45	-em	Willow Crk. 400 m down&ream of Site 1			
	4/8 11:30	*4/8* 11:43	Telemetry station			
164.685	*3/28 20:14*	3/28 21:51	Telemetry station	3/28 20:14	3/28 21:51	*0.07*
SNF	*3/29 15:07*	3/29 15:51	Telemetry station	3/29 15:07	3/29 15:51	*0.03*
165.025	*3/27 19:53*	3/27 20:44	Telemetry station	3/27 19:53	3/27 20:44	*0.04*
SNF	*3/28* 19:00	3/28 21:16	Telemetry station	3/28 19:00	3/28 21:16	*0.09*
	3/30 11:46	*3/30 14:46*	Telemetry station	3/30 11:46	4/24 6:44	*24.79*
	4/5 13:oo	---	Boles Crk. (41° 52.023". 120° 59.702")			
	4/24 6:09	4/24 6:44	Telemetry station			
165.045	*2/28 12:45*	2/28 22:45	Telemetry station	2/28 12:45	2/28 22:45	*0.42*
SNF	*3/14 22:02*	*3/15 0:27*	Telemetry station	3/14 22:02	3/15 8:12	*0.42*
	3/15 7:29	3/15 8:12	Telemetry station	3/17 15:43	3/18 6:25	*0.61*
	3/17 15:43	*3/17 16:37*	Telemetry station	3/26 19:14	3/27 3:12	0.33
	3/18 3:42	3/18 6:25	Telemetry station	3/28 20:21	4/9 4:09	11.33
	3/26 19:14	3/27 3:12	Telemetry station			
	3/28 20:21	*3/28 21:42*	Telemetry station			
	4/5 11:45	---	Boles Crk. (41°51.895",120° 59.680")			
	4/9 3:43	4/9 4:09	Telemetry station			

TABLE 2. (continued).

165.074	2/24	4:17	2/24	6:08	Telemetry station	2/24	4:17	2/24 6:08	0.08
SNF	2/26	1:56	2/26	2:36	Telemetry station	2/26	1:56	2/27 9:15	1.30
	2/26	7:17	2/26	10:14	Telemetry station				
	2/26	15:23	2/26	18:40	Telemetry station				
	2/27	8:20	2/27	9:15	Telemetry station				
165.125	3/16	19:23	3/16	20:07	Telemetry station	3/16	19:23	3/23 4:02	6.36
SNF	3/20	11:50	---		Willow Crk. (41° 54.238", 121° 01.709"; moving upstream)	3/27	4:39	3/27 5:46	0.05
	3/20	14:01	---		Willow Crk. (41° 53.638", 121'02.135")	4/4	13:31	4/4 17:55	0.18
	3/21	6:11	3/23	4:02	Telemetry station	4/6	1:24	unknown	>5
	3/27	4:39	3/27	5:46	Telemetry station				
	4/4	13:31	4/4	17:55	Telemetry station				
	4/6	1:24	4/6	2:01	Telemetry station				
	4/11	0:00	—		Boles crk. (41° 53.745",120° 59.741")				
165.134	3/16	19:46	3/16	19:50	Telemetry station	3/16	19:46	unknown	
SNM	3/21	6:23	3/21	6:25	Telemetry station	3/21	6:23	unknown	
	3/22	20:27	3/23	1:07	Telemetry station	3/22	20:27	3/23 3:26	0.29
	3/23	3:18	3/23	3:26	Telemetry station	3/23	3:18	unknown	
	4/4	13:42	4/4	15:54	Telemetry station	4/4	13:42	unknown	
	4/6	1:38	4/6	1:41	Telemetry station	4/6	1:38	Unknown	
165.205	2/19	16:39	2/19	17:25	Telemetry station	2/19	16:39	2/21 23:22	2.28
LRM	2/19	22:16	2/19	22:21	Telemetry station				
	2/20	20:37	2/21	4:13	Telemetry station				
	2/21	20:14	2/21	23:22	Telemetry station				
165.274	2/14	17:51	2/15	10:37	Telemetry station	3/6	23:08	unknown	
LRF	2/17	15:25	2/17	16:30	Telemetry station	2/14	1751	2/15 10:37	0.70
	2/18	2:58	2/18	7:16	Telemetry station	2/17	15:25	2/18 7:16	0.66
	2/18	14:32	2/18	15:29	Telemetry station	2/18	14:32	3/7 0:02	16.40
	2/24	14:00	---		Willow Crk. Site 1				
	3/6	22:33	3/7	0:02	Telemetry station				
	3/7	10:00	---		Willow Crk.				
	3/7	15:00	—		Willow Crk. 300 m downstream of Site 1				

[1] The third letter in the fish abbreviation indicates gender (M=male, F=female

[2] Willow Creek Site 1 is 3.7 km upstream from Clear Lake

Willow Creek flow gage is 4.9 km upstream from Clear Lake

TABLE 3. Timing of adult Lost River and shortnose sucker movements in and out of Willow Creek, 1995. Entry and departure times of fish implanted with radio transmitters were recorded at a receiver station located 1.2 km upstream from the mouth of Willow Creek. Water temperature is the mean of values from two dataloggers located in a riffle upstream of the telemetry station. Water flow was recorded at a USGS gaging station located upstream of the telemetry station. A "+" and/or "-" after temperature and flow values indicate that the parameter was increasing and/or decreasing, respectively, during the previous seven days.

		Entry to Willow Creek			Departure from Willow Creek			
Transmitter frequency (MHz)	Fish*	Date and time	Water temperature (°C)	Water discharge (m^3/s)	Date and time	Water temperature (°C)	Water discharge (m^3/s)	No. days in creek
165.274	LRF	2/18 14:32	6.9 (+)	5.10 (-)	3/7 0:02	3.8 (-)	9.57 (+-)	16.40
165.205	LRM	2/19 16:39	4.7 (+)	5.58 (-)	2/21 23:22	7.2 (+)	7.65 (+-)	2.28
164.636	SNM	2/24 14:00	10 (+)	6.51 (+-)	4/8 11:43	5.7 (-)	32.85 (+)	42.90
165.074	SNF	2/26 1:56	8.6 (+)	5.58 (-)	2/27 9:15	7.7 (+-)	5.58 (-)	1.30
165.125	SNF	3/16 19:23 4/6 1:24	8.0 (+-) 10.1 (+-)	61.16 (+-) 10.19 (+-)	3/23 4:02 unknown	1.2 (-) unknown	31.43 (+-) unknown	6.36 unknown
165.045	SNF	3/28 20:21	8.0 (+)	34.83 (+-)	4/9 4:09	4.4 (-)	27.47 (+-)	11.33
165.025	SNF	3/30 11:46	7.5 (+)	17.27 (-)	4/24 6:44	11.5 (+)	7.25 (+-)	24.79

*The first two letters indicate species (LR = Lost River; SN = shortnose) and the third letter indicates gender (M = male; F = female).

TABLE 4. Characteristics of Lost River (LR) and shortnose (SN) sucker spawning sites in the Clear Lake watershed. Velocity is the average of the water column (i.e., either 60% depth or the average of measurements at 20% and 80% depth). Infill depth indicates the depth at which substrate became infilled and compacted with sediment. Mean values are reported for substrate size composition when more than one substrate sample was collected.

					Water			Substrate size (cm) composition (%)					
Site location	Latitude	Longitude	Size (m)	Species observed	Depth (cm)	Velocity (m/s)	Infill depth (cm)	> 10	2.6 - 10	1.26 - 2.5	0.64 - 1.25	0.18 - 0.63	0.0425 - 0.17
Willow Crk. 1	41° 53.735"	121° 02.467"	2x3	LR	28-80	0.01-0.13	9.7-14.9	24.6	39.9	18.4	12.6	4.5	—
Willow Crk. 1b*	41° 53.735"	121° 02.467"	9x12	LR	95-128	0.22-0.45	—	—	—	—	—	—	—
Willow Crk. 2	41° 53.700"	121° 02.431"	3x16	LR	47-77	0.40-0.84	2.74	14.8	24.0	27.3	16.0	17.8	—
Boles Crk.	41° 52.023"	120° 59.741"	3x10	SN	83-84	0.66-0.82	—	—	—	—	—	—	—
Fletcher Crk., crossing of RT 73	41° 49.160"	120° 45.619"	10x33	SN	21-25	0.83-1.19	—	—	—	—	—	—	—
Bayley Crk., crossing of RT 73	41° 49.072"	120° 45.763"	5x15	SN	41-60	0.84-1.20	4.9-11.2	58.2	21.7	5.8	4.7	5.9	3.7

*Substrate was visually determined to consist primarily of rocks 8-12 cm across the longest axis.

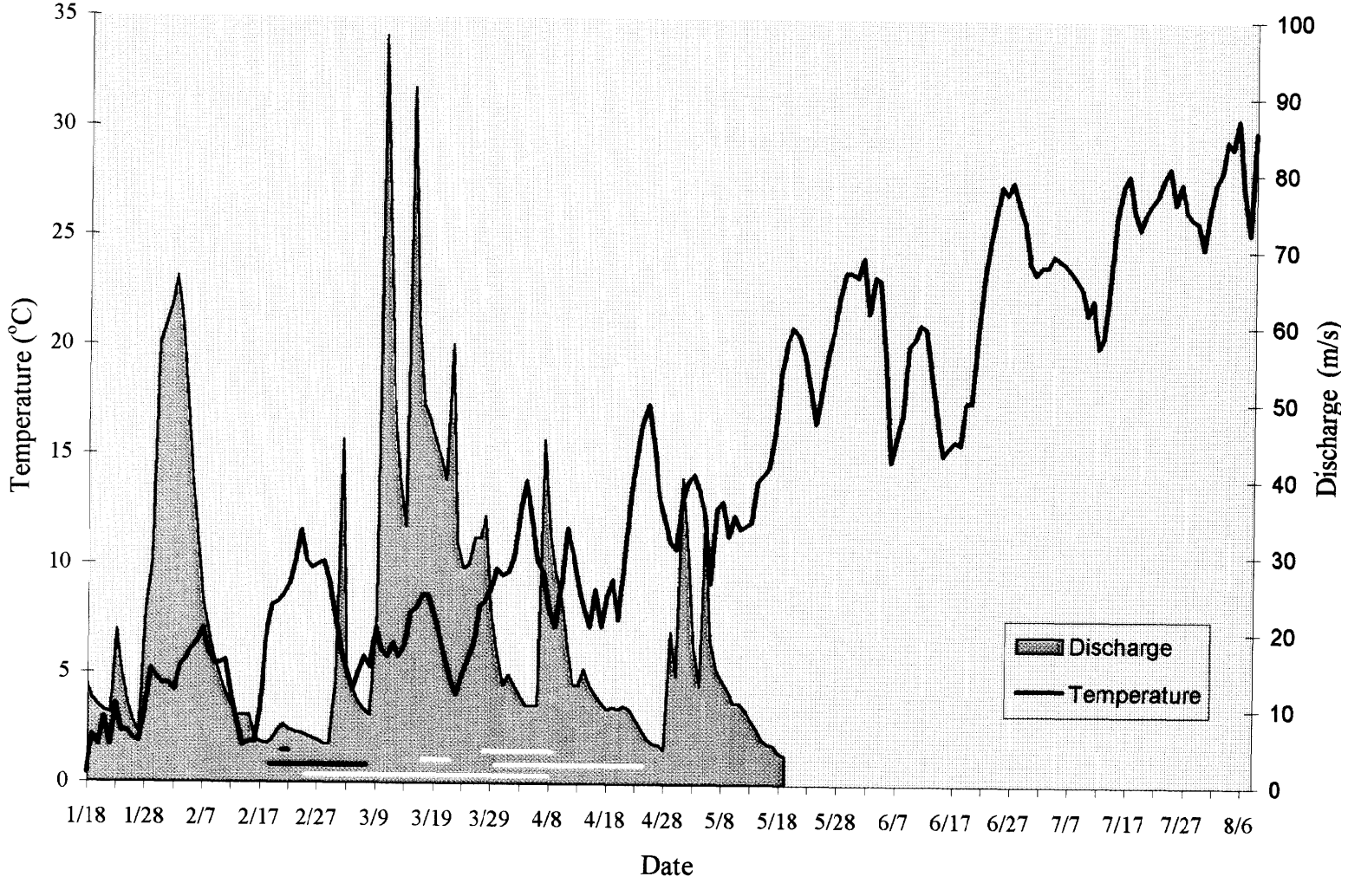

FIGURE 2. Maximum daily water temperature and discharge of Willow Creek, 1995. Horizontal lines represent individual shortnose (yellow) and Lost River (black) suckers and indicate periods that these radio-tagged suckers were in the Willow and Boles creeks.

