

Prepared in cooperation with the Bureau of Reclamation

**Spawning Migration Movements of Lost River and Shortnose
Suckers in the Williamson and Sprague Rivers, Oregon,
Following the Removal of Chiloquin Dam—2009 Annual Report**

Open-File Report 2011-1147

Spawning Migration Movements of Lost River and Shortnose Suckers in the Williamson and Sprague Rivers, Oregon, Following the Removal of Chiloquin Dam—2009 Annual Report

By Craig M. Ellsworth and Scott P. VanderKooi

Prepared in cooperation with the Bureau of Reclamation

Open-File Report 2011-1147

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit <http://www.usgs.gov> or call 1-888-ASK-USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit <http://www.usgs.gov/pubprod>

To order this and other USGS information products, visit <http://store.usgs.gov>

Suggested citation:
Ellsworth, C.M., and VanderKooi S.P., 2011, Spawning migration movements of Lost River and shortnose suckers in the Williamson and Sprague Rivers, Oregon, following the removal of Chiloquin Dam—2009 Annual Report: U.S. Geological Survey Open-File Report 2011-1147, 20 p.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted material contained within this report.

Contents

Abstract	1
Introduction.....	2
Background.....	2
Chiloquin Dam and its Effects	3
Current Study.....	4
Description of Study Area	4
Study Methods.....	5
Fish Collection, Radio Tags, and Surgical Procedures	5
Fish Tracking and Data Collection	6
Data Analysis	6
Results of Data Analyses.....	7
Lost River Sucker.....	7
Shortnose Sucker	8
Radio Tag Retention and Gear Performance.....	8
Sucker Spawning and Migration Patterns.....	9
Conclusions	11
Acknowledgments	11
References Cited	12

Figures

Figure 1. Map of the study area showing locations of remote telemetry stations used to determine the spawning area distribution and movements of Lost River and shortnose suckers in the Williamson and Sprague Rivers, Oregon, 2009	14
Figure 2. Farthest upstream detections of individual radio-tagged Lost River suckers released upstream of the Williamson River fish weir, Oregon, 2009	15
Figure 3. Farthest upstream detections of individual radio-tagged shortnose suckers released upstream of the Williamson River fish weir, Oregon, 2009	16

Tables

Table 1. Number of radio-tagged Lost River suckers and shortnose suckers released upstream of the Williamson River fish weir and detected at three remote telemetry stations in the lower Williamson and Sprague Rivers, Oregon, 2009	18
Table 2. Time spent upstream of the Williamson River fish weir, in the Sprague River, and within range of the telemetry receiver and the number of approaches on the dam site for radio-tagged Lost River and shortnose suckers prior to the removal of Chiloquin Dam (2006 and 2007; Ellsworth and others, 2007b; U.S. Geological Survey, unpub. data, 2007) and after its removal (2009), Oregon	19

Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
square centimeter (cm ²)	0.1550	square inch (ft ²)
square kilometer (km ²)	0.3861	square mile (mi ²)
Volume		
liter (L)	0.2642	gallon (gal)
cubic meter (m ³)	35.31	cubic foot (ft ³)
Flow rate		
meter per second (m/s)	3.281	foot per second (ft/s)
cubic meter per second (m ³ /s)	35.31	cubic foot per second (ft ³ /s)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to temperatures in degrees Fahrenheit (°F) by using the equation: °F=(1.8×°C)+32.

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Spawning Migration Movements of Lost River and Shortnose Suckers in the Williamson and Sprague Rivers, Oregon, Following the Removal of Chiloquin Dam—2009 Annual Report

By Craig M. Ellsworth and Scott P. VanderKooi

Abstract

The Chiloquin Dam was located at river kilometer (rkm) 1.3 on the Sprague River near the town of Chiloquin, Oregon. The dam was identified as a barrier that potentially inhibited or prevented the upstream spawning migrations and other movements of endangered Lost River suckers (*Deltistes luxatus*), shortnose suckers (*Chasmistes brevirostris*), and other fish in the Sprague River. Our research objectives in 2009 were to evaluate adult catostomid spawning migration patterns using radio telemetry to identify and describe shifts in spawning area distribution and migration behavior following the removal of Chiloquin Dam in 2008. We attached external radio transmitters to 58 Lost River suckers and 59 shortnose suckers captured at the Williamson River fish weir. A total of 17 radio-tagged Lost River suckers and one radio-tagged shortnose sucker were detected approaching the site of the former Chiloquin Dam but only two radio-tagged fish (one male Lost River sucker and one female Lost River sucker) were detected crossing upstream of the dam site. A lower proportion of radio-tagged shortnose suckers were detected migrating into the Sprague River when compared with previous years. Detections on remote passive integrated transponder (PIT) tag arrays located in the Sprague River show that although the proportion of fish coming into the Sprague River is small when compared to the number of fish crossing the Williamson River fish weir, the number of fish migrating upstream of the Chiloquin Dam site increased exponentially in the first year since its removal. These data will be used in conjunction with larval production and adult spawning distribution data to evaluate the effectiveness of dam removal in order to provide increased access to underutilized spawning habitat located further upstream in the Sprague River and to reduce the crowding of spawning fish below the dam site.

Introduction

Background

The upper Klamath Basin in south-central Oregon has several endemic fish species, two of which, Lost River sucker and shortnose sucker, were listed under the Endangered Species Act in 1988 (U.S. Fish and Wildlife Service, 2002). A third catostomid, Klamath largescale sucker, also is an upper Klamath Basin endemic and has been identified by the U.S. Fish and Wildlife Service (USFWS) as a species of concern (Oregon Natural Heritage Information Center, 2004). Like other lakesuckers of western North America (that is, cui-ui *Chasmistes cujus* and June sucker *Chasmistes liorus*), the Lost River sucker and shortnose sucker are long-lived (up to 40 years) obligatory lake dwellers that use the primary tributaries of the lakes they are found in for spawning (Koch, 1973; Scoppettone, 1988; Scoppettone and Vinyard, 1991; Moode and Muirhead, 1994; Cooperman and Markle, 2003). Most Lost River and shortnose suckers entering the Williamson River, a major tributary to Upper Klamath Lake, during their spring spawning migrations are believed to spawn on the shallow riffles in the lower Williamson River from the Williamson River fish weir at rkm (river kilometer) 9.5 (fig. 1) up to the confluence with the Sprague River (rkm 17.7) and in the Sprague River up to the Chiloquin Dam site (figs. 2 and 3). Some movement of Lost River suckers and shortnose suckers through the Chiloquin Dam fish ladder had been documented and catostomid eggs and larvae tentatively identified as belonging to these species have been collected from reaches above the dam (Perkins and others, 2000; Ellsworth and others, 2008; Ellsworth and others, 2009). Unlike Lost River suckers or shortnose suckers, Klamath largescale suckers are believed to be more of a riverine species, although they can be found in Upper Klamath Lake as well (Moyle, 2002). They too display an upstream migratory behavior in the early spring that is believed to be associated with a spawning migration from the lower reaches of the Williamson and Sprague Rivers to the upper reaches of the Sprague River drainage. Early radio telemetry studies have provided some descriptions of catostomid spawning migrations within the Williamson-Sprague River system (Buettner and Scoppettone, 1990; C. Bienz, The Nature Conservancy, written commun., 2004). Most radio-tagged Lost River suckers and shortnose suckers entering the Williamson River from Upper Klamath Lake were located in the lower Williamson River up to the confluence with the Sprague River (rkm 9.5 to 17.5) and in the lower Sprague River downstream of Chiloquin Dam (rkm 0 to 1.3). These studies documented some movement of catostomids through the Chiloquin Dam fish ladder and some radio-tagged Klamath largescale suckers and Lost River suckers were found migrating as far upstream as Beatty Gap (fig.1).

