A Feasibility Study on using Radio Biotelemetry to Monitor Migrating Pacific Lamprey (*Lampetra tridentata)* within the Klamath River Basin FY 2007 Final Report

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Introduction

Pacific lamprey (*Lampetra tridentata)* are an anadromous fish native to the Pacific Coast of North America and Asia. In North America the species range from the Aleutian Islands to Baja California (Scott and Crossman 1973). Currently there is limited scientific knowledge concerning historic distribution within its range, abundance, adult life history, migration, and spawning behaviors of Pacific lamprey. Adults typically leave the ocean and initiate upstream migration from March to mid-October (Beamish and Levings 1991; Moyle 2002); however, Pacific lamprey have been observed emigrating into the Klamath River year round (Belchik and Larson 1998). Pacific lamprey adults have been known to migrate several hundred kilometers upstream to spawn (Scott and Crossman 1973; Beamish and Levings 1991; Moyle 2002). Adult Pacific lamprey are able to reside in fresh water up to a year before spawning (Scott and Crossman 1973; Farlinger and Beamish 1984), although Beamish (1980) suggested fresh water residence may be eight months or less. Spawning occurs from April to late-July (Moffet and Smith 1950; Beamish 1980; Farlinger and Beamish 1984; Hardisty and Potter 1971). 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 the State of Washington do return to the ocean and are capable of spawning more than once (Michael 1984).

Pacific lamprey are a tribal trust species of great significance to the Yurok Tribe, both culturally and as part of subsistence harvests for Yurok Tribal fishermen. There is no quantitative data on historical abundance or distribution specific to the Klamath River watershed, but anecdotal evidence suggests that Pacific lamprey abundance has been in decline since the late 1980's (Belchik and Larson 1998). Presently few efforts have been made to identify causative factors for the decline. It has been hypothesized that the reduction in numbers could be correlated to declines of Pacific salmon and steelhead in the Klamath River watershed (Belchik and Larson 1998). Human disturbance and habitat alterations have contributed significantly to the decline of these salmonid stocks (NRC 2002) and these factors could also be responsible for the decline in the Pacific lamprey stocks in the Klamath River watershed (Belchik and Larson 1998; Close et al. 2002). Habitat alterations in the Klamath River watershed include, but are not limited to: alteration and reduction of river discharge; degradation of water quality; decreased prey base; altered sediment dynamics; and blockage of formerly accessible spawning and rearing habitat by dams (Belchik and Larson 1998).

In the fall of 2007 the Yurok Tribal Fisheries Program (YTFP) completed Phase II of a two year pilot study. Phase I of this study was completed in 2006 using sonic biotelemetry. It was determined that high turbidity levels in the Klamath River during the spring Pacific lamprey migration season caused sonic transmitters to be undetectable. In Phase II we investigated the feasibility of using radio biotelemetry to study movements and distribution of Pacific lamprey adults in the Klamath River watershed. This two year pilot project was aimed at finding the most effective biotelemetry method to study Pacific lamprey in the Klamath River watershed. Radio biotelemetry methods are not adversely

affected by high turbidity levels; therefore we hypothesized that this would be a successful research technique.

Objectives

1) Assess the feasibility using of radio biotelemetry to study Pacific lamprey within the Klamath River watershed.
2) Gather information related to Pacific lamprey migration behavior and spawning locations within the Klamath River watershed.

Materials and Methods

Tagging efforts began on March 19, 2007 and ended on May 24, 2007. We captured adult Pacific lamprey on the north and south beaches of the "chute" at the river's mouth were it joins the Pacific Ocean (Figure 1). We netted lamprey using a dip net with a hoop diameter of 120 cm, a pouch approximately 150 cm deep, and a mesh size of 1 cm. The fish were dipped out of small waves as they attempted to enter the estuary. Upon capture, the lamprey were stored in a lidded cooler filled with river water or in submerged plastic live tubes until tagged. This holding period lasted no more than four hours.