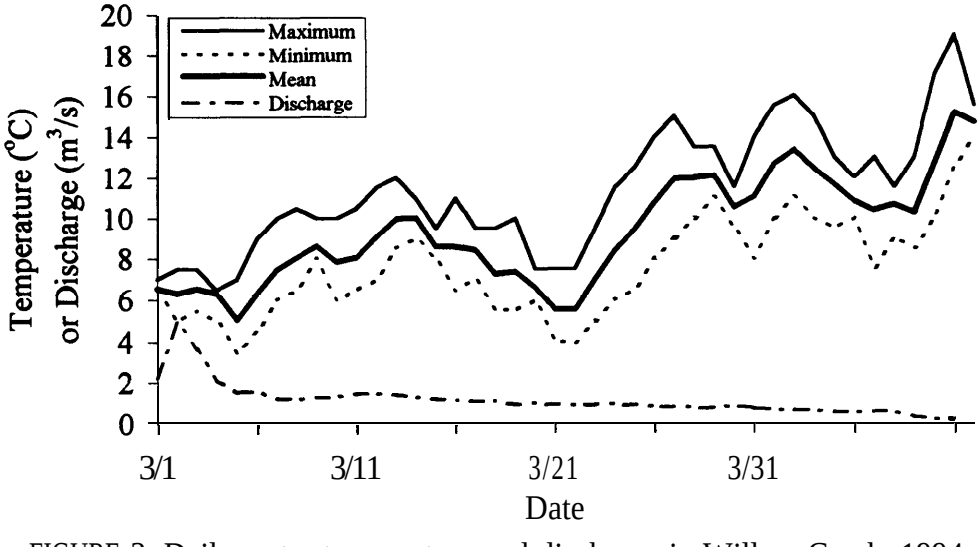

FIGURE 3. Daily water temperature and discharge in Willow Creek, 1994.

TABLE 5. Summary of spawning and young-of-year emigration dates for Lost River (LR) and shortnose (SN) suckers from Clear Lake. Spawning dates were back-calculated from emigration dates.

		Spawning			Emigration		
Species	Year	Start	End	No. Days	start	End	No. Days
LR	1993	l-7Mar	21-28 Apr	51	13 Apr	2 June	50
	1994	14-21 Mar	l-7Apr	18	29 Mar	21-28 Apr	26
	1995	l-7 Feb	---	---	12 Apr	---	---
SN	1993	21-28 Mar	l-7 June	72	22 Apr	27 Jul	96
	1994	21-28 Feb	14-21 Mar	11	29 Mar	12 Apr	14
	1995	---	2 l-28 Mav	---	---	12 Jun	---

We could not assess whether variations in water flow at the mouth of Willow Creek affected the timing of migration. In 1993 and 1994, gauge malfunction prevented data collection. In 1995, the high lake level inundated Willow Creek more than 1.2 km upstream of Clear Lake; thus, water velocity near the mouth of Willow Creek was minimal throughout the spawning season.

Spawning Site Characteristics

Three Lost River and three shortnose spawning sites were located and characterized (Tables 4, A3, and A4). Water depth ranged from 28 to 128 cm. Substrate at all sites was primarily rock greater than 1.25 cm in diameter. Substrate interstices became filled with sediment 2.7 to 14.9 cm below the surface. Sites used by shortnose suckers generally had greater water velocity than sites used by Lost River suckers (0.66-1.20 m/s vs. 0.01-0.84 m/s). One of the sites used by Lost River suckers (Willow Creek site 1) was located at a spring. While spawning was not observed at the Boles Creek site, radio telemetry located a shortnose sucker at this site and eggs were collected from the substrate. The Bayley Creek site was void of water when substrate was sampled, thus particles less than 0.18 cm were included. This site had many large boulders (0.5-2 m diameter) partially buried in the stream bed.

Emigration of Larvae and Juveniles

Sucker emigration began between the end of March and early April in 1993, 1994, and 1995 (Table 5). Emigration was most protracted in 1993 (50 days for Lost River suckers and 96+ days for shortnose suckers) and least protracted in 1994 (28 days for Lost River suckers and 15 days for shortnose suckers (Tables A6 and A7)). In 1995 emigration occurred over 61 days, but larvae were not identified to species (Table A8; for back calculation of spawning dates we assumed that Lost River suckers were present in the first group of larvae captured and that shortnose suckers were present in the last group).

All sucker emigrants were larvae (10 -16 mm fork length) except for shortnose suckers in 1993. In this year, the size of shortnose suckers increased weekly and by the end of June fish were primarily juveniles; however, some recently-emerged larvae were captured as late as 22 June. The largest emigrant (59.4 mm FL) was captured 25 August, 1993. Emigration of both sucker species occurred between 1800 and 0600 hours, with peak daily emigration between 2330 and 2400 hours (Table A9, Figure 4).

The number of emigrants varied considerably among years and between species (Figure 5). The estimated numbers of emigrants are as follows: Lost River suckers - 417,248 (1993) and 1,222,175 (1994); shortnose suckers - 12,439,581 (1993) and 11,733 (1994). In 1995 an estimated 2,594,282 suckers emigrated from Willow Creek to Clear Lake (the two species were not differentiated). The estimates above are subject to several sources of error. First, we assumed that drifting fish were evenly distributed throughout the water column. Tests of this assumption have not been made on Willow Creek. Coleman et al. (1988) found that Lost River sucker larvae emigrating in the Williamson River were more abundant in the middle and along the south shore of the river, but application of this data to Willow Creek is confounded by substantial differences in channel width and flow characteristics between sample sites of the two studies. A second

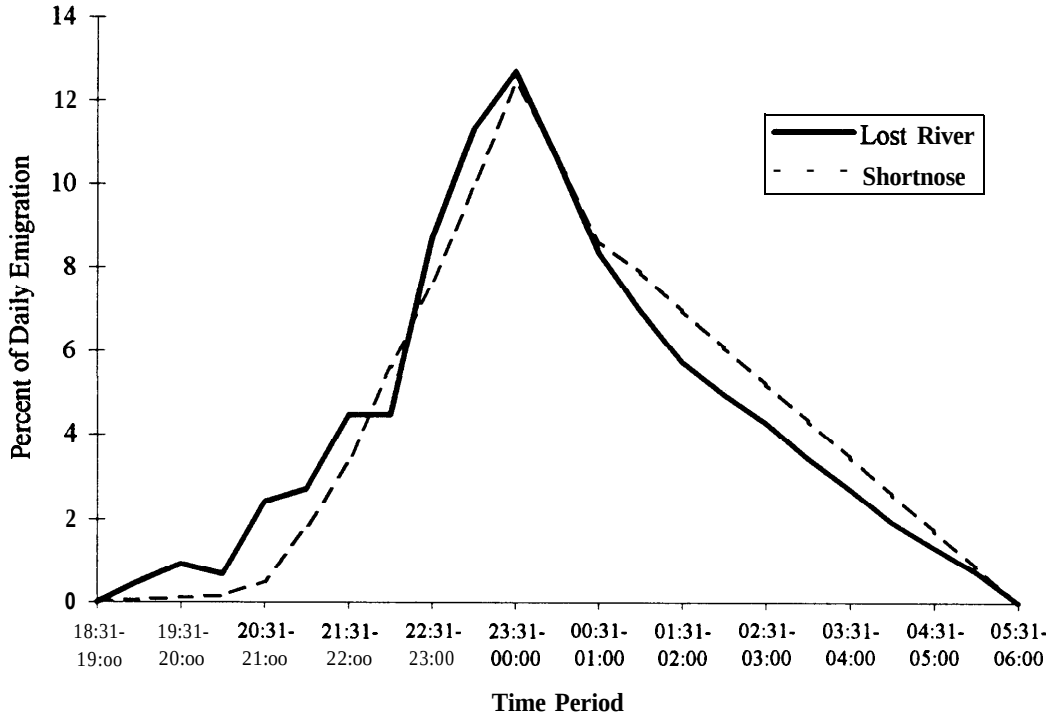

FIGURE 4. Daily emigration pattern of larval and juvenile Lost River and shortnose suckers in Willow Creek (based on mean daily fish capture in 1993). For time periods not shown, we assumed no larvae were emigrating.

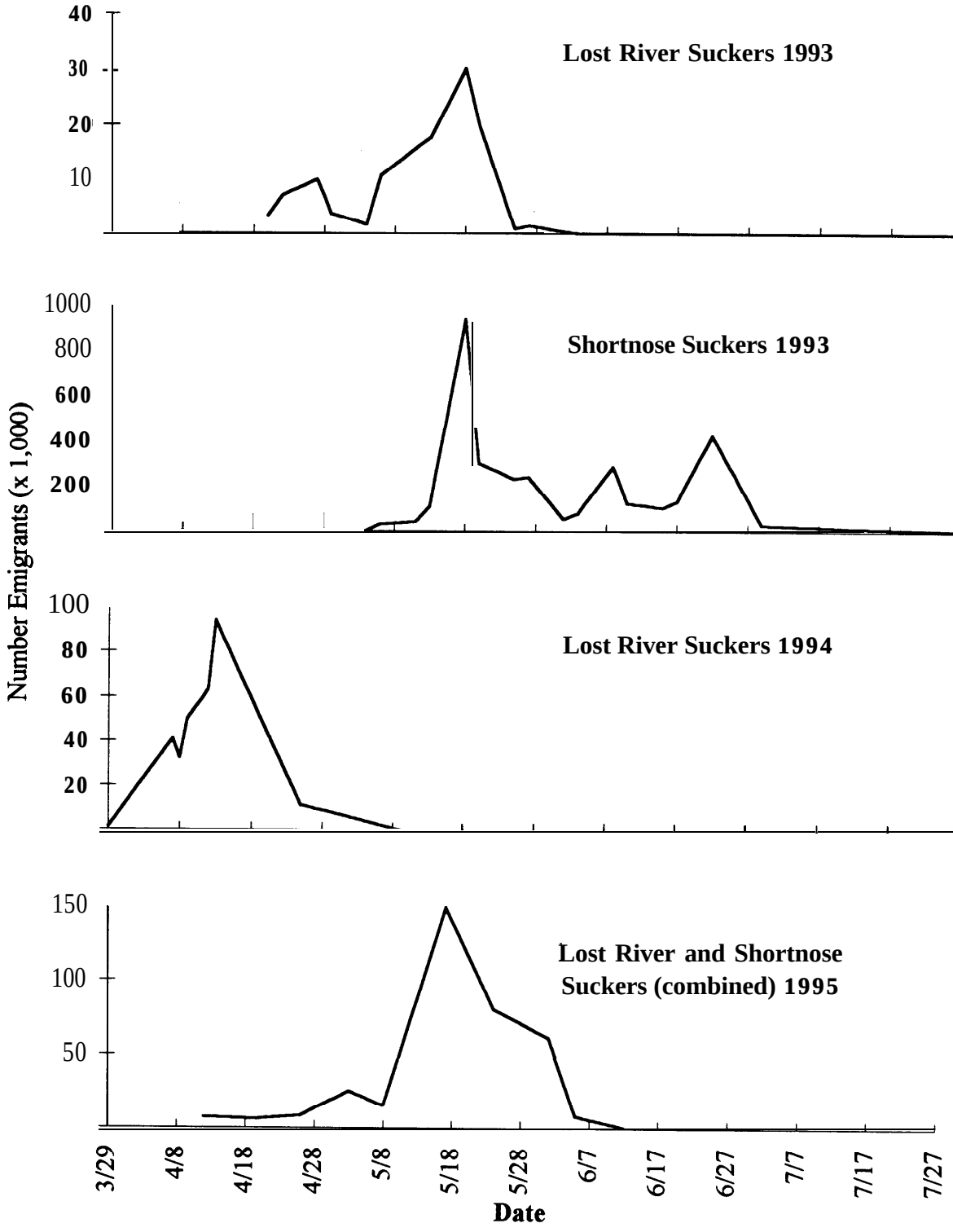

FIGURE 5. Daily emigration of young-of-year Lost River and shortnose suckers from Willow Creek into Clear Lake. Emigration of shortnose suckers in 1994 was minimal. Suckers were not identified to species in 1995. Note the different scales on the y-axes.

