Analysis of the Spawning Migration of Pacific Lamprey (*Lampetra tridentata*) in the Klamath River using Sonic Telemetry.

FY 2005 Pilot Study.

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INTRODUCTION

The Pacific lamprey (*Lampetra tridentata*) is an anadromous fish native to the Pacific coast of North America and Asia. In North America the species ranges from the Aleutian Islands to Baja, California (Scott and Crossman 1973). Currently there is limited scientific knowledge concerning historic distribution, abundance, adult life history, migratory activities, and spawning behavior. Typically, adults leave the ocean and initiate freshwater upstream migration from March to mid-October; however they have been observed migrating in January and February (Moffet and Smith 1950; Scott and Crossman 1973; Beamish 1980; Farlinger and Beamish 1984; Beamish and Levings 1991; Moyle 2002). Adults have been known to migrate several hundreds of kilometers upstream to spawn (Scott and Crossman 1973; Beamish and Levings 1991; Moyle 2002). Lamprey are able to overwinter in freshwater up to a year before spawning (Scott and Crossman 1973; Farlinger and Beamish 1984), although Beamish (1980) suggested freshwater residence may be eight months or less. Spawning occurs from April until late July (Moffet and Smith 1950; Hardisty and Potter 1971; Beamish 1980; Farlinger and Beamish 1984). Spent adults do not return to the ocean and are assumed to die after spawning (Moffet and Smith 1950; Wydoski and Whitney 1979; Beamish 1980). However, circumstantial evidence suggests spent adults in Washington do return to the ocean and are capable of spawning more than once (Michael 1984 Moyle 2002).

Pacific lamprey are of great significance to the Yurok People of Northern California. They are a tribal trust species, and are important both culturally and as part of the Tribes subsistence fishery. There is no quantitative data on historical abundance or distribution of Pacific lamprey in the Klamath River Basin (KRB), however anecdotal evidence suggests stocks have been in decline since the late 1980's (Belchik and Larson 1998). Presently no efforts have been made to identify causative factors for this decline. It has been hypothesized that the reduction in numbers could be correlated to declines of Pacific salmon (*Oncorhynchus spp.*) and steelhead (*Oncorhynchus mykiss*) in the KRB. It has been suggested that human disturbance and habitat alterations have caused the decline of salmon and steelhead stocks. These factors could also be responsible for the decline of the Pacific lamprey in the KRB. (Belchik and Larson 1998; Close et al. 2002). Habitat alteration specific to the Klamath River include alteration of river discharge and water quality, decrease in prey base, and blockage of formerly accessible spawning and rearing habitat by dams (Belchik and Larson 1998).

In 2006, the Yurok Tribal Fisheries Program (YTFP) initiated a pilot adult lamprey telemetry study to assess movement and distribution of migrating Pacific lamprey in the Klamath River and its tributaries. The feasibility of sonic telemetry was also investigated during this study. Primary questions addressed were: 1) what is the timing and rate of migration and spawning activity, 2) what is the distribution of important spawning locations, 3) what types of behavior do adult lamprey exhibit while migrating and spawning. In addition, results and recommendations of this pilot study will be used to test methods and refine protocols for future lamprey telemetry studies.

MATERIALS AND METHODS

On March 27, 2006, YTFP personnel began sampling for Pacific lamprey(*Lampetra tridentata*) in the Klamath River estuary (Figure 1). The primary area of capture was on the point of the sand spit that separates the estuary from the Pacific Ocean (Figure 2). Most lamprey were captured in the shallow wave swept area where the river and ocean meet. Samplers employed a large dip-net with a hoop diameter of 120 cm, and a pouch 150 cm deep. The net mesh was nylon webbing with a stretched mesh size of 1 cm. Lamprey were netted as they attempted to enter the estuary and swam parallel to the sand spit. Upon capture, lamprey were held in a mesh bag kept either in the river or in hole dug in the sand and filled with river water.