Chiloquin Dam and its Effects

Chiloquin Dam was located at river kilometer (rkm) 1.3 on the Sprague River and approximately 19 rkm upstream of Upper Klamath Lake (fig. 1). The dam was constructed in 1914 to serve as a diversion structure to supply irrigation water for the Modoc Point Irrigation District. After its construction, the dam was fitted with three fish ladders to aid in fish passage, only one of which was functional at the time of the dam's removal in August 2008. This fish ladder was built in 1966 and had been modified with baffle boards in an attempt to provide better passage for catostomids. The ladder consisted of a series of 10 concrete pools with an average drop of approximately 0.3 m between each pool. Data from PIT tag antennas installed at the ladder in 2008 indicated that passage for suckers migrating upstream was low. In this year only 11 of 871 PIT tagged Lost River suckers and 98 of 764 PIT tagged suckers shortnose suckers detected entering the ladder were successfully able to negotiate the ladder and continue upstream (U.S. Geological Survey, unpub. data, 2008).

Limited fish passage at Chiloquin Dam to upstream spawning habitats was identified as one of the primary factors limiting the recovery of the federally listed endangered Lost River sucker and shortnose sucker populations in Upper Klamath Lake (U.S. Fish and Wildlife Service, 2002; National Research Council, 2004). Additionally, these fish passage issues at Chiloquin Dam probably affect the migratory patterns of other fishes found in the Sprague River drainage including Klamath largescale suckers (*Catostomus snyderi*), redband trout (*Oncorhynchus mykiss* ssp.), and several species of endemic lamprey (*Lampetra* sp.). The Bureau of Reclamation (Reclamation) was authorized to study the feasibility of improving fish passage at Chiloquin Dam by a provision in the 2002 U.S. Farm Bill. Through this provision, a technical working group with representatives from federal, state, and local agencies and organizations was formed and reached consensus that dam removal would be the recommended fish passage alternative. Although existing data suggest some fish may have been able to successfully negotiate the dam's fish ladder under certain flow and temperature conditions, the working group concluded that dam removal would improve access for all fish species in the Sprague River to upstream spawning and rearing habitat. The amount of suitable habitat and the extent that fish would use spawning and rearing habitat upstream of the dam at the time of this recommendation was largely unknown.

Current Study

The USGS, in cooperation with the Bureau of Reclamation, has been investigating spawning run movements of Lost River suckers (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*) in the Williamson and Sprague Rivers prior to and after the removal of Chiloquin Dam. From 2004 to 2007, personnel of the USGS Klamath Falls Field Station fitted a combined total of 92 Klamath largescale suckers, 251 Lost River suckers, and 289 shortnose suckers with radio transmitters and released them both upstream and downstream of the dam to identify spawning area distribution and to evaluate migrational behavior during the spawning run of each respective species (Ellsworth and others, 2007a; Ellsworth and others, 2007b; Tyler and others, 2007). Findings from this study are expected to help assess changes in distribution and migratory behavior of catostomids in the Sprague River with the removal of Chiloquin Dam. This study was funded by the Bureau of Reclamation U.S. Department of Interior (Interagency Agreement 07AA200144, Modification 002) and the U.S. Geological Survey. Funding was provided by Reclamation as part of its mission to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. This report presents results of the analyses of data collected on the Sprague and Williamson Rivers in 2009.

Description of Study Area

Upper Klamath Lake is a remnant of the Pleistocene Lake Modoc on the eastern side of the Cascade Mountain Range in south-central Oregon. At full capacity, Upper Klamath Lake has a surface area of 259 km², making it one of the largest freshwater lakes in the western United States (Dicken, 1980). Although Upper Klamath Lake has a large surface area, it is relatively shallow, with an average depth of only 2.4 m. Historical records indicate that Upper Klamath Lake had been eutrophic prior to early Anglo settlement (Wood and others, 2006); however, it has since become hypereutrophic, due primarily to high nutrient loading from various land-use practices (U.S. Fish and Wildlife Service, 2002). This is a condition that promotes high production of the blue-green alga *Aphanizomenon flos-aquae*, which leads to subsequent deterioration of water quality and occasional fish kills.

The Sprague River originates to the east of Upper Klamath Lake in the Gearhart and Quartz mountains and drains an area of approximately 4,092 km². The Sprague River is a low gradient stream (approximately 0.4m/km) characterized by broad valleys with extensive riverine meanders interspaced with low canyons or gaps created by uplifts or block faulting geology. Associated with these uplifted areas is an upwelling of groundwater that discharges to the Sprague River as it cuts through these formations (Gannett and others, 2007). The Sprague River is the principal tributary of the Williamson River, which also originates east of Upper Klamath Lake in the Yamsay Mountains. The combined flow of the Williamson and Sprague Rivers provides approximately 50 percent of the annual inflow to Upper Klamath Lake (Kann and Walker, 2001). Both rivers typically exhibit a spring snowmelt hydrograph.

Study Methods

Fish Collection, Radio Tags, and Surgical Procedures

During the spring of 2009, 58 Lost River suckers and 59 shortnose suckers were collected from the upstream trap in the Williamson River fish weir (table 1), fitted with external radio transmitters, and released approximately 100 m upstream of the weir (Telemetry Station 2 in fig. 1). Each fish was identified to species, sex, and spawning condition, measured for fork length, and implanted with a 134 kHz passive integrated transponder (PIT) tag prior to the attachment of a radio transmitter. Species and gender determination for each fish was based on morphological characteristics as described in Markle and others (2005). Adult-size catostomids captured in the upstream trap in the weir in pre-spawn condition were assumed to be on an upstream migration. We also assumed, based on known life history characteristics for these and other closely related species, that upstream movement of these fish during this time of year is associated with spawning activity (Moyle, 2002). As an additional way of confirming spawning activity, a concurrent USGS project was conducted to monitor larval catostomid drift in the Sprague and lower Williamson Rivers to determine if larvae were emigrating from the reaches where we located adult fish. Data on larval drift collected during 2009 are planned to be presented in a separate report.

Fish selected for tagging were all in pre-spawn condition (no expression of gametes when lightly squeezed) and were previously unmarked in USGS adult monitoring efforts as indicated by a lack of a PIT tag. Minimum fork length for fish selected for tagging was 350 mm. Fish were tagged and released over the duration of each species' spawning migration through the Williamson River fish weir. Each fish was fitted with a small submersible external radio transmitter (Lotek MCFT-3A) measuring approximately 52×16 mm. This tag had similar transmitting capabilities and size and weight characteristics as the tag model (Grant Systems Pisces tag) used in previous years of this study. Tagging protocols for 2009 did not differ from tagging protocols used in previous years. Tags were programmed to transmit on one of two different frequencies (164.290 MHz and 164.310 MHz) and each tag was set to generate a unique coded identifier. Field tests for these tags showed that codes could be determined at a distance of approximately 100 m at ground level and approximately 600 m from a plane flying at 300 m elevation. External rather than internal radio transmitters were used to minimize surgically induced stress on these fish as they were preparing to spawn.