TABLE 6. Characteristics of sites where juvenile and adult shortnose suckers were located in Willow Creek, August 1995. All sites were in the **1.7-km** section of Willow Creek that is downstream from the crossing of USFS road 48NO8. All fish were resting on the bottom when observed; thus, focal depth equaled total depth. Dissolved oxygen, temperature, and pH were measured at the focal point.

			No. of	Size class	Total	Velocity (m/s)		DO	Temperature	
Date	Latitude	Longitude	fish	(mm)	depth (m)	60% total depth	Focal	(mg/L)	(°C)	pH
8/16/95	41° 59.387'	120° 48.610'	1	370-420	0.46	0.00	0.00	8.35	19.14	7.61
8/16/95	41° 59.387'	120° 48.610'	1	150-180	0.46	0.00	0.00	8.35	19.14	7.61
8/16/95	41° 59.253'	120° 48.694'	4	3 70-420	0.66	0.01	0.01	8.85	20.51	8.07
8/16/95	41° 59.253'	120° 48.694'	1	150-180	0.66	0.01	0.01	8.85	20.51	8.07
8/16/95	41° 59.195'	120° 48.677'	7	370-420	0.70	0.02	0.02	8.70	19.27	8.10
8/16/95	41° 59.108'	120° 48.752'	3	370-420	0.30	0.01	0.01	8.32	18.41	8.16
8/16/95	41° 59.085'	120° 48.858'	1	370-420	0.22	0.01	0.01	8.83	20.65	8.37
8/23/95	41" 58.969'	120" 49.006'	21	3 70-420	1.00	0.01	0.01	8.89	20.59	8.39
8/23/95	41° 58.915'	120° 48.868'	25	370-420	0.96	0.00	0.00	9.86	20.82	8.52

source of error is that the average diel emigration patterns observed in 1993 were applied to all sample dates to calculate 24-hour emigration rates. Potential errors caused by within and among season variation in diel emigration patterns have not been estimated.

Summer Occupation of Stream Habitat by Suckers

Sixty-two large (370-420 mm) and two small (150-180 mm) shortnose suckers were observed in the 1.7-km stretch of Willow Creek downstream of the crossing of USFS road 48N08 (Table 6). All fish were found resting on the bottom of pools. Fish used undercut banks, rocks, overhanging willow trees, and algae as cover. Fish appeared in good health. Water conditions at the seven sites were as follows: velocity - 0.00 to 0.02 m/s, temperature - 18 to 21 ^{o}C, and pH - 7.6 to 8.5. Suckers were not found at any other site surveyed.

Discussion

A large proportion of radio-tagged suckers did not migrate up Willow Creek during the spawning seasons in 1994 and 1995. Possible explanations for the lack of migration by some fish include: 1) Lost River and shortnose suckers in Clear Lake do not spawn every year due to energy limitations, 2) creek conditions were not attractive to many of the mature fish, 3) spawning occurred in places other than Willow Creek and its tributaries, and 4) fish behavior was influenced by the radio transmitters. Whether energy constraints limit spawning frequency cannot be adequately assessed at present. The turbidity of Clear Lake (caused largely by inorganic particles) and the general lack of aquatic vegetation suggests a low productivity system; however, the productivity has not been determined.

Creek conditions near the mouth of Willow Creek varied among the three years in this study and probably influenced the magnitude of spawning migration. During the 1994 spawning season, discharge from Willow Creek was low (less than 2 m^3/s except for the first week in March) and thus, may not have attracted spawners. During the 1995 spawning season, discharge was high (5-97 m^3/s); but, water velocity in the lower 1.4 km of Willow Creek was low (less than 0.25 m/s) because the high lake level extended into the Willow Creek gorge. Thus, fewer spawners may have been attracted than in 1993, when both discharge and water velocity at the creek mouth were high. Willow Creek's failure to attract some spawners was also indicated by the presence of three shortnose suckers with transmitters near the mouth of Mowitz Creek for several weeks in March 1995. In most years, flow in Mowitz Creek is minimal to non-existent; however, during spring 1995, flow was above average and apparently attracted shortnose suckers. Whether spawning occurred in the creek or in cobble areas near the mouth is unknown. Also unknown is whether spawning occurred in the lake or in the lower portion of Willow Creek below the telemetry station. In Upper Klamath Lake, some Lost River and shortnose suckers spawn at near-shore springs whereas others migrate up the Williamson River (Buettner and Scoppettone 1990). The high turbidity of Clear Lake prevents visual surveying for fish spawning; however, in-lake spawning could be assessed with egg collection devices.

The effect of the radio transmitters on the migration behavior of suckers included in the analysis of this study is thought to be minimal. Buettner (Bureau of Reclamation, Klamath Falls, OR, personal communication, 1996) found that during spawning migration, the effect of transmitter implantation varied among shortnose suckers; some fish continued their spawning migration whereas others returned to Upper Klamath Lake. In the current study, most transmitters were implanted at least three to four months before migration occurred and transmitters that did not exhibit movement patterns indicative of a live fish were excluded from analysis. This acclimation time, along with exclusion of suspect transmitters, is thought to have minimized any effect of transmitter on spawning migration.

Shortnose suckers seem prone to migrate further than Lost River suckers and thus, may have more spawning habitat available. In 1995, shortnose suckers were found spawning in Fletcher Creek 46.7 km upstream of Clear Lake[2], whereas Lost Rivers were found only 5.5 km upstream (Figure 1). Lost River suckers may have migrated further upstream than we observed, and indeed, continuing studies in 1996 have found Lost River suckers 22 km upstream; however, this is still less than half of the area used by shortnose suckers. That shortnose suckers migrate and spawn further upstream than Lost River suckers would explain why only shortnose suckers are found in many of the intermittent reservoirs in the Clear Lake watershed (Buettner and Scoppettone 1991) and why shortnose larvae and juveniles of continually increasing size were captured in drift nets for many weeks after the emigration of Lost River larvae ended in 1993.

Factors that affected recruitment of young-of-year suckers differed between Lost River and shortnose suckers. In 1993, emigration of shortnose larvae and juveniles substantially outnumbered Lost River larvae (12.4 million vs. 0.4 million), whereas in 1994 the opposite was true (11,733 shortnose vs. 1.2 million Lost River). The reduced shortnose emigration in 1994 was not unexpected given the low water discharge and few adults that migrated up Willow Creek. However, the number of Lost River sucker emigrants in 1993 was substantially less than the 2.9 million larvae expected given the population size, fecundity, and a conservative estimate of egg-to-larvae survival (Table 7). One possible explanation is that eggs of Lost River suckers were destroyed by high flows, whereas mortality of shortnose sucker eggs was less because much of the spawning took place further up in the watershed where flows were less severe.

Characteristics of Lost River and shortnose sucker spawning sites in the Clear Lake watershed were generally similar to those of conspecifics in the Williamson and Sprague rivers, the primary riverine spawning habitat of suckers in Upper Klamath Lake Coleman et al. (1988). The onset of spawning was consistently earlier in the Clear Lake watershed than in the Williamson and Sprague rivers. This could be due to genetic differences among the populations, the earlier peak in flow that occurs in Willow Creek, and/or water temperature differences between the drainages. Water temperatures at the onset of spawning were similar among the shortnose populations but the Lost River suckers in Willow Creek began spawning when water temperature was several degrees Celsius colder than conspecifics in the Williamson and Sprague rivers.

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[2] These shortnose suckers were not from Avanziono Reservoir, which is downstream from Fletcher Creek and was dry in late summer 1994 (M. Yamagiwa, U.S. Forest Service, Modoc, CA, pers. com.)

TABLE 7. Expected recruitment of Lost River and shortnose sucker larvae in Clear Lake given given different egg-to-larvae survival rates. The adult population size, proportion of females, and fecundity were based on unpublished data collected by the authors. The percentage of adults spawning is a rough approximation based on radio-telemetry data from this study.

	Adult population size	% females	Individual fecundity	% adults spawning	Survival from egg depostion to larvae	Number of larvae
Shortnose	73,000	63%	38,000	50%	10%	87,381,000
	73,000	63%	38,000	50%	5%	43,690,500
	73,000	63%	3 8,000	50%	1%	8,738,100
Lost River	23,000	50%	100,000	25%	10%	28,750,000
	23,000	50%	100,000	25%	5%	14,375,000
	23,000	50%	100,000	25%	1%	2,875,000

Acknowledgments

Field work was conducted largely by James Harvey, Bob Hines, Doug Larson, Chris Mace, Peter Rissler, Jose Setka, Sean Shea, John Stanziano, Daniel Waldeck, and John Whiteaker. Sean Shea and Mike Green (Bureau of Reclamation) implanted many of the radio transmitters in the suckers. The Bureau of Reclamation provided the automated receiving station used to monitor fish movement near the mouth of Willow Creek. We thank James Hainline and Gary Hagedorn for their cooperation and use of storage space on the Tule Lake National Wildlife Refuge. We also thank the Modoc National Forest staff for use of storage space at their Tule Lake facility.

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Appendix - Data Tables

TABLE Al. Daily discharge of Willow Creek, 1993-96. Values from 1993 were extrapolated from mean monthly discharges that were based on monthly changes in the water level of Clear Lake. Data from 3-27 January 19% were estimated from a visual recollection of the graph paper, which was subsequently lost.