Captured adults were anaesthetized with a 120 mg/L solution of clove oil. A 3 cm incision was made in the ventral side of the abdomen, slightly anterior to the first pectoral fin. A coded sonic transmitter was then inserted into the abdominal cavity. Four to six interrupted cross stitches were used to close the incision. The stitches were made using a 45 cm size 4 Prolene blue monofilament polypropylene suture which was attached to a FS-2 19mm, double edge cutting needle. A commercial antibiotic ointment was placed on the incision, and the tagged individual was allowed to recover in a low velocity backwater for up to 30 minutes. Prior to release a small tissue sample was taken from the dorsal fin. This tissue sample could be utilized in future genetic studies.

We implanted V9-2L (low power) or V9-2H (high power) coded sonic transmitters (Vemco Ltd.). Each transmitter has a length of 28-30mm, a diameter of 9 mm, and a mass of 2.8-3.1 g (in water). The expected battery life for each tag was 60-420 days, depending on the type of tag (Table 1).

Lamprey movements and locations were monitored with an array of Vemco Ltd. Vr2 sonic stationary receivers. Receivers were deployed in March in the Klamath, Trinity, and Salmon Rivers. This array was designed as part of concurrent Chinook salmon (*Oncorhynchus tshawytscha*) and green sturgeon (*Acipenser medirostris*) sonic telemetry studies (Figure 3). Sonic receivers were downloaded on a regular basis throughout the season. The final receiver download occurred on October 20, 2006.