Each fish to be fitted with a radio transmitter was first lightly anesthetized by placing it in a mixture of 0.1 g Tricaine Methane Sulfonate (MS-222) to 1 L river water. The radio transmitters were attached externally to the fish at the dorsal fin by threading anchor material (8.2-kg test nylon-coated, seven-strand stainless steel wire) through the dorsal pterygiophores with a 15.2 mm, 14-gauge Rosenthal needle. The anchor material was passed through each fish twice for a double-posted attachment technique. Each end of the anchor material was crimped with a stainless-steel sleeve behind a 6.4-cm² plastic backer. Each tagged fish was allowed to recover in a holding tank with a dilute amount of StressCoat® solution for 30 to 60 minutes prior to being released.

Fish Tracking and Data Collection

Fish locations were determined using remote telemetry stations (fig. 1) and biweekly boat surveys. Remote telemetry stations were located on the Williamson River at rkm 4.5 (River Bend) and rkm 9.5 (Williamson River fish weir); on the Sprague River at rkm 0.5 (Chiloquin), rkm 1.3 (Chiloquin Dam), rkm 13.0 (Braymill fish hatchery), rkm 47.1 (the lower end of S'Ocholis Canyon), and rkm 111.4 (the lower end of Beatty Gap); and on the Sycan River at rkm 3.6. A Grant Systems Orion receiver/data logger was used at each remote telemetry station to detect and record fish movements past the station. The reception of each receiver was tested by lowering a weighted radio tag to the bottom of the river at various locations near the station to ensure that a radio-tagged fish crossing the station would be detected. The hardware and location of each remote station was adjusted to maximize our ability to detect fish passing each station. Data were downloaded on a weekly basis to make sure the data loggers were recording data properly. Biweekly boat surveys were conducted during the daytime between the Braymill remote telemetry station and the Williamson River fish weir from April 15 to June 5, 2009. Visual observations of suckers and spawning activity were noted during each boat survey. Radio-tagged fish were located with a Lotek SRX_400 receiver and a hand-held 4-element Yagi antenna during these surveys. Locations of radio-tagged fish and observable spawning activity were determined and recorded using a Global Positioning System (GPS) unit.

Data Analysis

Data collected from fish tracking efforts were stored in an electronic database from which information for individual fish were extracted for processing. Migration destinations were determined from the farthest upstream detection for each individual fish. Time spent above the weir was calculated as the difference in time between when the fish departed the weir heading upstream and when the fish first made regular contact with the weir heading back downstream. Similar time calculations were made for fish migrating into the Sprague River from the telemetry data collected by the receiver located 160 m upstream of the Sprague River's confluence with the Williamson River. Fish movements at the Chiloquin Dam site were determined primarily by analyzing the timing and duration of detections received on the two directional antennas located on either side of the site. A fish's proximity to the site was determined by analyzing signal strength and reception on these two antennas. A fish's approach to the telemetry station was defined as when a fish entered the area where it was detected by at least one antenna for more than 30 consecutive minutes or moved past the station. This time was used in calculating the first detection at the station discussed below. A fish's approach to the site was similarly defined as when a fish entered the area where it was detected on both antennas for this telemetry station for more than 30 consecutive minutes or moved past the station. This time was used in calculating the amount of time spent at the site and for determining the number of approaches made on the site. Departures from the site were defined as when the fish was no longer detected on the respective antennas for more than 10 minutes. All detections of less than 30 minutes with an absentee time of more than 10 minutes were deleted to eliminate noise and code collisions as well as intermittent detections made with fish located on the fringe of the detection limit for the telemetry station.

Results of Data Analyses

Lost River Sucker

Lost River suckers were captured at the Williamson River fish weir from April 9 to May 20, with the greatest number of fish caught from April 10 to April 23 (Hewitt and others, 2011). We fitted 58 Lost River suckers (31 females and 27 males) with radio tags from April 6 to April 27, which encompassed the peak Lost River sucker catch at the weir. The mean (\pm SD) fork length of Lost River suckers fitted with radio transmitters at the weir was 615 ± 23 mm for males and 668 ± 24 mm for females. Lost River suckers captured in the weir and fitted with radio tags were detected in the Williamson and Sprague Rivers primarily downstream of the Chiloquin Dam site. Most (83 percent) of the farthest upstream detections for the radio-tagged Lost River suckers were made on riffles in the Williamson and Sprague Rivers, and more than one-half of these detections (63 percent) were made on the riffles in the Sprague River downstream of the Chiloquin Dam site (fig. 2). Spawning Lost River suckers were observed on all these riffles as well as on three riffles upstream of the dam site at rkms 2.4, 2.8, and 3.2 during daytime telemetry surveys (fig. 2).

We detected approximately the same proportion of radio-tagged Lost River suckers entering the Sprague River in 2009 as in 2006 and 2007 (table 1, Ellsworth and others, 2007b; and U.S. Geological Survey, unpub. data, 2007). In 2009, 53 percent of radio-tagged Lost River suckers released at the weir were detected entering the Sprague River whereas in 2006 and 2007, 51 and 46 percent of the radio-tagged Lost River suckers released from the weir were detected entering the Sprague River. Even though the proportions of radio-tagged Lost River suckers coming into the Sprague River were approximately the same between these years, we did observe a decrease in the proportion of Lost River suckers detected on the remote station at the Chiloquin Dam site in 2009. In 2006 and 2007, 82 and 83 percent of radio-tagged Lost River suckers detected entering the Sprague River were detected approaching the remote telemetry at the dam site whereas only 28 percent were detected at this site in 2009.

Of the 17 Lost River suckers detected by the remote telemetry station located at the dam site, only two radio-tagged Lost River suckers (one male and one female) were detected migrating upstream of the Chiloquin Dam site in 2009. The female Lost River sucker that migrated upstream of the dam site spent 37.3 hours upstream of the dam site and was located 0.5 rkm upstream of the dam site during one of our boating surveys. The male Lost River sucker that migrated upstream of the dam site spent 20.3 hours upstream of the dam site before returning downstream. This fish was not located upstream of the dam site during any of our river surveys. All Lost River suckers detected by the remote telemetry station at the dam site, including the two that crossed upstream, made multiple approaches on this site during their respective spawning runs into the Sprague River.

In 2009, male Lost River suckers spent more time on average upstream of the Williamson River fish weir than did females. Radio-tagged Lost River suckers were first detected in the Sprague River on April 15 and remained in the area until May 13. All radio-tagged Lost River suckers detected entering the Sprague River appeared to remain in the Sprague River until they resumed a downstream migration back into Upper Klamath Lake. The time spent in the Williamson and Sprague Rivers, mean (\pm SD) number of approaches to the Chiloquin Dam site, and amount of time spent within range of the telemetry receiver at the dam site for radio-tagged Lost River suckers followed patterns similar to those observed prior to dam removal (table 2).