Captured lampreys were anaesthetized using a 120 mg/L solution of clove oil and water. A 3 to 5 cm ventral incision was made approximately 1 cm anterior of the insertion of the first dorsal fin. A coded Pisces radio tag (Grant Systems Engineering; 149 mHz) was inserted into the abdominal cavity and a 12 gauge hollow needle was used to thread the radio antenna through the abdominal wall. Three to five interrupted cross stitches were made to close the incision. Sutures were made using a 4.0 Prolene blue monofilament polypropylene suture, which was 45 cm in length, and attached to a FS-2 cutting needle. A commercial anti-bacterial ointment was then applied to the completed sutures. The coded Pisces tags had an air weight of 2.0 g and an in-water weight of 0.2 g. The Pisces tag measured approximately 19 by 9 mm, was powered by a 3 volt battery, and had an expected life of 150 days at a burst rate of five seconds. The trailing antenna length was approximately 10 inches. Tagged lamprey were put into individual live tubes, which were submerged in the estuary for a 20 to 30 minute recovery period. There were two release sites utilized during this study, one release site was located near the Requa boat ramp (rkm 1.5) and the other release site was located at Starwin Riffle (rkm 15).

An array of seven Orion (Grant Systems Engineering) radio listening stations was used to track lamprey migration. Six stations were located on the mainstem Klamath River and one was installed on the Trinity River (Figure 2). The Starwin release site (rkm 15) was above one of the seven listening station (located at 13 rkm), thus this release site was used to access the possibility that tagged lamprey migrated downstream after the tagging process. Information from each station was downloaded on a weekly basis until July 2, 2007, at which point each station was monitored on bi-weekly.

Figure 1. Satellite photo of Klamath River mouth. Circles indicate primary lamprey capture areas (Google Earth 2007).

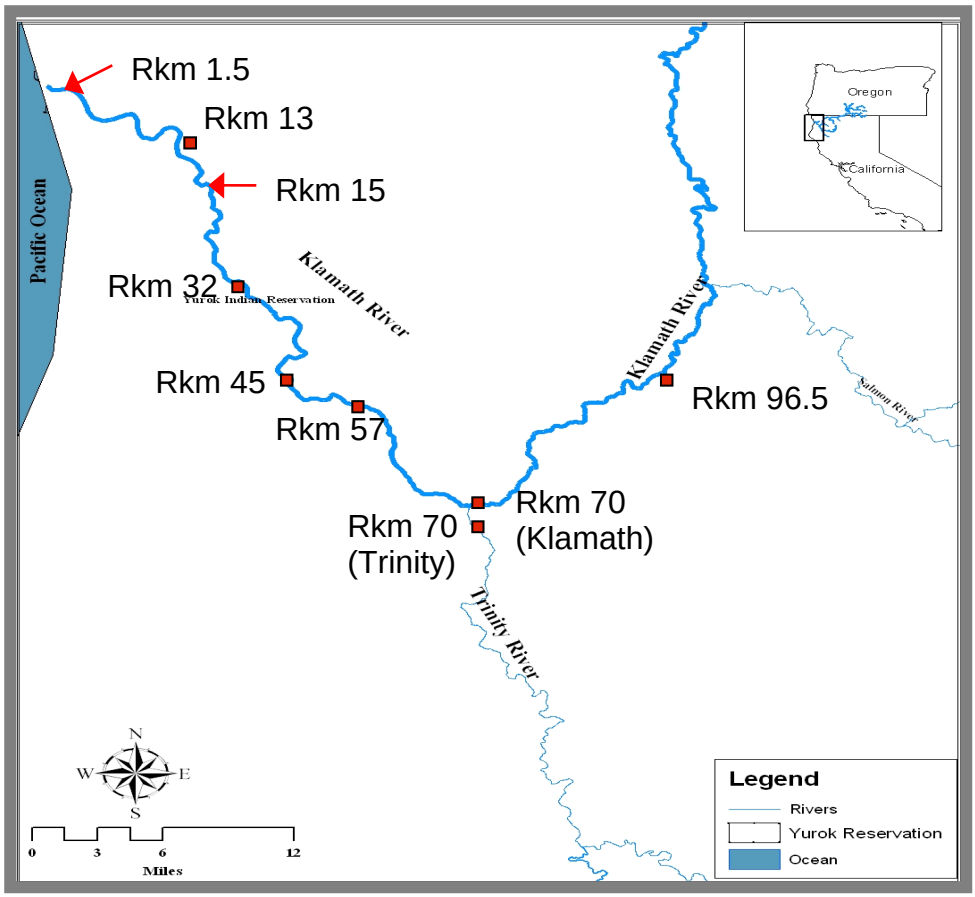

Figure 2. Map of 2007 lamprey telemetry stations and release sites for the Klamath and Trinity Rivers. Telemetry stations are shown with squares and lamprey release sites are represented by arrows.