	1993	1994		1995		1996	
Date	Discharge (m^3/s)	Cage height (+4540')	Discharge (m^3/s)	Discharge (m^3/s)	Gage height (+4540')	Discharge (m^3/s)	Gage height (+4540')
1/12	—	—	—	—		3.37	2.44
1/13	—	—	—	—	—	2.72	225
1/14	—	—	—	—	—	2.26	2.05
1/15	—	—	—	—	—	2.18	2.00
1/16	—	—	—	—	—	2.26	2.05
1/17	—	—	—	—	—	2.21	2.85
1/18	—	—	—	12.74	3.80	3.54	2.50
1/19	—	—	—	10.62	3.60	3.00	2.35
1/19	—	—	—	10.90	3.62	—	—
1/20	—	—	—	8.83	3.40	2.49	2.15
1/20	—	—	—	10.05	3.56	—	—
1/21	—	—	—	8.49	3.35	2.18	2.00
1/21	—	—	—	9.34	3.46	—	—
1/22	—	—	—	7.25	3.20	2.49	2.15
1/22	—	—	—	9.06	3.42	—	—
1/23	—	—	—	9.71	3.50	2.49	2.15
1/23	—	—	—	19.82	4.28	—	—
1/24	—	—	—	10.19	3.57	2.49	2.15
1/24	—	—	—	14.16	3.95	—	—
1/25	—	—	—	9.71	3.50	2.38	2.10
1/25	—	—	—	10.19	3.56	—	—
1/26	—	—	—	6.79	3.15	2.38	2.10
1/26	—	—	—	7.93	3.27	—	—
1/27	—	—	—	5.10	2.85	2.18	2.00
1/27	—	—	—	6.51	3.10	—	—
1/28	—	—	—	8.01	3.30	2.18	2.00
1/28	—	—	—	22.08	4.40	—	—
1/29	—	—	—	14.44	3.96	2.18	2.00
1/29	—	—	—	28.88	4.63	—	—
1/30	—	—	—	20.95	4.36	2.07	1.95
1/30	—	—	—	57.19	5.40	—	—
1/31	—	—	—	—	—	2.18	2.00
1/31	—	—	—	—	—	—	—
2/1	—	—	—	—	—	2.18	2.00
2/1	—	—	—	—	—	—	—
2/2	—	—	—	—	—	2.38	2.10
2/2	—	—	—	65.97	5.62	—	—
2/3	—	—	—	60.30	5.47	2.86	2.30
2/4	—	—	—	50.11	5.22	3.94	2.60
2/5	—	—	—	39.92	4.95	5.04	2.85
2/6	—	—	—	31.43	4.70	6.88	3.15
2/7	—	—	—	23.50	4.45	10.16	3.55
2/8	—	—	—	19.25	4.27	14.44	3.95
2/9	—	—	—	16.14	4.08	20.95	4.35
2/10	—	—	—	13.87	3.90	24.91	4.50
2/11	—	—	—	11.61	3.71	53.23	5.30
2/12	—	—	—	10.19	3.55	82.95	6.00
2/13	—	—	—	8 78	3.38	92.58	6.20
2/14	—	—	—	8.78	3.38	92.58	6.20

TABLE A 1. (continued).

2/15	—	—	—	8.78	3.38	83.94	6.05
2/16	—	—	—	5.66	2.98	82.95	6.00
2/17	—	—	—	5.29	2.90	69.36	5.70
2/18	—	—	—	5.10	2.84	61.15	5.50
2/19	—	—	—	5.58	2.95	51.24	5.25
2/20	—	—	—	6.94	3.17	43.46	5.05
2/21	—	—	—	7.64	3.25	38.22	4.90
2/22	—	—	—	6.96	3.18	33.12	4.75
2/23	—	—	—	6.65	3.12	28.03	4.60
2/24	—	—	—	6.51	3.09	23.50	4.45
2/25	—	—	—	6.17	3.05	20.95	4.35
2/26	—	—	—	5.86	3.00	19.82	4.30
2/27	—	—	—	5.58	2.93	18.97	4.25
2/27	—	—	—	—	—	18.12	4.25
2/28	—	—	—	5.10	2.85	18.12	4.2
2/29	—	—	—	—	—	17.00	4.17
3/1	62.34	2.15	2.49	5.10	2.85	17.00	4.15
3/1	—	1.86	1.90	—	—	—	—
3/2	61.27	3.20	7.25	13.31	3.85	19.00	4.25
3/2	—	2.33	2.65	—	—	—	—
3/3	60.19	2.88	5.19	44.73	5.08	19.82	4.3
3/3	—	1.98	2.14	—	—	—	—
3/4	59.11	2.17	2.54	14.01	3.92	23.00	4.45
3/4	—	1.80	1.78	—	—	—	—
3/5	58.04	1.68	1.58	12.17	3.73	28.03	4.65
3/5	—	1.60	1.44	—	—	—	—
3/6	56.96	1.85	1.88	10.62	3.60	22.08	4.43
3/6	—	1.53	1.35	—	—	—	—
3/7	55.89	1.52	1.33	9.57	3.48	19.82	4.31
3/7	—	1.46	1.23	—	—	—	—
3/8	54.81	1.48	1.27	8.83	3.40	19.82	4.29
3/8	—	1.43	1.18	—	—	—	—
3/9	53.74	1.48	1.27	22.08	4.40	19.82	4.27
3/9	—	1.50	1.30	—	—	—	—
3/10	52.66	1.47	1.25	97.39	6.30	19.82	4.29
3/10	—	1.60	1.44	—	—	—	—
3/11	51.58	1.62	1.48	40.77	4.97	19.82	4.3
3/11	—	—	—	72.19	5.77	—	—
3/12	50.51	.63	1.50	48.70	5.17	22.08	4.35
3/13	49.43	1.58	1.42	39.92	4.95	19.82	4.3
3/14	48.36	1.50	1.30	33.41	4.77	19.00	4.25
3/15	47.28	1.45	1.22	90.60	6.13	19.12	4.17
3/16	46.20	1.41	1.15	61.15	5.50	17.00	4.14
3/17	45.13	1.38	1.10	49.26	5.20	16.42	4.08
3/18	44.05	1.38	1.10	—	—	16.00	4.05
3/19	42.98	1.25	0.94	—	—	15.00	4.03
3/20	41.90	1.30	0.99	—	—	15.00	4
3/21	40.83	1.26	0.95	39.64	4.93	15.00	33.97
3/22	39.75	1.23	0.91	57.19	5.40	14.00	3.95
3/23	38.67	1.24	0.92	31.43	4.70	13.87	3.9
3/24	37.60	1.28	0.97	28.03	4.60	13.00	3.87
3/25	36.52	1.22	0.90	28.59	4.62	12.74	3.84
3/26	35.45	1.17	0.84	22.08	4.40	12.74	3.8
3/26	—	—	—	31.99	4.72	—	—
3/27	34.37	1.14	0.81	20.95	4.35	12.00	3.74
3/27	—	—	—	31.99	4.72	—	—
3/28	33.29	1.13	0.80	20.95	4.35	11 61	3.71

TABLE *A1.* (continued).

3/28	—	—	—	*34.82*	*4.80*	—	—
3/29	32.22	1.09	0.75	20.67	4.32	12.00	3.74
3/29	—	—	—	22.08	4.40	—	—
3/30	31.14	1.20	0.88	17.27	4.15	12.74	3.8
3/30	—	1.12	0.79	—	—	—	—
3/31	30.07	1.08	0.74	12.88	4.05	—	—
3/31	—	1.02	0.67	—	—	—	—
4/1	28.99	1.01	0.66	14.16	3.95	—	—
4/2	27.92	1.00	0.65	12.74	3.80	—	—
4/3	26.84	0.96	0.62	11.32	3.68	—	—
4/3	—	0.90	0.57	—	—	—	—
4/4	25.76	0.87	0.54	10.19	3.55	—	—
4/4	—	0.82	0.50	—	—	—	—
4/5	24.69	0.89	0.56	10.19	3.55	—	—
4/5	—	0.94	0.60	—	—	—	—
4/6	23.61	0.89	0.56	10.19	3.55	—	—
4/6	—	0.57	0.32	—		—	—
4/7	22.54	0.55	0.31	44.73	5.08	—	—
4/7	—	0.35	0.20	—	—	—	—
4/8	21.46	0.31	0.18	32.84	4.75	—	—
4/9	20.38	0.30	0.17	27.46	4.57	—	—
4/10	19.31	0.30	0.17	24.06	4.47	—	—
4/11	18.23	—	—	18.12	4.20	—	—
4/12	17.16	—	—	12.88	4.05	—	—
4/13	16.08	—	—	12.88	4.05	—	—
4/14	15.01	—	—	15.01	4.00	—	—
4/15	14.16	—	—	12.74	3.80	—	—
4/16	13.84	—	—	11.61	3.70	—	—
4/17	13.53	—	—	10.62	3.60	—	—
4/18	13.22	—	—	9.71	3.50	—	—
4/19	12.91	—	—	10.05	3.52	—	—
4/20	12.60	—	—	9.71	3.50	—	—
4/21	12.29	—	—	8.83	3.40	—	—
4/21	—	—	—	10.19	3.55	—	—
4/22	11.98	—	—	9.71	3.50	—	—
4/23	11.66	—	—	8.49	3.35	—	—
4/24	11.35	—	—	7.25	3.20	—	—
4/25	11.04	—	—	5.86	3.00	—	—
4/26	10.73	—	—	5.29	2.90	—	—
4/27	10.42	—	—	5.10	2.85	—	—
4/28	10.11	—	—	4.56	2.75	—	—
4/29	9.80	—	—	19.82	4.30	—	—
4/30	9.48	—	—	14.16	3.95	—	—
5/1	9.17	—	—	39.92	4.95	—	—
5/2	8.86	—	—	30.29	4.67	—	—
5/3	8.55	—	—	18.12	4.20	—	—
5/4	8.24	—	—	12.88	4.05	—	—
5/5	7.93	—	—	33.97	4.78	—	—
5/6	7.62	—	—	18.97	4.25	—	—
5/7	7.30	—	—	15.01	4.00	—	—
5/8	6.99	—	—	13.59	3.87	—	—
5/9	6.68	—	—	12.17	3.75	—	—
5J10	6.37	—	—	10.62	3.60	—	—
5J11	6.06	—	—	10.62	3.60	—	—
5/12	5.75	—	—	9.71	3.50	—	—
5/13	5.44	—	—	8.49	3.35	—	—
5/14	5.12	—	—	7.25	3.20	—	—

TABLE A1. (continued).

5/15	4.87	---	---	5.86	3.00	---	---
5/16	4.78	---	---	5.29	2.90	---	---
5/17	4.69	---	---	5.10	2.85	---	---
5/18	4.59	---	---	4.13	2.65	---	---
5/19	4.50	---	---	3.74	2.55	---	---
5/20	4.41	---	---	---	---	---	---
5/21	4.32	---	---	---	---	---	---
5/22	4.23	---	---	---	---	---	---
5/23	4.13	---	---	---	---	---	---
5/24	4.04	---	---	2.18	2.02	---	---
5/25	3.95	---	---	2.18	2.00	---	---
5/26	3.86	---	---	1.98	1.90	---	---
5/27	3.77	---	---	1.90	1.85	---	---
5/28	3.67	---	---	1.78	1.80	---	---
5/29	3.58	---	---	1.78	1.80	---	---
5/30	3.49	---	---	1.70	1.75	---	---
5/31	3.40	---	---	1.56	1.65	---	---
6/1	3.31	---	---	1.44	1.60	---	---
6/2	3.21	---	---	1.36	1.55	---	---
6/3	3.12	---	---	1.30	1.50	---	---
6/4	3.03	---	---	1.22	1.45	---	---
6/5	2.94	---	---	1.30	1.52	---	---
6/6	2.85	---	---	1.22	1.45	---	---
6/7	2.75	---	---	1.30	1.50	---	---
6/8	2.66	---	---	1.22	1.45	---	---
6/9	2.57	---	---	1.22	1.45	---	---
6/10	2.48	---	---	1.13	1.40	---	---
6/11	2.39	---	---	1.05	1.35	---	---
6/12	2.29	---	---	1.05	1.35	---	---
6/13	2.20	---	---	1.05	1.35	---	---
6/14	2.11	---	---	1.05	1.35	---	---
6/15	2.10	---	---	1.36	1.55	---	---
6/16	2.10	---	---	1.36	1.55	---	---
6/17	2.10	---	---	1.30	1.50	---	---
6/18	2.10	---	---	1.30	1.50	---	---
6/19	2.10	---	---	1.36	1.55	---	---
6/20	2.10	---	---	1.36	1.55	---	---
6/21	2.10	---	---	1.36	1.55	---	---
6/22	2.10	---	---	1.30	1.50	---	---
6/23	2.10	---	---	1.22	1.45	---	---
6/24	2.10	---	---	1.22	1.44	---	---
6/25	2.10	---	---	---	---	---	---
6/26	2.10	---	---	---	---	---	---
6/27	2.10	---	---	---	---	---	---
6/28	2.10	---	---	---	---	---	---
6/29	2.10	---	---	---	---	---	---
6/30	2.10	---	---	---	---	---	---
7/1	2.10	---	---	---	---	---	---
7/2	2.10	---	---	---	---	---	---
7/3	2.10	---	---	---	---	---	---
7/4	2.10	---	---	---	---	---	---
7/5	2.10	---	---	---	---	---	---
7/6	2.10	---	---	---	---	---	---
7/7	2.10	---	---	---	---	---	---
7/8	2.10	---	---	---	---	---	---
7/9	2.10	---	---	---	---	---	---
7/10	2.10	---	---	---	---	---	---

TABLE Al. (wntinued).