Shortnose Sucker

Shortnose suckers were captured in the Williamson River fish weir from March 28 to May 20, with the greatest number of fish caught from April 17 to April 24 and again from May 7 to May 11 (Hewitt and others, 2011). We tagged 59 shortnose suckers (36 females and 23 males) captured in the fish weir from April 13 to May 18, which encompassed the two periods with the highest number of shortnose sucker captures at the fish weir. The mean (\pm SD) fork length of shortnose suckers fitted with radio tags at the weir was 442 ± 27 mm for males and 467 ± 38 mm for females. Most (95 percent) of the farthest upstream detections of radio-tagged shortnose suckers made in 2009 occurred in the Williamson River from the weir to the confluence of the Sprague River (fig. 3). In contrast to Lost River suckers, most (73 percent) of the farthest upstream detections for shortnose suckers were made in pool areas located downstream of the riffles in the Williamson and Sprague Rivers, where spawning was observed during weekly boating surveys. Only three radio-tagged shortnose suckers, or 5 percent of the radio-tagged shortnose suckers released from the weir, were detected entering the Sprague River in 2009 (table 1). Of these three shortnose suckers, only one was detected within range of the telemetry receiving station located at the Chiloquin Dam site in 2009. Signal strength for this fish indicate that it never came within the 100 m range of the receiver and thus did not meet our criteria to be counted as an approach on this station.

As with our observations with Lost River suckers, male shortnose suckers spent more time on average upstream of the Williamson River fish weir than did females in 2009. Radio-tagged shortnose suckers were first detected entering the Sprague River on April 23 and remained in the area until May 22. The time spent in the Williamson River followed patterns similar to those observed prior to dam removal (table 2). The lack of radio-tagged shortnose suckers approaching the remote station at the Chiloquin Dam site in 2009 prevented us from making a comparison between pre- and post-dam removal behavior of shortnose suckers at this site for this year.

Radio Tag Retention and Gear Performance

We recorded 1,811 approaches or crossings of radio-tagged fish at the eight remote telemetry stations deployed in 2009. An analysis of fish movements indicated that only one known fish crossing was not detected. This fish crossing occurred at the Williamson River fish weir on a day when the receiver was not functioning properly. We conducted 13 boat tracking efforts between the Braymill remote telemetry station and the Williamson River fish weir between April 15 and June 5. Only one radio-tagged fish known to be in the survey area was missed during these boat surveys in 2009.

We successfully tracked 94 percent of the fish we fitted with external radio tags until they returned to Upper Klamath Lake at the end of the spawning season. We determined that the remaining 6 percent of tagged fish prematurely shed their tags in the Williamson River during their spawning run. Six of the seven fish were shortnose suckers and we believe that the larger tag used in 2009 may have reduced our ability to get both the attachment sutures anchored in the dorsal pterygiophores on these fish. All seven of the fish that shed their tags were detected on the PIT tag arrays at the Williamson River fish weir on their downstream migration in 2009 and five were detected on the same PIT tag arrays in 2010.

Sucker Spawning and Migration Patterns

Telemetry data collected in 2009 shows that radio-tagged Lost River suckers and shortnose suckers released from the Williamson River fish weir have continued to migrate to the same presumed spawning areas in the Williamson River downstream of its confluence with the Sprague River and to spawning areas in the Sprague River downstream of the site of the former Chiloquin Dam that were identified in the pre-dam removal phase of this study. Although only a small number of fish fitted with radio transmitters crossed upstream of the dam, the proportions of radio-tagged fish and PIT-tagged fish crossing the dam site compared to those remaining downstream of the dam site were similar (Hewitt and others, 2011). Additionally, the larger sample size of PIT-tagged fish clarifies the data collected from radio-tagged fish with respect to the distribution of spawning individuals in the reach where the dam was located. Although the number of PIT tagged suckers detected on the PIT tag arrays located upstream of the dam site in 2009 represent only a relatively small proportion of tagged fish detected crossing the weir, the number of tagged fish crossing the dam site has increased by an order of magnitude when compared to pre-dam removal data (U.S. Geological Survey, unpub. data, 2008). This demonstrates that dam removal has improved access to upstream spawning areas for those fish inclined to migrate to spawning areas upstream of the Chiloquin Dam site. These data also suggest that dam removal has improved conditions for catostomids spawning in the lower Sprague River by reducing crowding during spawning, thereby reducing risks associated with predation, hybridization, and the potential for late-spawning fish to disturb incubating eggs deposited by earlier spawners.

The apparent reduction in the numbers of radio-tagged Lost River, shortnose, and Klamath largescale suckers migrating to suspected spawning areas upstream of Chiloquin Narrows during the post-dam removal phase of our study may be due in large part to the change in tagging location after the dam was removed. Prior to the removal of the dam, fish for this study were collected from the Chiloquin Dam fish ladder, the Williamson River fish weir, lower Williamson River, and Upper Klamath Lake. We found that fish released from the Chiloquin Dam fish ladder tended to migrate farther upriver to suspected spawning areas in Beatty Gap, the Sycan River, the North Fork of the Sprague River, and in the Nine Mile area, as well as spawning areas in the lower Sprague and Williamson Rivers. In contrast, fish released from the Williamson River fish weir, lower Williamson River, and Upper Klamath Lake only migrated to spawning areas in the lower Sprague and Williamson Rivers downstream of Chiloquin Dam. After the removal of the dam and its fish ladder, fish for this study were obtained exclusively at the Williamson River fish weir. This change has likely reduced our ability to capture and tag

those fish more inclined to migrate to suspected spawning areas upstream of Chiloquin Narrows. It appears that the probability of collecting upstream migrants is greatly reduced when fish are selected for tagging at the weir, where all river spawners are available, as compared to those collected at the Chiloquin Dam fish ladder, where upstream migrants probably are more common. The detection of PIT-tagged Lost River, shortnose, and Klamath largescale suckers migrating upstream of the Chiloquin Dam site and the continued collection of sucker larvae emigrating from suspected spawning areas in 2009 indicates these spawning areas are still in use (U.S. Geological Survey, unpub. data, 2009; Hewitt and others, 2011). These data also suggest that no substantial shift in spawning distribution to or from these areas has occurred since the removal of Chiloquin Dam and that there may be some degree of spawning site fidelity for these groups of suckers spawning in the different reaches of the Sprague and lower Williamson Rivers.

We also detected what appears to be some inter-annual variation in the distribution of spawning Lost River and shortnose suckers in the lower Sprague and Williamson Rivers since the inception of this project. Some of this variation appears to be occurring independent of any action associated with the removal of Chiloquin Dam. We continue to see a relatively high percentage of radio-tagged shortnose suckers remaining in and presumably spawning in the Williamson River between the Williamson River fish weir and the confluence with the Sprague River (fig. 3; Buettner and Scopettone, 1990). The proportion of radio-tagged shortnose suckers entering the Sprague River in 2009 was considerably lower than in 2006 or 2007. In 2009, 5 percent of the radio-tagged shortnose suckers released from the weir were detected entering the Sprague River, whereas 38 and 32 percent of radio-tagged shortnose suckers were detected entering the Sprague River in 2006 and 2007, respectively (Ellsworth and others, 2007b; U.S. Geological Survey, unpub. data, 2007). The lower number of radio-tagged shortnose suckers entering the Sprague River may have been influenced by a smaller peak discharge occurring later in the season in 2009 when compared to 2006 and 2007 (fig. 4). We continued to see similar proportions of radio-tagged Lost River suckers entering the Sprague River and being contacted at the Chiloquin Dam site in 2009 when compared to 2006 and 2007. We also found that during our daytime telemetry surveys the farthest upstream detections for radio-tagged shortnose suckers were more likely to occur in pool habitats whereas radio-tagged Lost River suckers were more likely to be found in riffle habitats.