Results

From April 4, 2007 to May 24, 2007 a total of 19 Pacific lamprey were captured, tagged, and released. Total body lengths ranged from 562 to 680 mm (Table 1). An additional 14 lamprey were tagged during March of 2007, however, a programming malfunction led to inoperative tags and those individuals have been removed from analysis. Out of the total sample size of 19 lamprey released with operational tags, 14 lampreys were released at the Requa boat ramp (rkm 1.5) and five lampreys were released at the Starwin Riffle site (rkm 15).

Eight of the 19 tagged lamprey were detected by one or more of our listening stations. There were 19 detections from the various Orion listening stations (Table 2) with an overall detection probability of 88% on average per fish, per station. A total of 6 tagged lamprey (of the 14 lampreys released from the Requa boat ramp) migrated to at least the Blakes Riffle station (rkm 13). Three of the 19 Pacific lamprey with operational tags were detected at the Weitchpec listening station (rkm 70). There were no detections at the

Sandy Bar station on the Klamath River (rkm 96.5) and no valid detections at the Trinity River station located at Weitchpec (rkm 70). Lamprey movements in relation to date and rkm are summarized Figure 3.

A float trip of the main stem of the Klamath River with detection equipment was conducted from Dolans Bar (rkm 97.5) to Blakes Riffle (rkm 13) during the week of July 30 to August 3, 2007. There were no lamprey detections during the float. Portions of the study area between Dolans Bar and Blakes Riffle that were accessible by road were tracked on three separate occasions (June 20th, July 3rd, and July 16th). One lamprey (code 31) was detected on June 20, 2007 at Hopkins Creek riffle (rkm 75). Besides the Trinity River, tributaries of the Klamath River were not tracked due to logistical challenges and lack of funding.

During the time period when tagged Pacific lamprey migrations were detected, Klamath River mainstem temperatures ranged from 10.4°C to 21.8° C (Figure 3). All temperatures were taken from the Yurok Tribe Environmental Department real-time station at Blakes Riffle (rkm 13). During this same time period mainstem Klamath River discharge ranged from 20,500 cfs to 5840 cfs (Figure 3). All discharges were taken from the Blakes Riffle gauging station in Klamath, CA. (rkm 13).

All detected lamprey (*n*=8) migrated for an average of 25 days, and traveled an average of 34 km up the river with a mean travel rate of 1.97 km per day. Individual migration rates varied from 0.46 km per day to 5.75 km per day (Table 3).

Table 1. Individual lamprey tagging data, 2007. Fish in bold font designates migration above the first radio station at Blakes Riffle (rkm 13). Tag status is based on predicted tag battery life and was current as of September 15, 2007.

Tag Code	Tagging Date	Release Location	Length (mm)	Tag Status
15	**4-Apr**	**Requa Boat Ramp**	**570**	**Unknown**
16	8-May	Starwin	570	Operative
17	9-May	Starwin	562	Operative
18	9-May	Starwin	630.5	Operative
19	**9-May**	**Starwin**	**590.5**	**Operative**
20	**9-May**	**Starwin**	**630**	**Operative**
21	11-May	Requa Boat Ramp	650.5	Operative
22	**11-May**	**Requa Boat Ramp**	**600**	**Operative**
23	**11-May**	**Requa Boat Ramp**	**590.5**	**Operative**
24	23-May	Requa Boat Ramp	560	Operative
25	23-May	Requa Boat Ramp	620	Operative
26	23-May	Requa Boat Ramp	620.5	Operative
27	23-May	Requa Boat Ramp	620.5	Operative
28	23-May	Requa Boat Ramp	600.5	Operative
29	23-May	Requa Boat Ramp	670	Operative
30	**24-May**	**Requa Boat Ramp**	**610.5**	**Operative**
31	**24-May**	**Requa Boat Ramp**	**630**	**Operative**
32	**24-May**	**Requa Boat Ramp**	**630**	**Operative**
33	24-May	Requa Boat Ramp	580	Operative

Table 2. Complete 2007 lamprey detections. Only the first detection at a given radio station is reported. Code number represents an individual lamprey.