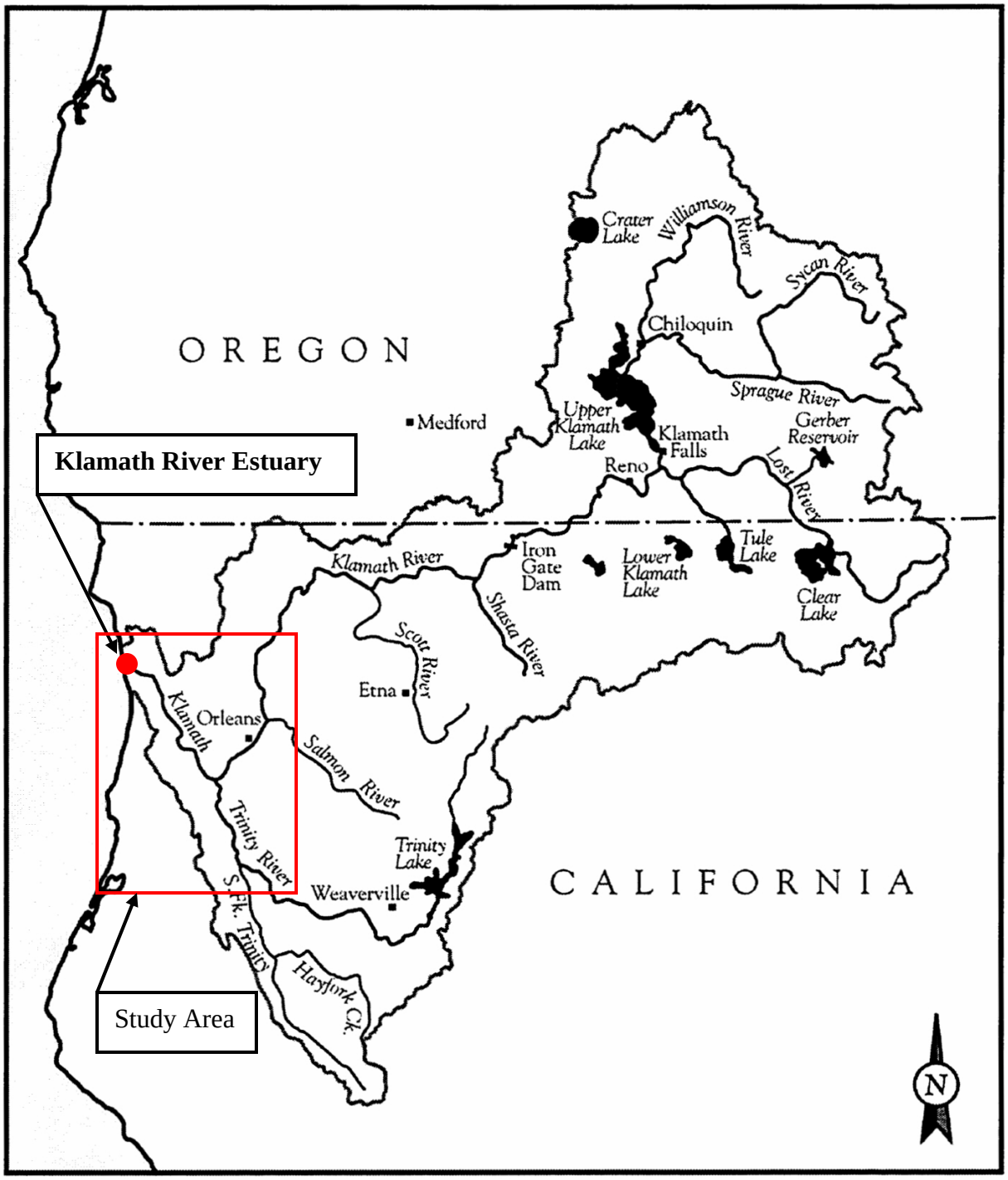

Figure 1. Map of the Klamath River Basin which is located in Northern California and Southern Oregon. Pacific lamprey were captured, tagged, and released at the Klamath River estuary as part of the 2006 adult lamprey telemetry pilot study. The primary study area is located within the square.

Figure 2. Satellite photo of the Klamath River estuary. The circled area represents the primary capture location of Pacific lamprey during the 2006 adult Pacific lamprey telemetry pilot study.

Table 1. Summary information on Vemco Ltd. Sonic transmitters used in 2006 Klamath River adult Pacific lamprey pilot study. Minimum (min.) and maximum (max.) ping intervals are measures in seconds (secs.).

Transmitter Model	ID Codes	Min./Max. Ping Interval	Approximate Battery Life
V9-2H	3407-3409	20-60 secs.	60 days
V9-2H	3410-3412	40-120 secs.	110 days
V9-2H	3413-3414	60-180 secs.	160 days
V9-2L	3415-3418	20-60 secs.	240 days
V9-2L	3419-3421	40-120 secs.	420 days