Although the focus of removing Chiloquin Dam was to improve access to additional spawning areas in the Sprague River for Lost River and shortnose suckers, dam removal has likely improved conditions for other fish migrating in the Sprague River as well. A pre-dam removal assessment of catostomid spawning migrations in the Sprague River indicated that Klamath largescale suckers primarily migrated, and presumably spawned, in the upper reaches of the Sprague River (Ellsworth and others, 2007a; Ellsworth and others, 2007b; Tyler and others, 2007). Several years of monitoring passage at the Chiloquin Dam fish ladder indicated that substantial numbers of Klamath largescale suckers attempted to negotiate the ladder each spring (Barry and others, 2007). In 2008, the year prior to the removal of the dam, just 5.4 percent of PIT tagged Klamath largescale suckers remotely detected at the weir were subsequently detected upstream of the dam (U.S. Geological Survey, unpub. data, 2008). In 2009, this percentage increased to 69.6 percent, indicating that the removal of Chiloquin Dam substantially improved access for fish migrating into the upper reaches of the Sprague River.

Conclusions

The removal of Chiloquin Dam appears to have improved access to upstream spawning habitat in the Sprague River for Lost River and shortnose suckers. Access to upstream habitats was likely improved for other migratory fish species found in the Sprague River as well. This action also appears to be having the desired effect of alleviating some of the crowding issues for spawning fish in the reach downstream of the dam. We have not observed substantial changes in migration timing or larval drift for Lost River or shortnose suckers. This suggests that any redistribution of spawning has been largely localized and is likely confined to the reach where the dam was located. A substantial increase in the number of PIT tagged Lost River, shortnose, and Klamath largescale suckers migrating past the dam site was observed in 2009. This evaluation of post-dam removal changes to spawning migrations, however, occurred during a year of below average discharge in the Sprague River and may not represent the full extent of impacts of dam removal on the spawning migrations for the Lost River and shortnose suckers spawning in the lower reaches of the Sprague River. Repetition of this work under higher flow conditions would likely provide a means to better quantify changes in spawning migrations and help natural resource managers evaluate the full impact of dam removal on these endangered fish populations.

Acknowledgments

We thank Josh Murphy and other staff members at the Klamath Falls Field Station for their hard work and dedication in collecting and processing data and reviewing this manuscript. Fish were captured by the U.S. Geological Survey under the scientific sampling permits No. TE007907-10 issued by the U.S. Fish and Wildlife Service and No. 14177 issued by the State of Oregon.

References Cited

- Barry, P.M., Scott, A.C., Luton, C.D., and Janney, E.C., 2007, Monitoring of Lost River and shortnose suckers at the Sprague River Dam fish ladder, *in* Investigations of adult Lost River suckers and Shortnose suckers in Upper Klamath Lake and its tributaries, Oregon—Annual Report 2005: Annual report of research to the Bureau of Reclamation, 7 p.
- Buettner, M., and Scopettone, G., 1990, Life history and status of catostomids in Upper Klamath Lake, Oregon: U.S. Fish and Wildlife Service completion report, 108 p.
- Cooperman, M., and Markle, D.F., 2003, Rapid out-migration of Lost River and shortnose sucker larvae from in-river spawning beds to in-lake rearing grounds: Transactions of the American Fisheries Society, v. 132, p. 1138-1153.
- Dicken, S.N., 1980, Pluvial Lake Modoc, Klamath County, Oregon, and Modoc and Siskiyou Counties, California: Oregon Geology, v. 42, p. 179-187.
- Ellsworth, C.M., Tyler, T.J., VanderKooi, S.P., and Shively, R.S., 2007a, Riverine movements of adult Lost River, shortnose, and Klamath largescale suckers in the Williamson and Sprague Rivers, Oregon—Annual Report 2005: Annual report of research to the Bureau of Reclamation, 30 p., contract # 01AA200026.
- Ellsworth, C.M., Tyler, T.J., VanderKooi, S.P., and Shively, R.S., 2007b, Riverine movements of adult Lost River, shortnose, and Klamath largescale suckers in the Williamson and Sprague Rivers, Oregon—Annual Report 2006: Annual report of research to the Bureau of Reclamation, 49 p., contract # 01AA200026.
- Ellsworth, C.M., Tyler, T.J., VanderKooi, S.P., and Markle, D.F., 2008, Patterns of larval catostomid emigration from the Sprague and lower Williamson Rivers of the Upper Klamath Basin, Oregon, prior to the removal of Chiloquin Dam—2004–2005 Annual Report: Annual report of research to the Bureau of Reclamation, 45 p., contract # 06AA204054.
- Ellsworth, C.M., Tyler, T.J., VanderKooi, S.P., and Markle, D.F., 2009, Patterns of larval sucker emigration from the Sprague and lower Williamson Rivers of the Upper Klamath Basin, Oregon, prior to the removal of Chiloquin Dam—2006 annual report: U.S. Geological Survey Open-File Report 2009-1027, 32 p.
- Gannett, M.W., Lite, K.E., Jr., La Marche, J.L., Fisher, B.J., and Polette, D.J., 2007, Ground-water hydrology of the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2007-5050.
- Hewitt, D.A., Hayes, B.S., Janney, E.C., Harris, A.C., Koller, J.P., and Johnson, M.A., 2011, Demographics and run timing of adult Lost River (*Deltistes luxatus*) and Shortnose (*Chasmistes brevirostris*) Suckers in Upper Klamath Lake, Oregon, 2009: U.S. Geological Survey Open-File Report 2011-1088, 38 p.
- Kann, J., and Walker, W.W., 2001, Nutrient and hydrologic loading to Upper Klamath Lake, Oregon, 1991-1998: Prepared for the Bureau of Reclamation, Klamath Falls, OR, 114 p.
- Koch, D.L., 1973, Reproductive characteristics of the cui-ui lakesucker (*Chasmistes cujus* Cope) and its spawning behavior in Pyramid Lake, Nevada: Transactions of the American Fisheries Society, v. 102, p. 145-149.