Tag Code	Date	Location	RKM
15	6/4/2007	Blakes	13
15	6/9/2007	Surpur	32
19	5/14/2007	Surpur	32
19	5/16/2007	Metah	45
19	5/17/2007	Coon	57
19	6/2/2007	Weitchpec K	70
20	5/11/2007	Surpur	32
20	5/29/2007	Metah	45
22	5/13/2007	Blakes	13
23	5/11/2007	Blakes	13
23	5/26/2007	Surpur	32
23	6/6/2007	Coon	57
23	6/13/2007	Weitchpec K	70
30	6/5/2007	Blakes	13
31	6/5/2007	Blakes	13
31	6/9/2007	Surpur	32
31	6/15/2007	Weitchpec K	70
31	6/20/2007	Hopkins	75
32	6/11/2007	Blakes	13

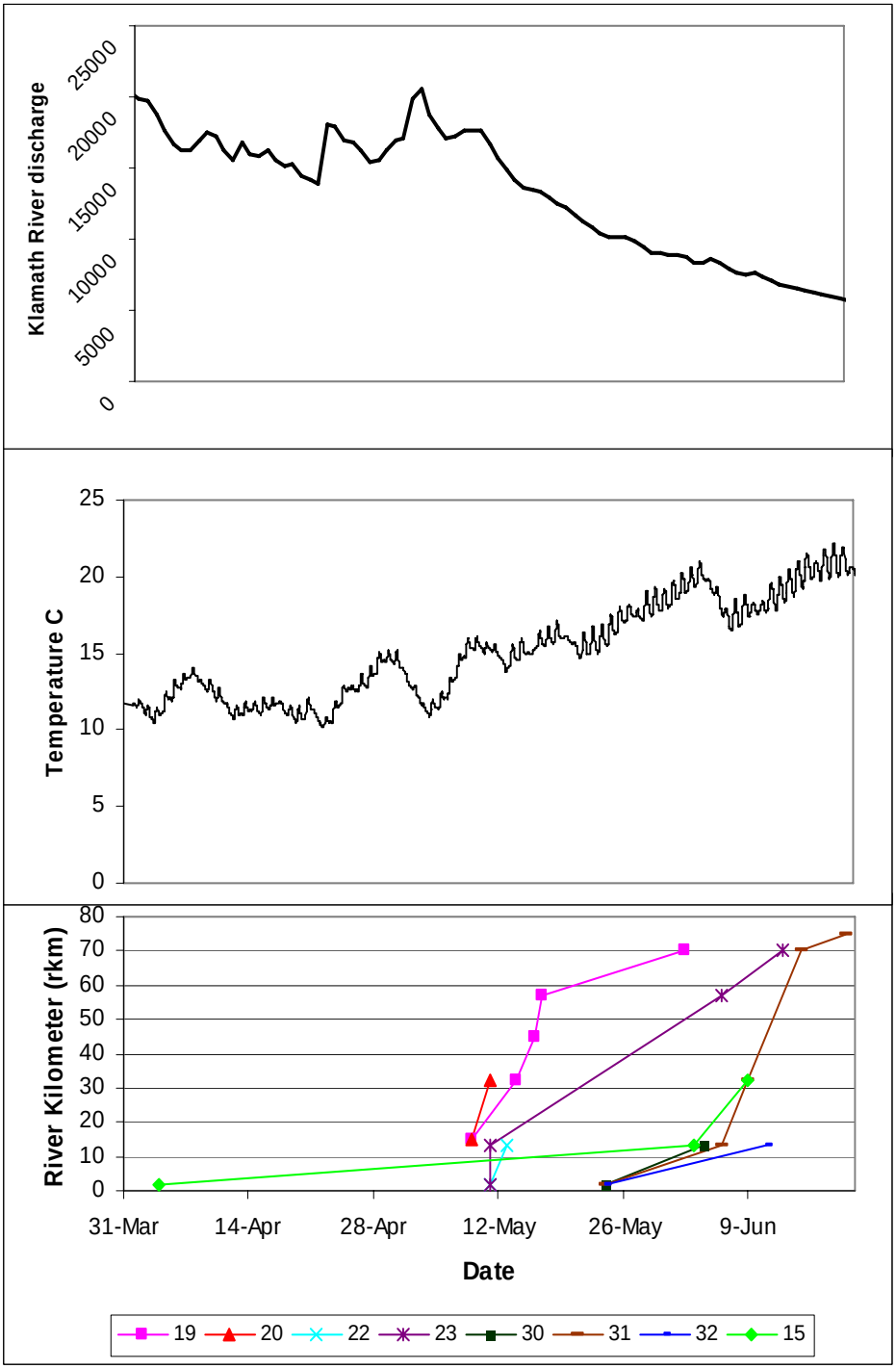

Figure 3. Klamath River discharge, temperature, and all tagged lamprey detections from rkm 1.5 to rkm 70 for duration of the study period. Discharge is measured in cubic feet per second, was recorded at Blakes Riffle (rkm 13), and is presented as daily averages. Temperatures were measured at Blakes Riffle (rkm 13) and are also presented as daily averages in degrees Celsius. The first point on each line of the detection chart is the release point after tagging. Each line represents the numeric code of a single lamprey.

Table 3. Migration rates presented in kilometers per day for tagged lamprey with a minimum of two Orion detections. Initial release point after tagging is included in these calculations. Actual migration durations were likely greater due to tag battery life and station array limitations. Code number represents individual lamprey.

Fish Code Number	Days of Migration	Total Distance Migrated (km)	Mean Daily Migration Rate (km/d)
15	66	30.5	0.46
19	24	55	2.29
20	18	12	0.66
22	2	11.5	5.75
23	34	68.5	2.01
30	12	11.5	0.95
31	24	72.5	3.02
32	18	11.5	0.63
	24.75	34.13	1.97

Discussion

Of the 19 lamprey successfully tagged during this study, eight (42%) made upstream migrations beyond the release location. The remaining 11 undetected lamprey (58%) were presumably lost to predation, tagging induced mortality, transmitter failure, non-detection, or returned to sea for the duration of their tag's lifespan. Pinniped and avian predation have been observed on Pacific lamprey in the Klamath River estuary by YTFP personnel (YTFP unpublished data), and pinniped predation on lamprey has been observed in the Rogue River estuary (Roffe and Mate 1984). The Rogue River estuary is located approximately100 km kilometers north of the Klamath River estuary. The surgical tagging process has been observed as a factor in short term (hours) suspension of migration due to physiological stress in studies conducted on Columbia River Pacific lamprey, however long term stress (days) was not found to be a significant problem (Close et al. 2003; Mesa et al. 2002).

