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PACIFIC LAMPREY RESEARCH AND RESTORATION ANNUAL REPORT 1997

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PACIFIC LAMPREY RESEARCH AND RESTORATION

ANNUAL REPORT 1997

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INTRODUCTION

The once abundant stocks of Pacific lamprey (*Lampetra tridentata*) above Bonneville Dam are currently depressed (Close et al. 1995). It is likely that many of the same factors that led to the decline of wild stocks of Columbia River Pacific salmon and steelhead have impacted Pacific lamprey populations as well. The Pacific lamprey is an important part of the food web of North Pacific ecosystems, both as predator and prey (Semekula and Larkin 1968; Beamish 1980; Pike 1951; Galbreath 1979; Roffe and Mate 1984; Merrell 1959; Wolf and Jones 1989). Lamprey are a valuable subsistence food and cultural resource for Native American Indian Tribes of the Pacific Northwest. Depressed Pacific lamprey runs have impacted treaty secured fishing opportunities by forcing tribal members to gather this traditional food in lower Columbia River locations.

The Pacific Lamprey Research and Restoration Project, funded by Bonneville Power Administration, is a cooperative effort between the Confederated Tribes of the Umatilla Indian Reservation, the Columbia River Inter-Tribal Fish Commission, and Oregon State University with the goal to increase Pacific lamprey stocks above Bonneville Dam. The initial objectives of the project are to determine the past and current abundance of Pacific lamprey stocks in major mid Columbia tributaries and at various hydroelectric facilities, and to determine factors limiting Pacific lamprey abundance and distribution. Ultimately, Pacific lamprey restoration plans will be developed and implemented.

Part (A)-CTUIR

1) determine past and present abundance and distribution in NE Oregon and SE Washington tributaries.
2) determine limiting habitat factors.

Part (B)-CRITFC

1) adult abundance monitoring at Columbia and Snake River dams.
2) juvenile abundance monitoring at Columbia and Snake River dams.
3) juvenile passage impediments and needed improvements at Columbia and Snake River dams.

Part (C)- OSU

1) adult passage impediments and needed improvements at Columbia and Snake River dams.
2) juvenile passage impediments and needed improvements at Columbia and Snake River dams.

Pacific Lamprey Research and Restoration

Part (A)

Historic and Current Pacific Lamprey (*Lampetra tridentata*) Abundance and Possible Reasons for Population Decline, Based on Oral Interviews, Review of Records, Literature, and Presence/Absence Sampling, in CTUIR Ceded Areas of Northeast Oregon and Southeast Washington Subbasins of the Columbia River.

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ABSTRACT

Based on oral interviews with tribal informants, current and former state and federal fisheries personnel, review of records and literature, and presence/absence sampling, it is apparent that Pacific lamprey were once abundant in ceded area streams of the Umatilla Indian Reservation (John Day, Umatilla, Walla Walla, Tucannon, and Grande Ronde subbasins). Current population levels appear severely depressed in all subbasins except possibly the John Day, which could be classified as depressed. The most probable reasons for population declines include: dams, chemical treatment activities, declining habitat quality (e.g. high water temperatures, poor water quality, low instream flows), and angle-iron in fishways to prevent lamprey passage.

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INTRODUCTION

"The Pacific lamprey maintains a place of cultural significance in the Columbia and Snake River Basins. Tribal people of the Pacific Coast and interior Columbia Basin have harvested these fish for subsistence, ceremonial, and medicinal purposes for many generations" (Close et al.1995).

Because of the severely depressed status of Pacific lamprey populations in ceded area streams above Bonneville Dam, tribal elders have discussed the restoration of "eels" in various ceded area streams with Umatilla Tribal Fisheries Staff for at least the last eight years. This project was a direct result of their diligent efforts.

Before reintroduction or rehabilitation is feasible, it is critical to determine the current status of indigenous Pacific lamprey populations in the John Day, Umatilla, Walla Walla, Tucannon, and Grande Ronde subbasins. Another important consideration was to understand the reasons for the decline in lamprey populations. The following information represents the first two years of gathering past and current population data. Subsequent study years will build upon this effort and eventually lamprey restoration plans and recommendations will be made for each subbasin.

METHODS

Past and Current Abundance

Phone and/or personal interviews were conducted with tribal informants and past and current employees of various state and federal agencies who work or have worked in the subject subbasin(s). Past and current records and literature were reviewed to document past and current Pacific lamprey abundance and possible reasons for population decline in each subbasin.