- Markle, D.F., Cavalluzzi, M.R., and Simon, D.C., 2005, Morphology and taxonomy of Klamath Basin suckers (Catostomidae): *Western North American Naturalist*, v. 65, p. 473-489.
- Moode, T., and Muirhead, N., 1994, Spawning chronology and larval emergence of June sucker (*Chasmistes liorus*): *Great Basin Naturalist*, v. 54, p. 366-370.
- Moyle, P.B., 2002, *Inland Fishes of California*: University of California Press, Berkeley and Los Angeles, California, 502 p.
- National Research Council, 2004, *Endangered and threatened fishes in the Klamath River Basin: Causes of decline and strategies for recovery*: National Academy Press, Washington, D.C., 398 p.
- Oregon Natural Heritage Information Center, 2004, *Rare, threatened, and endangered species of Oregon, 2004*: Oregon Natural Heritage Information Center, Oregon State University, Portland, Oregon, 105 p.
- Perkins, D.L., Scoppettone, G.G., and Buettner, M., 2000, *Reproductive biology and demographics of endangered Lost River and shortnose suckers in Upper Klamath Lake, Oregon*: Report to the Bureau of Reclamation, 40 p.
- Scoppettone, G.G., and Vinyard, G., 1991, Life history and management of four endangered lacustrine suckers, in Minckley, W.L., and Deacon, J.E., eds., *Battle against extinction: native fish management in the American West*: Tucson, University of Arizona Press, p. 359-377.
- Scoppettone, G.G., 1988, Growth and longevity of the cui-ui and longevity of other catostomids and cyprinids in western North America: *Transactions of the American Fisheries Society*, v. 117, p. 301-307.
- Tyler, T.J., Ellsworth, C.M., VanderKooi, S.P., and Shively, R.S., 2007, *Riverine movements of adult Lost River, shortnose, and Klamath largescale suckers in the Williamson and Sprague Rivers, Oregon—Annual Report 2004*: Annual report of research to the Bureau of Reclamation, 30 p., contract # 01AA200026.
- Wood, T.M., Hoilman, G.R., and Lindenberg, M.K., 2006, *Water-quality conditions in Upper Klamath Lake, Oregon, 2002-04*: U.S. Geological Survey Scientific Investigations Report 2006-5209, 52 p.
- U.S. Fish and Wildlife Service, 2002 *Biological/Conference Opinion Regarding the Effects of Operation of the U.S. Bureau of Reclamation Project on the Endangered Lost River Sucker (*Deltistes luxatus*), Shortnose Sucker (*Chasmistes brevirostris*), Threatened Bald Eagle (*Haliaeetus leucocephalus*), and Proposed Critical Habitat for the Lost River/Shortnose Suckers for June 1, 2002 – March 31, 2012*: Klamath Falls, Oregon.

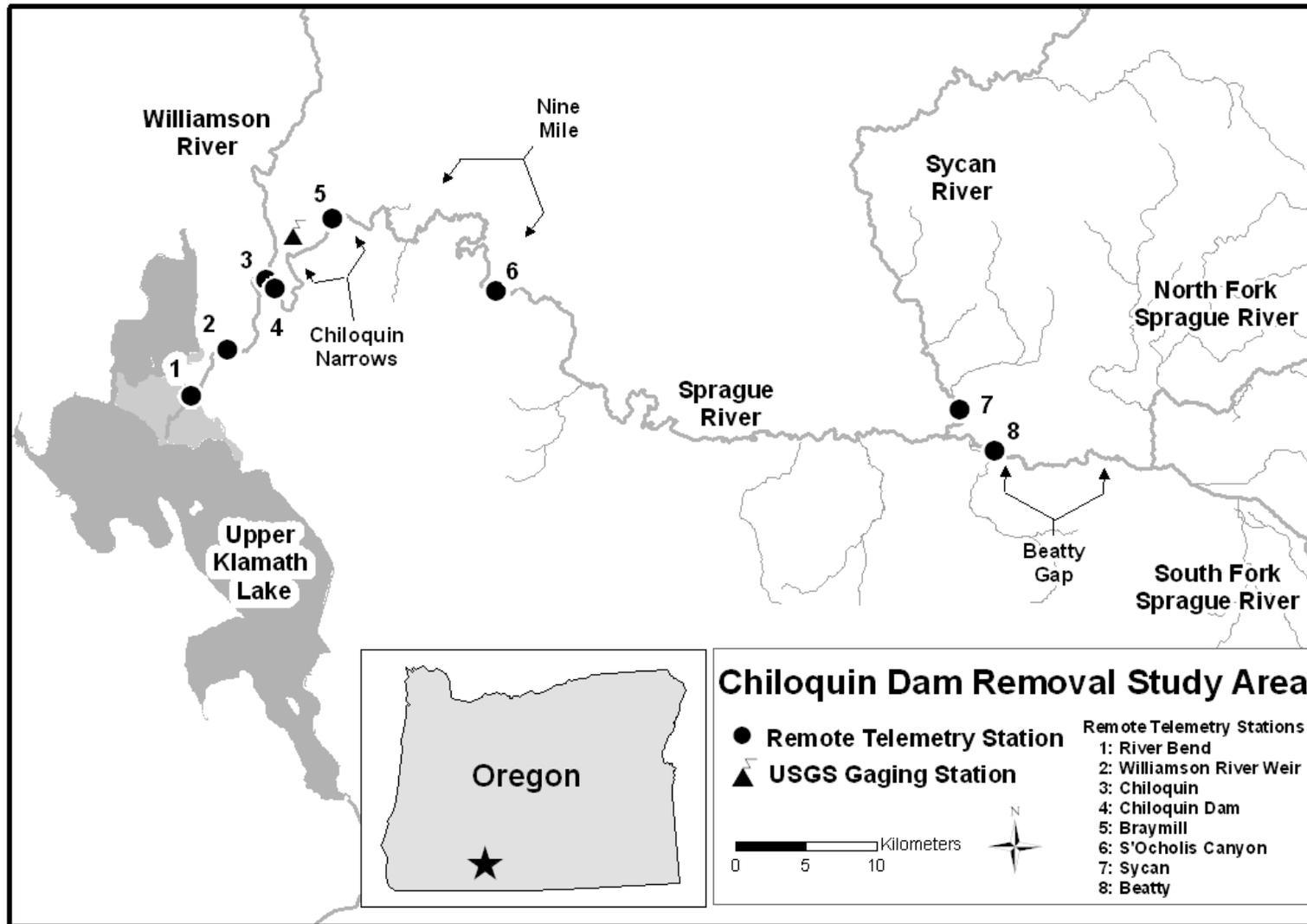


Figure 1. Map of the study area showing locations of remote telemetry stations used to determine the spawning area distribution and movements of Lost River and shortnose suckers in the Williamson and Sprague Rivers, Oregon, 2009.