No lamprey with operational tags were detected at the furthest upriver station at Sandy Bar (rkm 96.5) on the main stem of the Klamath River. Although there were two detections on the Trinity River station, it is assumed that no tagged lamprey entered the Trinity River. Instead, we believe that these fish were actually in the mainstem of the Klamath River due to the close proximity of the Trinity River station and the weakness of the signal detected there. No tagged lamprey were detected during mainstem tracking floats that encompassed the study area down stream of rkm 97.5. These floats were initiated five weeks after the last detection was made on a receiver station. Also, no lamprey were detected at any station after passing by it the first time, implying that

lamprey did not retreat downstream, out-migrate, or perish and float back downstream. Additionally, none of the five lamprey with operational tags that were released at rkm 15 were detected at the downstream listening station located at rkm 13.

The lack of detections during the float trip would suggest that the tagged lamprey were either predated upon in the mainstem Klamath River and their tags were transported outside of the river corridor (out of tracking range), had their transmitters fail, or migrated into a small tributary of the lower Klamath River (downstream of the Trinity River confluence). YTFP personnel have observed adult lamprey and lamprey redds in a number of the tributaries of the Klamath River in the past (YTFP unpublished data). Due to logistical challenges and lack of funding, no manual tracking was conducted in any of these tributaries. There are approximately 12 of these streams that could potentially be utilized by Pacific lamprey. We believe the migration into tributaries is the most feasible fate of the lamprey that were released or migrated into but not above the lower Klamath River (rkm 13 to 70). Tributaries of the Klamath River have significantly cooler water temperatures (Bartholow 2005), which would provide a bioenergetic advantage to lamprey that held in such creeks through the summer prior to spawning.

Upstream movements by Pacific lamprey in this study seemed to be correlated with increases in river temperature which coincided with decreasing river discharge (Figure 3). However, the small sample size (n=8) and limited monitoring season may have played a significant role in this observation. A detailed examination of this observation would benefit by having more tagged lamprey migrating in the river system preceding seasonal increases in temperature and decreases in discharge.

One objective of this project was to locate Pacific lamprey spawning locations within the Klamath River watershed. We believe that this would only be possible with intense manual tracking. This was not achievable during the 2007 project due to funding constraints.