7/11	2.10						
7/12	2.10						
7/13	2.10						
7/14	2.10						
7/15	2.10						
7/16	2.10						
7/17	2.10						
7/18	2.10						
7/19	2.10						
7/20	2.10						
7/21	2.10						
7/22	2.10						
7/23	2.10						
7/24	2.10						
7/25	2.10						
7/26	2.10						
7/27	2.10						
7/28	2.10						
7/29	2.10						
7/30	2.10						
7/31	2.10						

TABLE A2. Water turbidity in the Clear Lake drainage.

Date	Latitude	Longitude	Turbidity (ntu) Sample 1	Sample 2
Willow Creek				
3/16/95	41° 53.765'	121° 02.457'	37.2	38.0
3/21/95	41" 53.710'	121" 02.320'	31.2	35.8
4/3/95	41° 48.985'	121° 08.139'	87.9	88.4
4/3/95	41° 48.925'	121° 08.214'	89.4	90.1
4/3/95	41" 50.650'	121" 08.772'	88.3	87.7
4/3/95	41° 50.692'	121" 09.001'	86.8	87.7
Fletcher Creek				
3/30/95	41° 49.160'	120" 45.619'	15.6	15.2
3/30/95	41" 49.43 1'	120" 45.463'	7.6	7.4
Boles Creek				
4/5/95	41" 51.895'	120" 59.622'	27.1	27.4
4/5/95	41° 52.023'	120° 59.741'	27.7	27.2

TABLE A3. Water depth and velocity at Lost River and shortnose sucker spawning sites in the Clear Lake watershed, 1995.

Distance from right bank(m)	Total depth	Flow (m/s) % of total depth (cm)	20	60	80	100
Willow Creek, site #1 (41" 53.735, 121° 02.467'), 3/16/95						
0.17	58	---	0.13	---	---	---
0.34	71	---	0.01	---	---	---
0.41	80	0.07	---	0.03	---	---
0.58	78	0.01	---	0.02	---	---
0.75	28	---	0.01	---	---	---
Willow Creek, site #1b, 15 m above site #1 above, 2/25/95						
3	16	---	0.07	---	---	---
6	24	---	0.21	---	---	---
8	36	---	0.27	---	---	---
11	38	---	0.3 1	---	---	---
13	56	---	0.24	---	---	---
14[1]	95	0.35	---	0.08	---	---
16	112	0.35	---	0.28	---	---
18	124	0.49	---	0.37	---	---
21	128	0.49	---	0.40	---	---
23[2]	124	0.57	---	0.42	---	---
25	104	0.59	---	0.52	---	---
27	94	0.52	---	0.27	---	---
28	86	---	---	---	---	---
29	82	---	---	---	---	---
30	72	---	---	---	---	---
31	70	---	---	---	---	---
32	62	---	---	---	---	---
33	51	---	---	---	---	---
34	49	---	---	---	---	---
35	42	---	---	---	---	---
36	38	---	---	---	---	---
37	31	---	---	---	---	---
38	16	---	---	---	---	---
Willow Creek site #2 (41" 53.700', 121" 02.43 1'), 2/25/95						
10	70	0.49	---	0.30	---	
12	77	0.72	---	0.45	---	
14	70	0.73	---	0.61	---	

TABLE A3. (continued).

16	66	0.99	---	0.68	---
18	63	0.87	---	0.53	---
21	47	0.71	---	0.43	---
25	52	0.56	---	0.28	---
26	50	---	0.00	---	---
27	44	---	0.00	---	---
28	41	---	0.00	---	---
29	38	---	0.00	---	---
30	25	---	0.00	---	---
Boles Creek (41° 52.023', 120° 59.741'), 4/5/95					
1	41	---	0.28	---	0.06
2.5	64	---	0.85	---	0.53
3.5	66	---	1.17	---	0.13
4.5	79	---	1.08	-a-	0.01
5.5	85	---	1.24	---	0.10
6.5	87	---	1.20	---	0.23
7.5[1]	84	---	1.46	---	0.32
8.5	84	---	1.23	---	0.40
9.5	83	---	1.16	---	0.17
10.5[2]	81	---	0.96	we-	0.03
11.5	78	---	0.68	---	0.03
12.5	78	---	0.26	---	0.01
Fletcher Creek, N road crossing, (41" 49.160', 120" 45.619'), 3/30/95					
3	25	---	1.39	---	0.26
5	21	---	1.39	---	0.98
Fletcher Creek, S road crossing, (41" 49.430', 120" 45.463') 3/30/95					
7	32	---	0.58	---	0.37
8	32	---	0.82	---	0.65
9	32	---	1.01	---	0.81
10	37	---	0.91	---	0.67
11	50	---	1.07	---	0.74
12	46	---	1.19	---	0.86
13	48	---	1.44	---	1.08
14	49	---	1.33	---	1.02
15	49	---	1.52	---	0.73
16	46	---	1.48	---	1.00
17	50	---	1.63	---	0.04

TABLE A3. (continued).

18	45	---	1.63	---	0.1 1
19	41	---	1.58	---	0.3 1
20	49	---	1.48	---	0.32
21	52	---	1.38	---	1.02
22	60	---	1.11	---	0.88
23	6 0	---	1.25	---	0.76
24	56	---	0.98	---	0.73
25	54	---	1.16	---	0.12
26	50	---	1.16	---	0.44
27	52	---	1.27	---	0.44
28	60	---	1.01	---	0.42
29	56	---	1.16	---	0.77
30	51	---	1.14	---	0.79
31	43	---	1.09	---	0.90
32	42	---	1.14	---	0.80
33	41	---	1.08	---	0.71
34	40	---	1.09	---	0.37
35	31	---	0.87	---	0.36

'Substrate changed from mud to cobble (8-12 cm, <25% embedded)

*Substrate changes back to mud and vegetation.

TABLE A4. Substrate size composition at two Lost River sucker spawning sites in Willow Creek and one shortnose sucker spawning site in Fletcher Creek (multiple samples were collected at two of the sites). At the Willow Creek sites, the smallest substrate size class was not included in the samples. Samples were collected from an area 50 cm x 50 cm, to the depth at which interstitial spaces of the substrate were infilled and compacted with sediment (i.e. infill depth).

Substrate measure	Willow Crk. 1		Willow Crk. 2	Bayley Crk.			
Size distribution (%)							
> 10 cm	16.3	33.0	14.8	41.3	63.3	72.6	55.6
2.6 - 10 cm	39.5	40.4	24.0	32.0	14.2	15.9	24.8
1.26 - 2.5 cm	21.7	15.0	27.3	8.6	6.2	2.7	5.7
0.64 - 1.25 cm	17.5	7.6	16.0	7.0	3.7	2.9	5.2
0.18 - 0.63 cm	4.9	4.1	17.8	8.0	5.1	4.4	6.1
0.0425 - 0.17 cm	---	---	---	3.2	7.5	1.6	2.6
Infill depth (cm)	14.9	9.7	2.7	7.1	5.1	11.2	4.9
Sample volume (L)	37.21	24.28	6.74	17.79	12.65	28.03	12.32

Site locations:

Willow Crk. 1 = 41" 53.735',121° 02.467'

Willow Crk. 2 = 41° 53.700',121° 02.431'

Fletcher Crk. = 41" 49.072',120° 45.763'

TABLE A5. Lost River (LR) and shortnose (SN) sucker emigrants captured in paired drift nets in Willow Creek, 1993. Flow meter revolutions less than 1,000 indicated the meter was malfunctioning. When this occurred, the volume sampled was estimated by the average of other samples from the same day or the previous sampling date. Discharge was estimated from monthly changes in lake level. Duration values that are italicized were actually one minute longer than indicated for Net 2.

									Mean daily	No. fish captured			
	Start	Duration	Flow meter revolutions		Velocity (cm/s)		Vol. sampled (m^3/s)		discharge	LR		SN	
Date	time	(min.)	Net 1	Net2	Net 1	Net 2	Net 1	Net 2	(m^3/s)	Net 1	Net 2	Net 1	Net 2
04/20/93	19:30	30	32810	32904	48.98	49.12	0.0962	0.096	12.60	0	3	0	0
04/20/93	20:oo	30	32300	32604	48.22	48.68	0.0947	0.096	12.60	0	0	0	0
04/20/93	20:30	30	31331	27468	46.78	41.01	0.0918	0.08 1	12.60	0	2	0	0
04/20/93	21:oo	30	29497	34130	44.04	50.95	0.0865	0.100	12.60	0	3	0	0
04/20/93	21:30	30	3 1605	24179	47.18	36.10	0.0926	0.071	12.60	0	0	0	0
04/20/93	22:oo	30	26940	33243	40.22	49.63	0.0790	0.097	12.60	0	4	0	0
04/20/93	22:30	30	27129	28725	40.50	42.88	0.0795	0.084	12.60	0	0	0	0
04/20/93	23:00	30	28316	27988	42.27	41.78	0.0830	0.082	12.60	1	0	0	0
04/20/93	23:30	30	3 1292	30927	46.72	46.17	0.0917	0.09 1	12.60	9	0	0	0
04/22/93	19:30	30	23839	23093	35.59	34.48	0.0699	0.068	11.98	0	2	0	0
04/22/93	20:oo	30	2088 1	20609	31.17	30.77	0.06 12	0.060	11.98	0	2	0	1
04/22/93	20:30	30	24519	23850	36.61	35.61	0.0719	0.070	11.98	0	1	0	0
04/22/93	21:oo	30	22013	23698	32.86	35.38	0.0645	0.069	11.98	1	0	0	0
04/22/93	21:30	30	23189	2400 1	34.62	35.83	0.0680	0.070	11.98	3	0	0	0
04/22/93	22:oo	30	21356	21079	31.88	31.47	0.0626	0.062	11.98	1	5	1	0
04/22/93	22:30	30	21387	22953	31.93	34.27	0.0627	0.067	11.98	0	10	0	0
04/22/93	23:00	30	24192	23903	36.12	35.69	0.0709	0.070	11.98	8	1	0	0
04/22/93	23:30	30	24937	23450	37.23	35.01	0.073 1	0.069	11.98	1	2	0	1
04/27/93	19:30	30	15113	17522	22.56	26.16	0.0443	0.05 1	10.42	0	1	0	0
04/27/93	20:oo	30	11995	16451	17.91	24.56	0.0352	0.048	10.42	0	1	0	1
04/27/93	20:30	30	18552	17358	27.70	25.91	0.0544	0.05 1	10.42	3	4	1	1
04/27/93	21:oo	30	18290	19451	27.3 1	29.04	0.0536	0.057	10.42	2	1	0	1
04/27/93	21:30	30	16363	16045	24.43	23.95	0.0480	0.047	10.42	2	3	0	0
04/27/93	22:oo	30	13962	13607	20.84	20.3 1	0.0409	0.040	10.42	3	4	0	0
04/27/93	22:30	30	16770	16172	25.04	24.14	0.0492	0.047	10.42	2	3	0	0

TABLE A5.(continued).