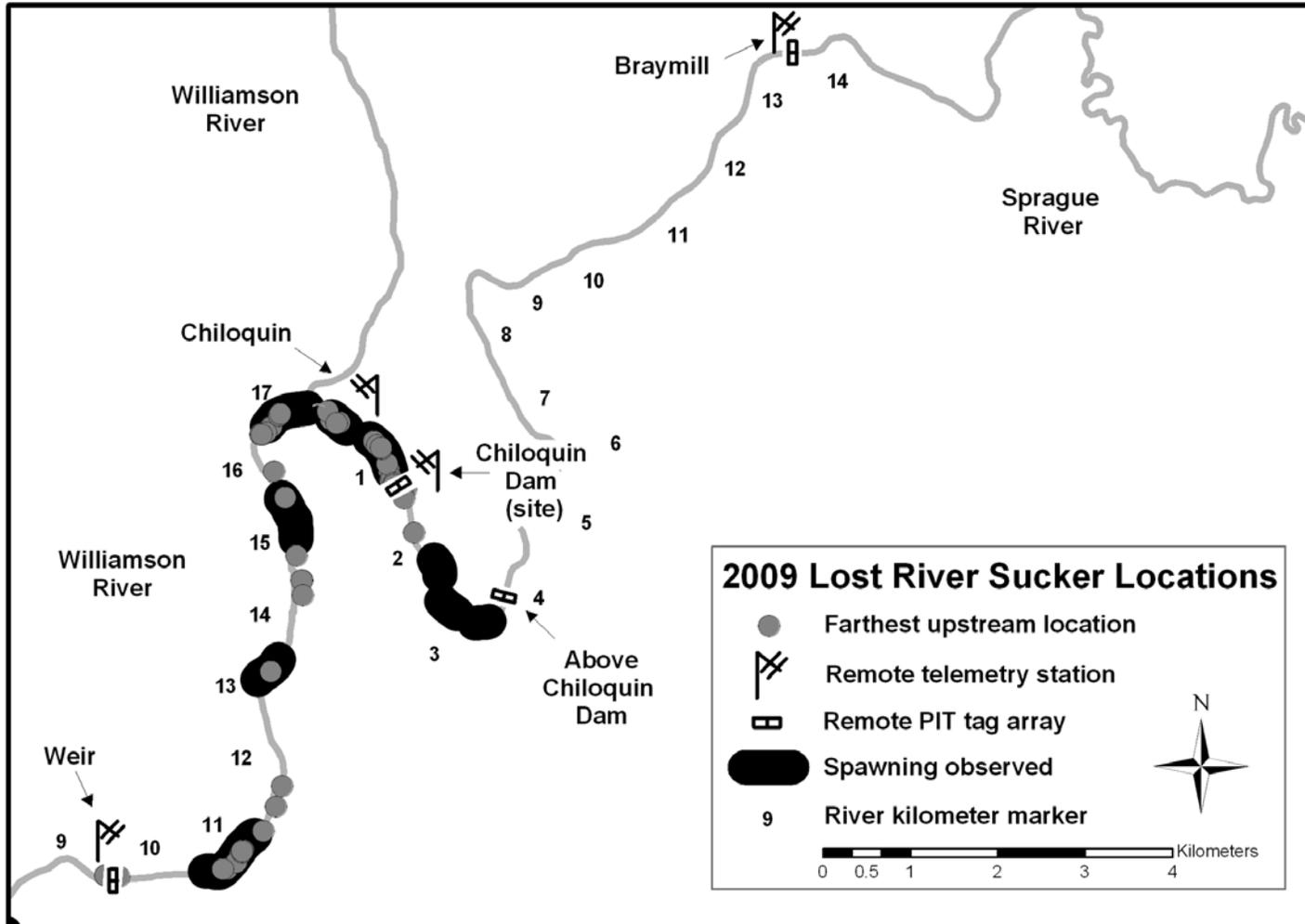


Figure 2. Farthest upstream detections of individual radio-tagged Lost River suckers released upstream of the Williamson River fish weir, Oregon, 2009. Map also shows remote telemetry station locations, remote PIT tag array locations, and where spawning was observed during the 2009 field season.

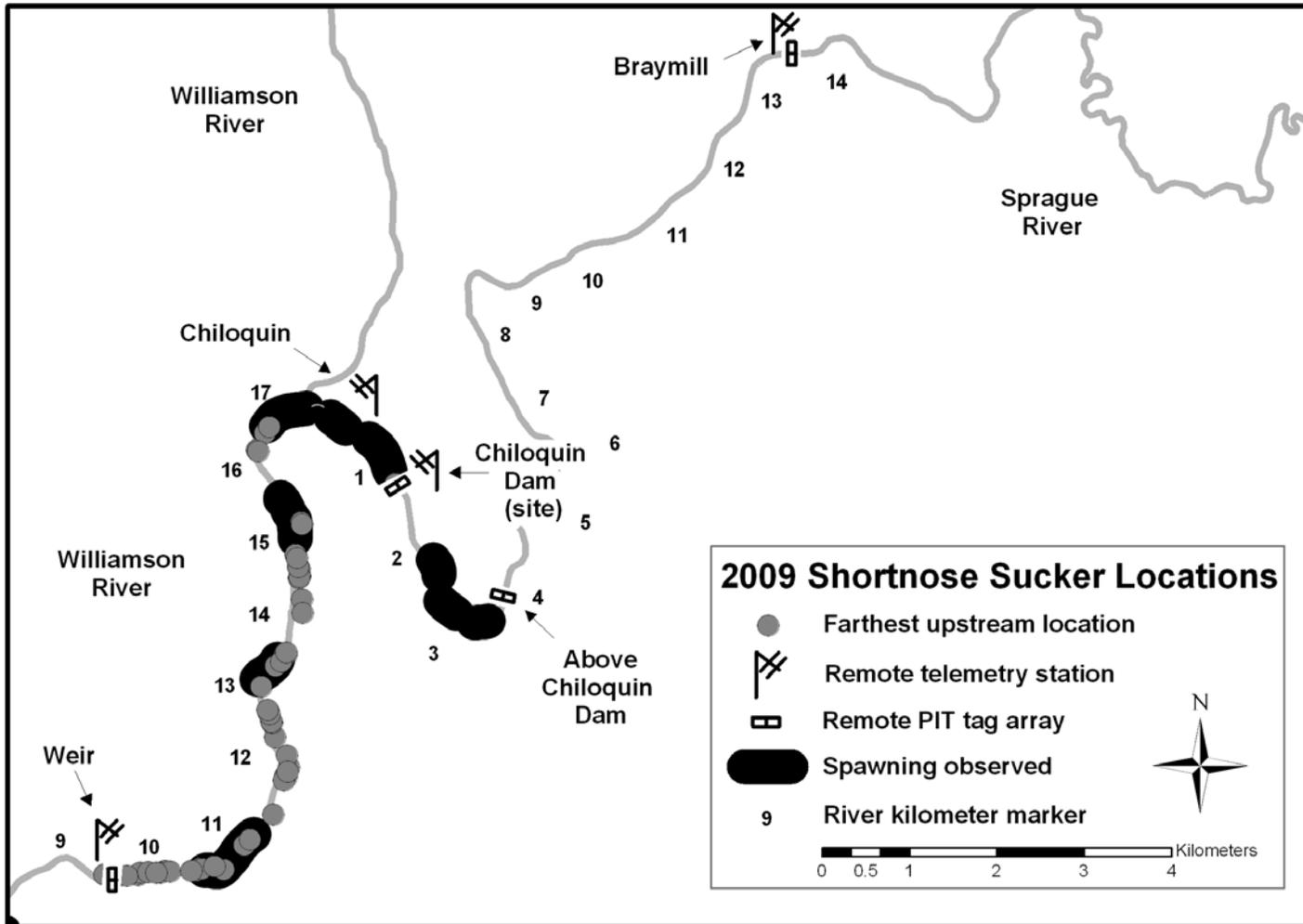


Figure 3. Farthest upstream detections of individual radio-tagged shortnose suckers released upstream of the Williamson River fish weir, Oregon, 2009. Figure also shows remote telemetry station locations, remote PIT tag array locations, and where spawning was observed during the 2009 field season.