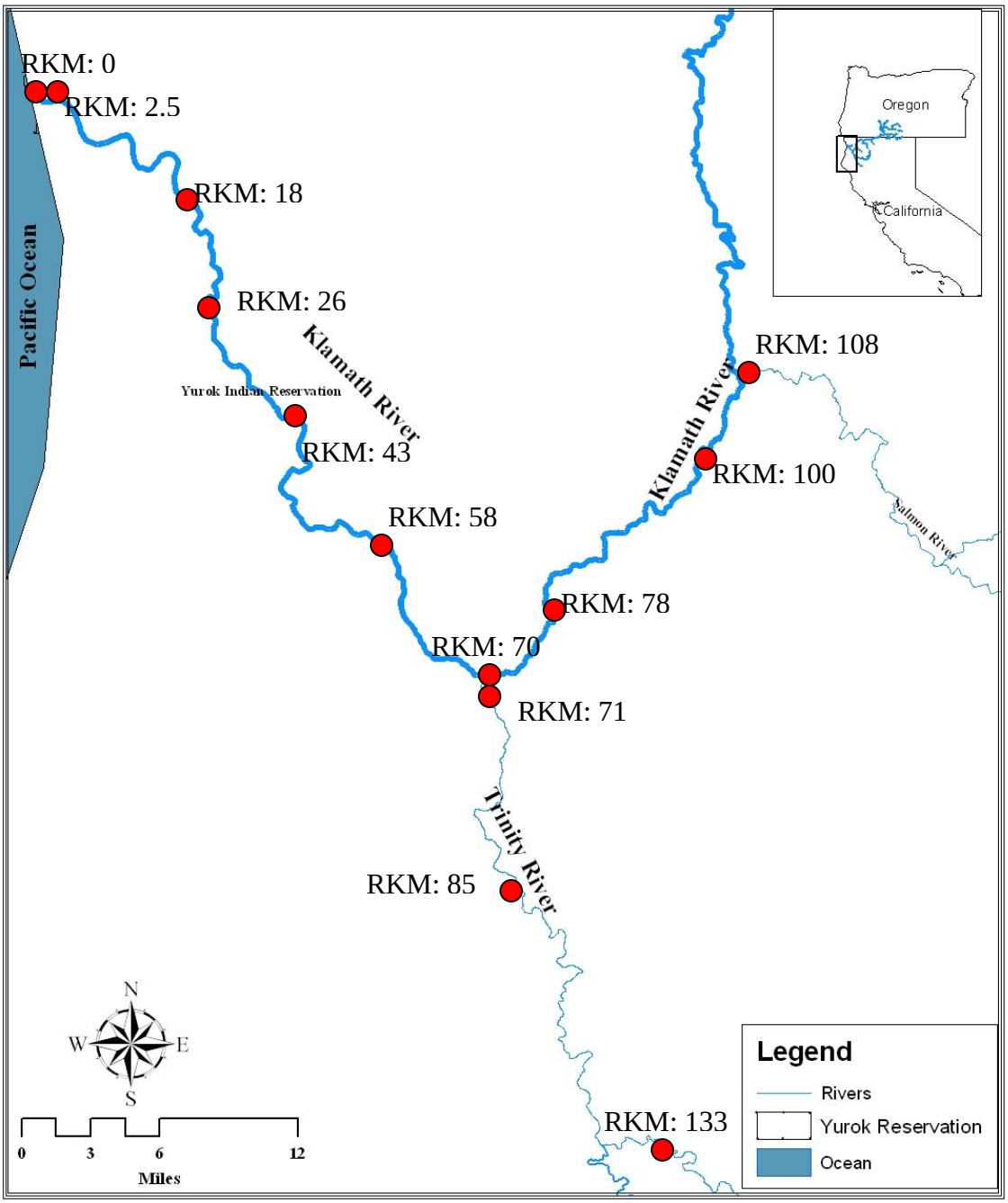

Figure 3. Map of study area showing sonic receiver station array. The nearest river kilometer (RKM) to the station is listed. This receiver array was constructed to track green sturgeon, Chinook salmon, and Pacific lamprey during the 2006 adult lamprey telemetry pilot study.

RESULTS

From April 5 to May 23, 2006, 14 adult lamprey were captured and tagged (8 male, 2 female, 4 unknown). Total length ranged from 552-670 mm (mean 598 mm). Biological data and sonic tag specifications are summarized (Table 2). No transmitters were detected on any of the sonic receivers throughout the study period (Table 3).

Table 2. Summary of biological statistics and transmitter specifications for adult Pacific lamprey tagged in the Klamath River estuary in 2006. Tag powers are either high (H) or low (L), and sexes are represented as male (M), female (F), or unknown (U).

Tagging Date	Total Length (mm)	Sex	Tag ID	Tag life (days)	Tag Power	Expiration Date
5-Apr-06	588	M	3408	60	H	4-Jun-06
5-Apr-06	596	M	3412	110	H	24-Jul-06
5-Apr-06	670	M	3413	160	H	12-Sep-06
11-Apr-06	596	M	3418	240	L	7-Dec-06
18-Apr-06	552	U	3410	110	H	6-Aug-06
18-Apr-06	616	U	3411	110	H	6-Aug-06
18-Apr-06	600	M	3415	160	H	25-Sep-06
18-Apr-06	610	U	3419	420	L	12-Jun-07
18-Apr-06	582	U	3421	420	L	12-Jun-07
25-Apr-06	578	F	3420	420	L	19-Jun-07
9-May-06	592	M	3414	160	H	16-Oct-06
9-May-06	585	F	3417	240	L	4-Jan-07
16-May-06	575	M	3407	60	H	15-Jul-06
23-May-06	637	M	3409	60	H	22-Jul-06

Table 3. Sonic receiver locations, river kilometer (RKM), deployment/retrieval dates and detections for adult lamprey telemetry plot study. This study was conducted in the Lower Klamath Basin in 2006.