04/27/93	23:00	30	16517	16756	24.66	25.02	0.0484	0.049	10.42	0	8	1	0
04/27/93	23:30	30	14763	14951	22.04	22.32	0.0433	0.044	10.42	4	2	0	0
04/29/93	19:oo	30	13060	13431	19.50	20.05	0.0383	0.039	9.80	1	2	0	0
04/29/93	19:30	30	7758	7309	11.58	10.91	0.0227	0.02 1	9.80	0	0	0	0
04/29/93	20:oo	30	9904	9049	14.79	13.5 1	0.0290	0.027	9.80	0	0	0	1
04/29/93	20:30	30	7960	7254	11.88	10.83	0.0233	0.02 1	9.80	0	0	1	0
04/29/93	21:oo	30	9609	10588	14.35	15.81	0.0282	0.03 1	9.80	0	0	0	0
04/29/93	21:30	30	8739	7933	13.05	11.84	0.0256	0.023	9.80	0	1	0	0
04/29/93	22:oo	30	9972	8524	14.89	12.73	0.0292	0.025	9.80	1	0	0	1
04/29/93	22:30	30	8077	7478	12.06	11.16	0.0237	0.022	9.80	0	0	0	0
04/29/93	23:00	30	9995	8113	14.92	12.11	0.0293	0.024	9.80	0	1	1	0
04/29/93	23:30	30	8878	8546	13.25	12.76	0.0260	0.025	9.80	2	2	0	0
05/04/93	19:oo	30	347	136	0.52	0.20	0.0275	0.026	8.24	1	0	1	0
05/04/93	19:30	30	54	572	0.08	0.85	0.0275	0.026	8.24	0	0	0	0
05/04/93	20:oo	30	79	627	0.12	0.94	0.0275	0.026	8.24	1	0	0	0
05/04/93	20:30	30	146	634	0.22	0.95	0.0275	0.026	8.24	1	0	0	0
05/04/93	21:oo	30	94	366	0.14	0.55	0.0275	0.026	8.24	0	0	0	0
05/04/93	21:30	30	203	155	0.30	0.23	0.0275	0.026	8.24	0	0	0	0
05/04/93	22:oo	30	260	329	0.39	0.49	0.0275	0.026	8.24	0	0	0	0
05/04/93	22:30	30	251	358	0.37	0.53	0.0275	0.026	8.24	0	0	0	0
05/04/93	23:00	30	190	386	0.28	0.58	0.0275	0.026	8.24	1	1	0	0
05/04/93	23:30	30	224	194	0.33	0.29	0.0275	0.026	8.24	0	0	0	0
05/06/93	19:oo	30	27927	28827	41.69	43.04	0.08 19	0.085	7.62	2	1	4	4
05/06/93	19:30	30	28007	25185	41.81	37.60	0.082 1	0.074	7.62	6	1	7	1
05/06/93	20:oo	30	30545	31871	45.60	47.58	0.0895	0.093	7.62	1	0	8	1
05/06/93	20:30	30	29665	2969 1	44.29	44.33	0.0870	0.087	7.62	8	1	22	2
05/06/93	21:oo	30	41571	37665	62.06	56.23	0.1219	0.110	7.62	15	1	23	3
05/06/93	21:30	60	60537	49129	45.19	36.67	0.0887	0.072	7.62	16	0	46	3
05/06/93	22:30	60	76069	61438	56.78	45.86	0.1115	0.090	7.62	72	3	89	22
05/06/93	23:30	30	36016	26632	53.77	39.76	0.1056	0.078	7.62	8	4	58	30
05/11/93	21:oo	30	14704	12556	21.95	18.75	0.043 1	0.037	6.06	0	0	19	3
05/11/93	21:30	30	17153	12381	25.61	18.48	0.0503	0.036	6.06	8	0	28	1

TABLE A5. (continued).

05/11/93	22:oo	15	235	6020	0.70	17.98	0.045 1	0.035	6.06	0	0	7	2
05/11/93	23:00	15	7877	5914	23.52	17.66	0.0462	0.035	6.06	11	0	24	8
05/11/93	23:35	15	6962	6112	20.79	18.25	0.0408	0.036	6.06	28	1	16	4
05/13/93	19:oo	30	59	7623	0.09	11.38	0.0490	0.022	5.44	1	0	0	3
05/13/93	19:30	30	13401	6742	20.01	10.07	0.0393	0.020	5.44	1	0	0	0
05/13/93	20:oo	30	1505 1	6984	22.47	10.43	0.044 1	0.020	5.44	5	0	3	2
05/13/93	20:30	30	17761	9810	26.52	14.65	0.052 1	0.029	5.44	8	0	23	4
05/13/93	21:oo	30	16996	8459	25.37	12.63	0.0498	0.025	5.44	12	1	35	9
05/13/93	21:30	30	16991	6844	25.37	10.22	0.0498	0.020	5.44	5	2	62	6
05/13/93	22:oo	30	15235	7144	22.75	10.67	0.0447	0.02 1	5.44	3	2	47	13
05/13/93	22:30	15	10718	4809	32.00	14.36	0.0628	0.028	5.44	18	4	76	16
05/13/93	23:30	15	8220	4935	24.54	14.74	0.0482	0.029	5.44	15	1	35	18
05/13/93	00:30	15	7406	4759	22.11	14.21	0.0434	0.028	5.44	13	1	69	24
05/13/93	01:30	15	9579	5762	28.60	17.20	0.0562	0.034	5.44	7	0	38	5
05/18/93	19:30	30	4985	6599	7.44	9.85	0.0146	0.019	4.59	1	0	0	0
05/18/93	20:oo	30	4131	8911	6.17	13.30	0.0121	0.026	4.59	0	1	0	0
05/18/93	20:30	30	10909	7932	16.29	11.84	0.0320	0.023	4.59	1	2	13	24
05/18/93	21:oo	30	7932	6405	11.84	9.56	0.0233	0.019	4.59	0	0	95	142
05/18/93	21:30	30	12389	6695	18.50	10.00	0.0363	0.020	4.59	16	8	251	199
05/18/93	22:45	15	5223	2635	15.60	7.87	0.0306	0.015	4.59	0	13	0	355
05/18/93	23:45	15	3825	4368	11.42	13.04	0.0224	0.026	4.59	7	20	232	334
05/18/93	00:45	15	4906	2961	14.65	8.84	0.0288	0.017	4.59	2	6	77	63
05/20/93	19:30	30	8695	949	12.98	1.42	0.0255	0.02 1	4.41	0	0	0	0
05/20/93	20:oo	30	10338	7544	15.43	11.26	0.0303	0.022	4.41	0	0	1	0
05/20/93	20:30	30	9146	5472	13.65	8.17	0.0268	0.016	4.41	5	3	17	10
05/20/93	21:oo	30	10890	7759	16.26	11.58	0.03 19	0.023	4.41	2	7	95	49
05/20/93	21:30	30	13431	10698	20.05	15.97	0.0394	0.03 1	4.41	4	9	153	115
05/20/93	22:45	15	3758	3041	11.22	9.08	0.0220	0.018	4.41	5	3	45	31
05/20/93	23:45	15	6049	4538	18.06	13.55	0.0355	0.027	4.41	7	4	71	84
05/20/93	00:45	15	5184	2239	15.48	6.69	0.0304	0.013	4.41	9	2	104	35
05/25/93	19:30	30	118	15246	0.18	22.76	0.0299	0.045	3.95	0	0	0	0
05/25/93	20:30	30	13393	17694	20.00	26.42	0.0393	0.052	3.95	0	1	7	5

TABLE A5. (continued).

05/25/93	21:30	30	6756	14632	10.09	21.84	0.0198	0.043	3.95	0	0	88	119
05/25/93	22:30	15	4981	6940	14.87	20.72	0.0292	0.04 1	3.95	0	3	47	52
05/25/93	23:30	15	5137	7243	15.34	21.63	0.030 1	0.042	3.95	0	0	41	233
05/25/93	00:30	15	5293	6987	15.80	20.86	0.03 10	0.04 1	3.95	0	0	58	89
05/27/93	19:00	30	8628	12546	12.88	18.73	0.0253	0.037	3.77	0	0	0	0
05/27/93	20:oo	30	7271	10981	10.86	16.39	0.0213	0.032	3.77	0	0	0	0
05/27/93	21:oo	30	60	11460	0.09	17.11	0.0235	0.034	3.77	0	0	43	54
05/27/93	22:oo	15	127	7178	0.38	21.43	0.0235	0.042	3.77	0	0	53	78
05/27/93	23:00	15	78	5963	0.23	17.80	0.0235	0.035	3.77	3	0	51	55
05/27/93	00:00	15	4095	6155	12.23	18.38	0.0240	0.036	3.77	0	0	86	153
06/01/93	20:oo	30	21033	10815	31.40	16.15	0.0617	0.032	3.31	0	0	16	16
06/01/93	20:30	30	9668	3600	14.43	5.37	0.0283	0.011	3.31	0	0	0	1
06/01/93	21:oo	30	12545	2413	18.73	3.60	0.0368	0.007	3.31	0	0	2	0
06/01/93	21:30	30	14320	5311	21.38	7.93	0.0420	0.016	3.31	0	0	19	9
06/01/93	22:oo	30	1590	862	2.37	1.29	0.0350	0.013	3.31	0	0	2	7
06/01/93	22:30	30	12556	4213	18.75	6.29	0.0368	0.012	3.31	0	0	23	24
06/01/93	23:00	30	10139	3208	15.14	4.79	0.0297	0.009	3.31	0	0	38	34
06/01/93	23:30	30	10758	2972	16.06	4.44	0.03 15	0.009	3.31	1	0	24	30
06/01/93	00:00	30	12520	2722	18.69	4.06	0.0367	0.008	3.31	0	1	14	21
06/01/93	00:30	30	12009	4390	17.93	6.55	0.0352	0.013	3.31	0	0	24	24
06/03/93	20:oo	30	32203	43270	48.08	64.60	0.0944	0.127	3.12	0	0	4	0
06/03/93	20:30	30	39358	51336	58.76	76.64	0.1154	0.150	3.12	0	0	50	12
06/03/93	21:oo	30	31627	3983 1	47.22	59.47	0.0927	0.117	3.12	0	0	138	28
06/03/93	22:20	10	11404	15395	51.08	68.95	0.1003	0.135	3.12	0	0	82	106
06/03/93	23:20	10	10323	14669	46.24	65.70	0.0908	0.129	3.12	0	0	50	127
06/03/93	00:20	10	11918	12419	53.38	55.62	0.1048	0.109	3.12	0	0	26	0
06/08/93	19:30	30	46218	66994	69.00	100.02	0.1355	0.196	2.66	0	0	9	13
06/08/93	20:oo	30	53955	69074	80.55	103.12	0.1582	0.202	2.66	0	0	18	11
06/08/93	20:30	30	49646	64839	74.12	96.80	0.1455	0.190	2.66	0	0	173	116
06/08/93	21:50	10	18383	23 152	82.33	103.69	0.1617	0.204	2.66	0	0	361	321
06/08/93	22:55	5	6502	8707	58.24	77.99	0.1144	0.153	2.66	0	0	172	226
06/08/93	23:55	5	7719	11110	69.14	99.52	0.1358	0.195	2.66	0	0	201	222

TABLE A5. (continued).