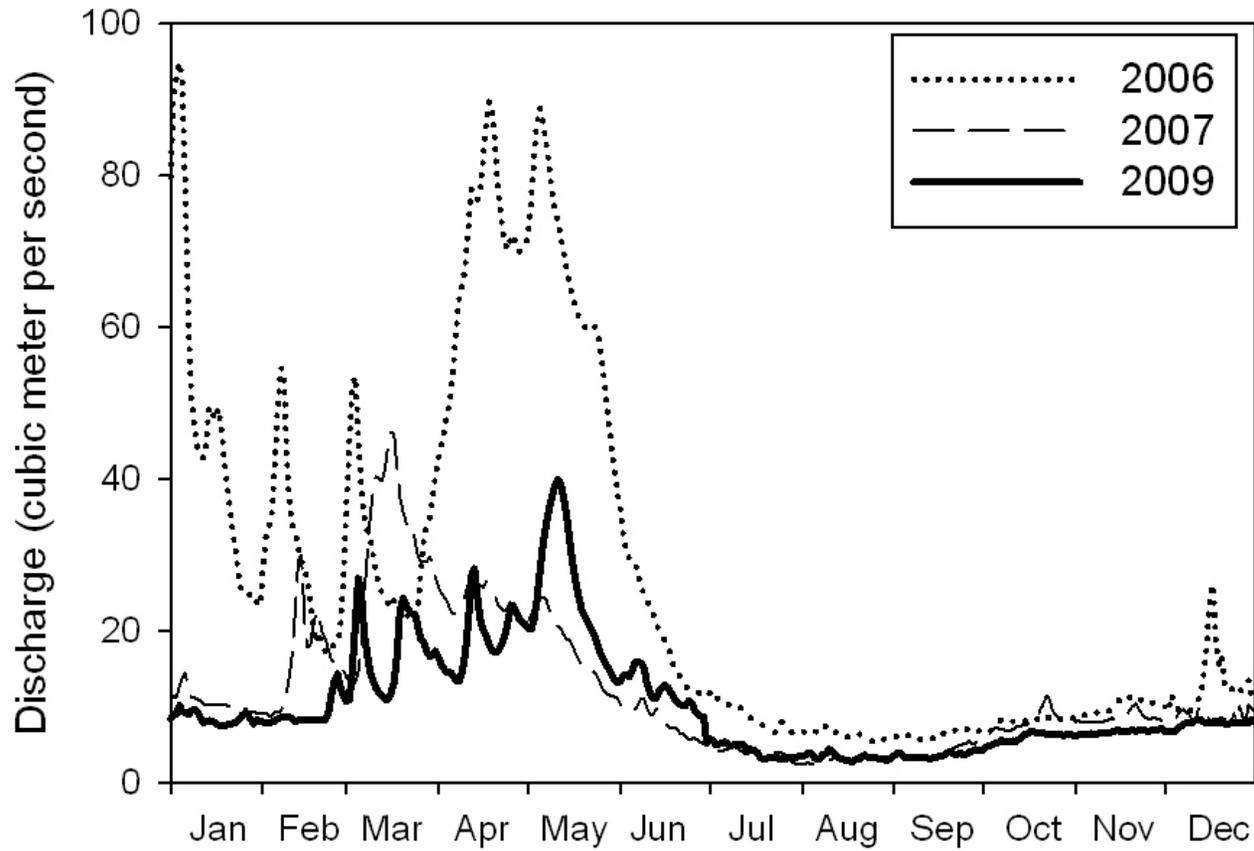


Figure 4. Hydrographs for the Sprague River at Chiloquin, Oregon (USGS Gaging Station No.11501000), 2006, 2007, and 2009. Station location is shown in figure 1.

Table 1. Number of radio-tagged Lost River suckers and shortnose suckers released upstream of the Williamson River fish weir and detected at three remote telemetry stations in the lower Williamson and Sprague Rivers, Oregon, 2009.

[The difference in the number of fish detected at each remote telemetry station indicates the number of fish that ceased their upstream migration in the reach between each station. River kilometers (rkm) are given as a distance from Upper Klamath Lake and site locations are shown in figure 1]

		Released at the Williamson River fish weir (rkm 9.966)	Detected at the Chiloquin Remote Station (rkm 17.881)	Detected at the Chiloquin Dam Remote Station (rkm 19.028)	Detected upstream of the Chiloquin Dam site
Lost River sucker	Male	27	12	10	1
	Female	31	15	7	1
Shortnose sucker	Male	23	1	1	0
	Female	36	2	0	0
Total		117	32	18	2

Table 2. Time spent upstream of the Williamson River fish weir, in the Sprague River, and within range of the telemetry receiver and the number of approaches on the dam site for radio-tagged Lost River and shortnose suckers prior to the removal of Chiloquin Dam (2006 and 2007; Ellsworth and others, 2007b; U.S. Geological Survey, unpub. data, 2007) and after its removal (2009), Oregon.

	Hours (mean \pm SD) spent upstream of the weir	Hours (mean \pm SD) spent in the Sprague River	Hours (mean \pm SD) spent at the dam site	Approaches (mean \pm SD) on the dam site
Lost River sucker Male				
2006	347.7 \pm 114.2	205.0 \pm 138.8	211.3 \pm 137.5	5.6 \pm 8.7
2007	405.0 \pm 149.9	170.0 \pm 193.9	326.3 \pm 172.6	22.4 \pm 18.2
2009	457.3 \pm 145.5	251.6 \pm 9.7	185.2 \pm 71.6	33.0 \pm 13.1
Lost River sucker Female				
2006	172.4 \pm 38.2	140.7 \pm 135.6	63.5 \pm 40.3	4.3 \pm 3.3
2007	167.0 \pm 75.2	55.6 \pm 73.2	34.1 \pm 50.6	5.6 \pm 4.2
2009	262.4 \pm 112.4	90.9 \pm 36.0	45.0 \pm 10.8	12.2 \pm 7.7
Shortnose sucker Male				
2006	497.7 \pm 266.2	335.7 \pm 253.6	97.3 \pm 140.9	8.7 \pm 8.6
2007	449.5 \pm 182.0	202.6 \pm 116.7	169.5 \pm 149.2	9.3 \pm 6.1
2009	254.9 \pm 195.2	170.5	(¹)	(¹)
Shortnose sucker Female				
2006	243.1 \pm 204.9	83.9 \pm 57.3	31:27 \pm 28:16	5.7 \pm 6.1
2007	395.9 \pm 209.3	227.9 \pm 180.0	18.4 \pm 25.1	13.5 \pm 17.7
2009	230.5 \pm 183.5	36.9 \pm 9.7	(¹)	(¹)

¹No shortnose suckers were detected approaching the Chiloquin Dam site in 2009.

This page left intentionally blank

Publishing support provided by the U.S. Geological Survey
Publishing Network, Tacoma Publishing Service Center

For more information concerning the research in this report, contact the
Director, Western Fisheries Research Center
U.S. Geological Survey
6505 NE 65th Street
Seattle, Washington 98115
<http://wfrc.usgs.gov/>