The results of this study indicate that radio biotelemetry is a feasible method for investigating the movements of Pacific lamprey in the Klamath River. Radio telemetry has been a successful monitoring method in numerous studies in the Columbia River basin. Unlike sonic telemetry used in the first year of the pilot study (2006), radio telemetry used in the second year (2007) is not affected by high turbidity levels that are common in the Klamath River during winter and spring.

Furthermore, radio telemetry is compatible with manual tracking methods, which is a technique critical to answering many of the questions concerning lamprey biology in the Klamath River. Limitations in the maximum battery life of micro radio tags is their main shortcoming, but this applies to micro-tags of all types. A study plan that included manual tracking and an expansion of radio listening station locations would allow researchers to track lamprey to spawning locations, better determine migration behavior, evaluate the possibility of lamprey spending extended amounts of time in freshwater before spawning, and extend the study area to encompass a much larger range.

We believe that further research into the migratory behaviors of Pacific lamprey in the Klamath River watershed is required. Increased knowledge of Pacific lamprey biology will assist managers in critical decisions regarding this vulnerable tribal trust species.

Recommendations

- Conduct another season of tagging using Pices radio tags.
- Increase the number of tags.
- Begin tagging in January and end in July.
- Increase the number of radio listening stations and their spatial distribution (more above Weitchpec and at the mouths of tributaries).
- Increase the amount of time spent manual tracking in the mainstem Klamath.
- Initiate manual tracking surveys in tributaries of the Klamath River below Weitchpec that are known to be used by Pacific lamprey

Literature Cited

Bartholow, J. M. 2005. Recent water temperature trends in the Lower Klamath River, California. North American Journal of Fisheries Management 25:152-162.

Beamish, R.J. 1980. Adult biology of the river lamprey *(Lampetra ayersi)* and the Pacific lamprey *(Lampetra tridentata)* from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 37:1906-1923.

Beamish, R.J. and C.D. Levings. 1991. Abundance and freshwater migrations of the anadromous parasitic lamprey, *Lampetra tridentata*, in a tributary of the Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 48: 1250-1263.

Belchik, M.R. and Z.S. Larson. 1998. A preliminary status review of eulachon and Pacific lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program Technical Report.

Close, D.A., M.S. Fitzpatrick, and H.W. Li. 2002. The ecological importance of a species at risk of extinction, Pacific lamprey. Fisheries 27: 19-25.

Close, D. A., M. S. Fitzpatrick, C. M. Lorion, H. W. Li, and C. B. Schreck. 2003. Effects of intraperitoneally implanted radio transmitters on the swimming performance and physiology of Pacific lamprey. North American Journal of Fisheries Management 23:1184-1192.

Farlinger, S.P. and R.J. Beamish. 1984. Recent colonization of a major salmon-producing lake in British Columbia by Pacific lamprey (*Lampetra tridentata*). Canadian Journal of Fisheries and Aquatic Sciences 41: 278-285.

Hardisty, M.W. and I.C. Potter. 1971. The general biology of adult lampreys. P 127-206 *In* M.W. Hardisty and I.C. Potter [eds.]. The biology of lampreys. Vol 1. Academic Press Inc., London.

Michael, J.H. Jr. 1984. Additional notes on the repeat spawning by Pacific lamprey. California Fish and Game 70: 186-188.

Mesa, Matthew G., Jennifer M. Bayer, and James G. Seelye. 2003. Swimming performance and physiological responses to exhaustive exercise in radio-tagged and untagged Pacific lampreys. Transactions of the American Fisheries Society 132:483-492.

Moffet, J.W. and S.H. Smith. 1950. Biological investigations of the fishery resources of Trinity River, California. USFWS Special Scientific Report on Fish. 12. 71 pp.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley, California. 502 pp.

NRC (National Research Council). 2002. Scientific evaluation of Biological Opinions on endangered and threatened fishes in the Klamath River Basin: Interim report. National Academy Press, Washington DC.

Roffe, T.J. and B.R. Mate. 1984. Abundances and feeding habits of pinnipeds in the Rogue River, Oregon Journal of Wildlife. Management 48(4); 1262-1274.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Wydoski, R.S. and R.R. Whitney. 1979. Inland fishes of Washington. University of Washington Press, Seattle, Washington. 270 pp.