06/08/93	00:55	5	8007	11293	71.72	101.16	0.1408	0.199	2.66	0	0	276	224
06/08/93	01:55	5	8520	11492	76.32	102.94	0.1499	0.202	2.66	0	0	226	160
06/10/93	20:oo	30	42868	54963	64.00	82.06	0.1257	0.161	2.48	0	0	2	6
06/10/93	20:30	30	43015	55297	64.22	82.56	0.1261	0.162	2.48	0	0	11	5
06/10/93	21:oo	30	39684	55320	59.25	82.59	0.1163	0.162	2.48	0	0	146	98
06/10/93	22:20	10	12727	16932	57.00	75.84	0.1119	0.149	2.48	0	0	134	147
06/10/93	23:25	5	6604	9049	59.16	81.06	0.1162	0.159	2.48	0	0	104	58
06/10/93	00:25	5	6819	9580	61.08	85.81	0.1199	0.168	2.48	0	0	138	93
06/10/93	01:25	5	6157	9744	55.15	87.28	0.1083	0.171	2.48	0	0	113	157
06/15/93	19:30	31	33746	48869	48.76	70.6 1	0.0957	0.139	2.10	0	0	3	2
06/15/93	20:o 1	29	26944	35443	41.61	54.74	0.0817	0.107	2.10	0	0	2	0
06/15/93	20:30	30	19709	37295	29.42	55.68	0.0578	0.109	2.10	0	0	2	1
06/15/93	21:oo	30	21153	33634	31.58	50.2 1	0.0620	0.099	2.10	0	0	10	9
06/15/93	21:30	30	25376	3533 1	37.88	52.75	0.0744	0.104	2.10	0	0	82	60
06/15/93	22:55	5	4446	5755	39.83	51.55	0.0782	0.101	2.10	0	0	81	20
06/15/93	23:55	5	6041	6694	54.11	59.96	0.1063	0.118	2.10	0	0	282	225
06/15/93	00:55	5	5141	6400	46.05	57.33	0.0904	0.113	2.10	0	0	145	123
06/17/93	20:oo	30	584	275	0.87	0.41	0.0891	0.121	2.10	0	0	2	2
06/17/93	20:30	30	27996	42339	41.80	63.2 1	0.082 1	0.124	2.10	0	0	5	2
06/17/93	21:oo	30	33984	46472	50.74	69.38	0.0996	0.136	2.10	0	0	138	34
06/17/93	21:30	30	30527	42926	45.58	64.09	0.0895	0.126	2.10	0	0	238	110
06/17/93	22:55	5	4958	7139	44.4 1	63.95	0.0872	0.126	2.10	0	0	321	177
06/17/93	23:55	5	5017	6715	44.94	60.15	0.0882	0.118	2.10	0	0	126	180
06/17/93	00:55	5	4991	4554	44.7 1	40.79	0.0878	0.080	2.10	0	0	0	0
06/22/93	21:27	20	20725	33329	46.4 1	71.08	0.09 11	0.140	2.10	0	0	86	70
06/22/93	22:27	*16*	14861	28188	41.60	74.26	0.0817	0.146	2.10	0	0	641	1364
06/22/93	23:28	4	4842	8085	54.22	72.42	0.1065	0.142	2.10	0	0	445	464
06/22/93	00:26	5	4438	8923	39.75	79.93	0.078 1	0.157	2.10	0	0	269	216
06/29/93	19:30	30	17049	39448	25.45	58.89	0.0500	0.116	2.10	0	0	0	1
06/29/93	20:30	30	29264	3703 1	43.69	55.29	0.0858	0.109	2.10	0	0	1	3
06/29/93	21:30	10	10423	12495	46.68	55.96	0.0917	0.110	2.10	0	0	8	18
06/29/93	22:30	5	5848	8044	52.38	72.06	0.1029	0.141	2.10	0	0	21	28

TABLE A5. (continued).

06/29/93	23:30	5	7562	7955	67.74	7 1.26	0.1330	0.140	2.10	0	0	40	46
06/29/93	00:30	5	6774	8555	60.68	76.63	0.1191	0.150	2.10	0	0	19	37
07/13/93	19:16	30	40359	24677	60.25	36.84	0.1183	0.072	2.10	0	0	0	1
07/13/93	20:16	30	36344	16712	54.11	24.95	0.1062	0.049	2.10	0	0	1	0
07/13/93	21:16	30	37604	28864	55.24	43.09	0.1085	0.085	2.10	0	0	3	15
07/13/93	22:16	10	9044	12114	40.5 1	54.26	0.0795	0.107	2.10	0	0	12	8
07/13/93	23:16	10	9074	10408	40.64	46.62	0.0798	0.092	2.10	0	0	21	29
07/13/93	00:16	10	9314	12807	4 1.72	57.36	0.0819	0.113	2.10	0	0	13	20
07/27/93	19:26	30	34285	20829	51.19	31.10	0.1005	0.06 1	2.10	0	0	1	1
07/27/93	20:26	30	35112	17626	52.42	26.3 1	0.1029	0.052	2.10	0	0	1	1
07/27/93	21:26	30	35946	9391	53.67	14.02	0.1054	0.028	2.10	0	0	2	9
07/27/93	22:26	30	34299	9801	51.21	14.63	0.1005	0.029	2.10	0	0	4	0
07/27/93	23:26	30	3525 1	27857	52.63	41.59	0.1033	0.082	2.10	0	0	8	19
07/27/93	00:26	30	34790	29505	5 1.94	44.05	0.1020	0.086	2.10	0	0	8	15

*Duration values that are italicized were actually one minute longer than indicated.

TABLE A6. Lost River (LR) and shortnose (SN) sucker emigrants captured in paired drift nets in Willow Creek, 1994. Flow meter revolutions less than 1,000 indicated the meter was malfunctioning. When this occurred, the volume sampled was estimated by the average of other samples from the same day or the previous sampling date. Discharge was estimated from monthly changes in lake level.

							Volume sampled		Mean daily	No. fish captured			
	Start	Duration	Flow meter revolutions		Velocity (cm/s)		(m^3/s)		discharge	LR		SN	
Date	time	(min)	Net 1	Net 2	Net 1	Net2	Net 1	Net2	(m^3/s)	Net 1	Net 2	Net1	Net2
03/29/94	19:00	15	16551	17878	49.42	53.38	0.0970	0.1048	0.765	0	0	0	0
03/29/94	20:00	15	18236	20372	54.45	60.83	0.1069	0.1194	0.765	0	0	0	0
03/29/94	2 1:00	15	20667	22807	61.71	68.10	0.1212	0.1337	0.765	2	4	1	1
03/29/94	22:00	15	14226	18056	42.48	53.91	0.0834	0.1059	0.765	4	6	2	0
03/29/94	23:00	15	17432	16561	52.05	49.45	0.1022	0.097 1	0.765	1	9	5	0
03/29/94	00:00	15	17078	17911	50.99	53.48	0.1001	0.1050	0.765	11	13	5	2
04/1 2/94	19:00	15	27	2022	0.08	6.04	0.0002	0.0119	0.170	0	0	0	0
04/12/94	20:00	30	507	2318	0.76	3.46	0.0015	0.0068	0.170	23	111	1	1
04/12/94	21:oo	15	79	2562	0.24	7.65	0.0005	0.0150	0.170	12	23	0	0
04/12/94	22:00	15	71	2860	0.21	8.54	0.0004	0.0168	0.170	11	27	0	0
04/12/94	23:00	15	820	2938	2.45	8.77	0.0048	0.0172	0.170	22	37	0	0
04/ 12/94	00:00	15	279	3291	0.83	9.83	0.0016	0.0193	0.170	31	36	0	0
04/25/94	2 1 :00	15	1052	—	3.14	---	0.0062	—	0.170	29	---	0	---
04/25/94	22:oo	15	2313	—	6.91	---	0.0136	—	0.170	29	---	0	---
04/25/94	23:00	15	1375	—	4.11	---	0.008 1	—	0.170	12	---	0	---
04/25/94	00:00	15	1632	—	4.87	---	0.0096	—	0.170	12	---	0	---
05/09/94	20:oo	15	2080	—	6.21	---	0.0122	—	0.170	0	---	0	---
05/09/94	2 1 :00	15	5665	—	16.92	---	0.0332	—	0.170	0	---	0	---
05/09/94	22:oo	15	6747	---	20.15	---	0.0396	---	0.170	0	---	0	---
05/09/94	23:00	15	2620	—	7.82	---	0.0154	---	0.170	0	---	0	---

TABLE A7. Lost River (LR) and shortnose (SN) sucker larvae captured from Willow Creek in paired drift nets, 1995. Discharge was recorded at a gaging station upstream of the sample site. Low-flow propellers were used on the flow meters from 24 May 23:04 to 6 June 1: 10. Odd numbered nets were located on the left side of the river, even numberd nets were located on the right side.