Receiver Location	RKM	Date Deployed	Date Retrieved	Detections
Requa	0	3/23/2006	10/24/2006	0
Jet Boat Tours	2.5	3/23/2006	10/24/2006	0
McCovey's	18	3/23/2006	10/24/2006	0
Blue Creek	26	3/23/2006	10/24/2006	0
Moores Rock	40	3/24/2006	10/23/2006	0
Coon Creek	58	3/24/2006	10/23/2006	0
Weitchpec (Klamath)	70	3/24/2006	10/23/2006	0
Aikins Hole	78	3/25/2006	10/26/2006	0
Dolans Bar	100	3/25/2006	10/26/2006	0
Salmon River	108	3/29/2006	10/25/2006	0
Weitchpec (Trinity)	71	3/24/2006	10/23/2006	0
Hoopa	85	3/25/2006	10/27/2006	0
Hawkins Bar	133	3/28/2006	10/27/2006	0

DISCUSSION

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As of March, 2007, at least three transmitters have active batteries (Table 1). Pacific lamprey have been observed overwintering in freshwater before spawning the following spring and summer (Scott and Crossman 1973; Beamish 1980; Farlinger and Beamish 1984; Anglin 1994). It is possible that these three individuals are still in freshwater and will spawn within the next few months; however none of these lamprey were detected on any of the sonic receivers. The remaining 11 transmitter batteries have expired, therefore, it is not possible to determine if spawning occurred in 2006 or 2007. With no detections it is also impossible to determine spawning locations, migration timing, migration rates, migratory behavior, or spawning behaviors.

A large winter rain storm occurred in the Klamath Basin in January 2006. There was also an above average snow pack in the Klamath Mountains. Klamath River flows were unusually high and conditions were extremely turbid until May and June. Sonic transmitter and receiver tests conducted during this period resulted in poor detection rates. The manufacturer concedes that transmitters and receivers perform sub-optimally in turbid conditions; however, Vemco has not tested transmitters and receivers over a range of turbidity for performance. Preliminary results indicate that sonic telemetry has the potential to perform poorly in highly turbid conditions. High turbidity in the river usually occurs in the spring, presumably when upstream spawning migration occurs.

There were several months during the summer and early fall when river conditions were favorable for sonic telemetry and all tags were still active. At this time there was an extensive sonic receiver array installed in the Klamath and Trinity Rivers to monitor movements of Chinook salmon (*Oncorhynchus tshawytscha*). However, no tagged lamprey were detected during this time period. Some possible reasons for this are: 1) The sonic tags or simply did not work. 2) The receivers were placed in poor locations. 3) The tagged lamprey migrated past the receivers during higher, more turbid flows, possibly entering tributaries without receivers to spawn. 4) The tagged lamprey were not migrating at this time. 5) The tagged lamprey did not migrate from the estuary, possibly because of predation or tagging stress. The sonic receiver array was removed from the river in late October of 2006. This coincided with the onset of the rainy season and increased turbidity.

Sonic telemetry has worked well on the Klamath River on Chinook salmon; however these studies were conducted during the summer and fall when turbidity is relatively low. These Chinook investigations also found that sonic telemetry is best suited for stationary monitoring. Attempts to manually track acoustically tagged salmon with an acoustic hydrophone were not very successful (J. Strange, personal. communication of unpublished data, December 2006). Any information concerning spawning locations and spawning behavior of Pacific lamprey would need to be gathered using manual telemetry. Radio telemetry is a proven method for gathering these types of data concerning Chinook salmon (J. Strange, personal. communication of unpublished data, December 2006).therefor it can be assume dthat manual radio tracking would have equal success if used on Pacific lamprey. Manual tracking adds significant costs to telemetry studies. Field crews would have to drive, boat, or fly to various locations throughout the Lower Klamath Basin on a regular basis to collect adequate data. In order for accurate spawning data to be collected manual radio telemetry must be employed. This method could be hindered by budgetary constraints.

The purpose of this pilot study was to evaluate the use of sonic telemetry on adult Pacific lamprey in the Klamath River. More specifically, the study examined how sonic telemetry could add to our knowledge of lamprey spawning locations, migration timing, migration rates, migratory behavior, and spawning behaviors. No detections were made over the course of the study, therefore sonic telemetry is not a feasible method to study lamprey on the Klamath River. This is valuable knowledge that was only attainable through the trial and error process of this pilot study. In any future studies of this nature, we recommend that the use of stationary and manual radio telemetry be employed.

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