Date	Start Time	Net	Duration no. (1)	Flow meter revolution8	Revolutions per second	Water velocity (cm/s)	Volume sampled (m3/s)	Mean daily discharge (m^3/s)	No. LR and SN Captured
4/12/95	21:55	1	1800	26881	14.9	40.1319	0.0788	12.88	1
4/12/95	21:50	2	2460	46295	18.8	50.5726	0.0992	12.88	12
4/12/95	23:06	3	1980	24454	12.4	33.1895	0.0651	12.88	2
4/12/95	23:03	4	2280	37120	16.3	43.75 12	0.0859	12.88	1
4/13/95	0:12	5	2160	15248	7.1	18.9704	0.0372	12.88	0
4/13/95	0:10	6	2160	39649	18.4	49.3282	0.0968	12.88	9
4/13/95	1:24	7	1860	27186	14.6	39.2780	0.077 1	12.88	6
4/13/95	1:21	8	2220	42509	19.1	51.4570	0.1010	12.88	9
4/19/95	21:23	1	1620	17794	11.0	29.5172	0.0579	10.05	1
4/19/95	21:19	2	1920	14998	7.8	20.9918	0.0412	10.05	1
4/19/95	22:23	3	1740	3942	2.3	6.0881	0.0119	10.05	0
4/19/95	22:21	4	1980	22461	11.3	30.4846	0.0598	10.05	2
4/19/95	23:29	5	1560	16897	10.8	29.1073	0.0571	10.05	2
4/19/95	23:27	6	1800	11259	6.3	16.8091	0.0330	10.05	4
4/20/95	0:38	7	1440	6891	4.8	12.8599	0.0252	10.05	0
4/20/95	0:36	8	1620	14857	9.2	24.6452	0.0484	10.05	1
4/26/95	22:05	1	1800	10672	5.9	15.9327	0.0313	5.29	3
4/26/95	22:02	2	2040	10504	5.1	13.8370	0.0272	5.29	4
4/26/95	23:06	3	1980	11066	5.6	15.0190	0.0295	5.29	6
4/26/95	23:09	4	1920	5407	2.8	7.5678	0.0149	5.29	2
4/27/95	0:10	5	1800	14754	8.2	22.0269	0.0432	5.29	3
4/27/95	0:08	6	1980	16036	8.1	21.7644	0.0427	5.29	9
4/27/95	1:12	7	1680	13690	8.1	21.8983	0.0430	5.29	5
4/27/95	1:10	8	1860	138%	7.5	20.0768	0.0394	5.29	2
4/27/95	2:10	9	1740	15223	8.7	23.5108	0.0461	5.29	10
4/27/95	2:09	10	1860	14712	7.9	21.2557	0.0417	5.29	3
5/3/95	21:57	1	1980	51069	25.8	69.3121	0.1360	18.12	10
5/3/95	21:59	2	1800	51028	28.3	76.1820	0.1495	18.12	9
5/3/95	23:01	3	1800	49275	27.4	73.5649	0.1444	18.12	5
5/3/95	23:04	4	1740	44761	25.7	69.1301	0.1357	18.12	25
5/4/95	0:04	5	1800	47185	26.2	70.4447	0.1382	18.12	10
5/4/95	0:06	6	1860	46538	25.0	67.2375	0.1320	18.12	23
5/4/95	1:05	7	1800	42000	23.3	62.7037	0.1231	18.12	10
5/4/95	1:07	8	1560	40541	26.0	69.8371	0.1371	18.12	21
5/4/95	2:08	9	1860	44463	23.9	64.2395	0.1261	18.12	16
5/4/95	2:09	10	1740	45097	25.9	69.6490	0.1367	18.12	18
5/8/95	21:56	1	2100	41586	19.8	53.2163	0.1044	13.59	14
5/8/95	22:00	2	1800	35495	19.7	52.9921	0.1040	13.59	6
5/8/95	23:01	3	1920	37376	19.5	52.3128	0.1027	13.59	5
5/8/95	23:02	4	1800	34752	19.3	51.8829	0.1018	13.59	13
5/9/95	0:04	5	1800	36437	20.2	54.3985	0.1068	13.59	7
5/9/95	0:05	6	1680	33052	19.7	528695	0.1038	13.59	9
5/9/95	1:01	7	1920	38946	20.3	54.5103	0.1070	13.59	11
5/9/95	1:02	8	1800	32164	17.9	48.0191	0.0942	13.59	10
5/9/95	1:58	9	1920	372.34	19.4	52.1141	0.1023	13.59	11
5/9/95	1:59	10	1800	33345	18.5	49.7823	0.0977	13.59	7
5/17/95	22:07	1	2100	5990	2.9	7.6652	0.0150	5.10	35
5/17/95	22:10	2	1800	13352	7.4	19.9338	0.0391	5.10	86
5/17/95	23:08	3	2040	6065	3.0	7.9895	0.0157	5.10	26
5/17/95	23:09	4	1860	12213	6.6	17.6452	0.0346	5.10	63
5/18/95	0:12	5	1920	9759	5.1	13.6591	0.0268	5.10	107

TABLE A7. (continued).

5/18/95	0:14	6	1740	12145	7.0	18.7571	0.0368	5.10	96
5/18/95	1:14	7	1980	8719	4.4	11 .8336	0.0232	5.10	81
5/18/95	1:16	8	1740	11448	6.6	17.6806	0.0347	5.10	83
5/18/95	2:15	9	1980	13169	6.7	17.8733	0.035 1	5.10	53
5/18/95	2:17	10	1740	10506	6.0	16.2257	0.0318	5.10	82
5/24/95	22:03	1	1980	189	0.1	0.2565	0.0005	2.18	9
5/24/95	22:06	2	1680	1493	0.9	23882	0.0047	2.18	10
5/24/95	23:04	3	1920	3560	1.9	9.4600	0.0186	218	21
5/24/95	23:05	4	1740	3651	2.1	10.7054	0.0210	218	24
5/25/95	0:09	5	1860	3070	1.7	8.421 I	0.0165	218	34
5/25/95	0:10	6	1860	3577	1.9	9.8118	0.0193	218	8
5/25/95	1:06	7	2100	2346	1.1	5.6997	0.0112	2.18	27
5/25/95	1:07	8	1980	3923	2.0	10.1087	0.0198	218	20
5/25/95	2:10	9	1860	2771	1.5	7.6009	0.0149	2.18	15
5/25/95	2:11	10	1860	3213	1.7	8.8133	0.0173	2.18	32
6/1/95	22:02	1	2280	792	0.3	1.7723	0.0035	1.44	1
6/1/95	22:08	2	1860	161	0.1	0.4416	0.0009	1.44	0
6/1/95	23:05	3	2040	1548	0.8	3.8715	0.0076	1.44	5
6/1/95	23:06	4	1920	1588	0.8	4.2198	0.0083	1.44	8
6/2/95	0:00	5	1980	477	0.2	1.2291	0.0024	1.44	7
6/2/95	0:01	6	1860	1213	0.7	3.3273	0.0065	1.44	8
6/2/95	1:00	7	1920	366	0.2	0.9726	0.0019	1.44	10
6/2/95	1:01	8	1800	650	0.4	1.8424	0.0036	1.44	8
6/2/95	2:01	9	1920	125	0.1	0.3322	0.0007	1.44	12
6/2/95	2:02	10	1800	118	0.1	0.3345	0.0007	1.44	3
6/5/95	22:30	1	1920	-329	-0.2	0.8742	0.0017	1.30	0
6/5/95	22:31	2	1800	29	0.0	0.0822	0.0002	1.30	0
6/5/95	23:05	3	1860	4%	0.3	1.3605	0.0027	1.30	0
6/5/95	23:08	4	1620	5	0.0	0.0157	0.0000	1.30	0
6/6/95	0:09	5	2520	558	0.2	1.1297	0.0022	1.30	1
6/6/95	0:15	6	1980	12	0.0	0.0309	0.0001	1.30	0
6/6/95	1:09	7	1920	525	0.3	1.3951	0.0027	1.30	0
6/6/95	1:10	8	1800	40	0.0	0.1134	0.0002	1.30	1
6/12/95	18:23	1	1920	28150	14.7	39.3998	0.0773	1.05	0
6/12/95	18:25	2	1740	26381	15.2	40.7435	0.0800	1.05	1
611295	19:20	3	1980	29286	14.8	39.7476	0.0780	1.05	2
6/12/95	19:21	4	1860	26059	14.0	37.6497	0.0739	1.05	3
6/12/95	20:21	5	1860	26821	14.4	38.7506	0.0760	1.05	4
6/12/95	20:22	6	1740	25458	14.6	39.3 180	0.0772	1.05	5
6/12/95	21:17	7	1740	25142	14.4	38.8300	0.0762	1.05	6
6/12/95	21:15	8	1740	25047	14.4	38.6833	0.0759	1.05	1
6/12/95	22:09	9	1920	2543 1	13.2	35.5942	0.0699	1.05	2
6/12/95	22:10	10	1800	26659	14.8	39.8004	0.078 1	1.05	4
6/12/95	23:10	11	1980	24092	12.2	32.6982	0.0642	1.05	2
6/12/95	23:11	12	1800	29102	16.2	43.4471	0.0853	1.05	0
6/13/95	0:05	13	1920	24418	12.7	34.1763	0.0671	1.05	2
6/13/95	0:07	14	1680	20799	12.4	33.2698	0.0653	1.05	0
6/13/95	1:04	15	1680	19314	11.5	30.8944	0.0606	1.05	0
6/13/95	1:01	16	1740	25566	14.7	39.4848	0.0775	1.05	0
6/13/95	2:00	17	1860	15324	8.2	22.1399	0.0434	1.05	0
6/13/95	2:01	18	1740	25644	14.7	39.6053	0.0777	1.05	0
6/13/95	3:01	19	1800	20762	11.5	30.9965	0.0608	1.05	0
6/13/95	3:03	20	1620	25829	15.9	42.8459	0.0841	1.05	0
6/13/95	4:01	21	1680	22418	13.3	35.8595	0.0704	1.05	0
6/13/95	4:00	22	1680	23222	13.8	37.1456	0.0729	1.05	0
6/13/95	4:58	23	1980	18232	9.2	24.7449	0.0486	1.05	0
6/13/95	4:59	24	1860	29829	16.0	43.0965	0.0846	1.05	0

A7. (continued).

95	5:59	25	1860	23326	12.5	33.7011	0.0661	1.05	0
95	6:00	26	1860	30072	16.2	43.4476	0.0853	1.05	0
95	6:59	27	1980	22081	11.2	29.9689	0.0588	1.05	0
95	7:00	28	2040	30994	15.2	40.8286	0.080 1	1.05	0
95	8:00	29	1740	20663	11.9	31.9125	0.0626	1.05	0
95	8:01	30	1740	17970	10.3	27.7534	0.0545	1.05	0
95	8:59	31	1860	22774	122	329036	0.0646	1.05	0
95	9:00	32	1860	29262	15.7	422773	0.0830	1.05	0
95	10:00	33	1860	23132	12.4	33.4208	0.0656	1.05	0
95	10:01	34	1860	29622	15.9	42.7975	0.0840	1.05	0
95	11:01	35	1860	24502	13.2	35.4002	0.0695	1.05	0
95	11:02	36	1860	26998	14.5	39.0063	0.0765	1.05	0
95	12:00	37	1800	20847	11.6	31.1234	0.0611	1.05	0
95	12:00	38	1860	26651	14.3	38.5050	0.0756	1.05	0
95	13:00	39	1800	23756	13.2	35.4664	0.06%	1.05	0
95	13:01	40	1800	27777	15.4	41.46%	0.0814	1.05	0
95	14:00	41	1860	23303	12.5	33.6679	0.0661	1.05	0
95	14:01	42	1860	26530	14.3	38.3302	0.0752	1.05	0
95	15:00	43	1800	18026	10.0	26.9118	0.0528	1.05	0
95	15:01	44	1800	24605	13.7	36.7339	0.0721	1.05	0
95	16:02	45	1680	19106	11.4	30.5617	0.0600	1.05	0
95	16:02	46	1740	22040	12.7	34.0392	0.0668	1.05	0
95	16:59	47	1860	22509	12.1	32.5207	0.0638	1.05	0
95	17:00	48	1860	23194	12.5	33.5104	0.0658	1.05	0
95	17:58	49	1860	22460	12.1	32.4499	0.0637	1.05	0
95	17:59	50	1860	26099	14.0	37.7075	0.0740	1.05	0

TABLE A8. Daily emigration pattern of larval and juvenile Lost River and shortnose suckers in Willow Creek (based on mean values of1993). For time periods not shown, we assumed no fish were emigrating.

	Percentage of total daily emigration	
Time period	Lost River	Shortnose
18:31-19:00	0.000	0.000
19:01-19:30	0.484	0.058
19:31-20:00	0.908	0.103
20:01-20:30	0.666	0.158
20:31-21:00	2.42 1	0.492
21:01-21:30	2.724	1.813
21:31-22:00	4.479	3.33 1
22:01-22:30	4.479	5.599
22:31-23:00	8.717	7.597
23:01-23:30	11.320	9.93 1
23:31-00:00	12.712	12.412
00:01-00:30	10.593	10.598
00:31-01:00	8.354	8.625
01:01-01:30	6.961	7.890
01:31-02:00	5.751	6.974
02:01-02:30	4.964	6.105
02:31-03:00	4.298	5.23 1
03:01-03:30	3.450	4.359
03:31-04:00	2.724	3.489
04:01-04:30	1.937	2.617
04:31-05:00	1.332	1.746
05:01-05:30	0.726	0.874
05:31-06:00	0.000	0.000