Presence/Absence Surveys

Sampling Locations:

Thirty-six presence/absence sites were sampled throughout the John Day, Umatilla, and Walla Walla river subbasins. The Tucannon and Grande Ronde river subbasins were not sampled in 1997 because ESA permits were not obtained. Streams sampled were chosen because historical information review (screen trap records, personal communications, biological survey data, historical literature) stated lamprey were once abundant in these systems. Ammocoetes burrow into the mud along the margin of streams where they feed upon vegetable material (Clemens and Wilby 1967). Pacific lamprey ammocoetes prefer silt/sand substrate in backwaters and quiet eddies of streams (Wydoski and Whitney 1979), therefore sites that looked to represent habitat preferred by Pacific lamprey ammocoetes were chosen for sampling. Areas were also chosen for accessibility to vehicles and supplies. Most sites that were sampled comprised of one or two habitat types (i.e. lateral pool and glide). Sites sampled usually contained sand/silt substrate (>2" deep) in the margin areas of site and gravel/cobble/boulder material throughout the rest of unit with slow water velocity. Lamprey require extended shock times before retraction from silt/sand substrate will occur (van de Wetering, pers. comm.). Based on observation, lamprey tend to burrow when shocking begins to avoid the electrical current. After extended shock times, lamprey retracted from substrate and were captured for measuring and identification. Standard volt (700-1000) and pulse (J-1) settings were usually used to perform sampling. Site conditions measured included: date sampled, site number, river mile, habitat unit type, site dimensions (length x width x depth), water temperature, silt temperature, discharge, water clarity, volts and pulse used, and weather conditions. Notes were added giving detailed description of sites, and photographs of sites were taken. When necessary, private landowners were contacted and permission was obtained prior to sampling.

Equipment Used:

A model 12-B Smith-Root electrofisher was utilized to perform sampling. Lamprey were captured with dipnets, placed in buckets and anethesized with MS-222 (Ticaine Methanesulfonate). Once anethesized, lamprey were measured (tip of snout to tip of tail), keyed to species, and checked for abnormalities. Lamprey were placed in recovery buckets for 5-10 minutes and then released where the majority of catch was made.

Species Identification:

Species identification of Pacific lamprey was difficult. Juvenile Pacific lamprey and juvenile western brook lamprey share many of the same physical characteristics. According to Wydoski and Whitney (1979), the distinguishing characteristic between the western brook and the Pacific lamprey is the pigment above and below the tip of the tail. The Pacific lamprey (Figure C-8) has a dark line above and below the tip of the tail, whereas, the western brook lamprey (Figure C-7) lacks pigment in the membranous tip of the caudal fin (transparent like). Although we found variation in the amount of pigment of both species, we utilized Wydoski and Whiteny's methods for identifying each species.

RESULTS/DISCUSSION/RECOMMENDATIONS

JOHN DAY SUBBASIN

Historic Abundance:

The John Day Subbasin has historically produced many species of salmonids including: spring and fall races of chinook salmon (*Oncorhynchus tshawytscha*), summer steelhead (*Oncorhynchus mykiss*), red-band rainbow (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), western-slope cutthroat (*Oncorhynchus clarki lewisi*), and mountain whitefish (*Prosopium williamsoni*), and two species of lamprey: western brook lamprey (*Lampetra richardsoni*), and Pacific lamprey (*Lampetra tridentata*).

Historic estimates of Pacific lamprey abundance are unavailable but according to Claire (ODFW, pers. comm.) they were once very numerous. This subbasin was historically utilized for fishing purposes by the Umatilla, Columbia River, Pauite, Shoshone-Bannock, and Warm Springs Indian Tribes (A. Minthorn, pers. comm.). The subbasin was also utilized by the Rock Creek Indian Tribe (Swindell Report 1941). Although Celilo Falls was the major fishing site for Columbia Basin Tribes, the John Day River and tributaries supported a fishery at one time (Swindell Report 1941). The John Day River primarily was utilized for salmon and trout fishing but harvest of Pacific lamprey did occur within the subbasin (A. Minthorn, pers. comm.). The Middle and North Forks were the most popular areas chosen for harvesting. Lane and Lane (1979) noted one area in the John Day River utilized by the Umatilla and Columbia River Tribes was known as "*tuck-pus*", near Albert Phillipi Park. Salmon, eels, and whitefish were harvested near this area. Camas Creek and the North Fork John Day were also noted as areas that eels were once harvested. Percy Brigham, CTUIR elder and fisherman, stated that he harvested eels at the mouth of the John Day River, and at an area he called "little falls" on the John Day River.

Current Abundance:

The John Day Subbasin currently supports a remnant run of anadromous Pacific lamprey and non-anadromous western brook lamprey (Claire, pers. comm.). Although adult population levels are unknown, screen trap operators have observed a few Pacific lamprey in screen trap boxes. ODFW observed one dead adult Pacific lamprey in the North Fork John Day subbasin, near Texas Bar Creek, in the fall of 1997. The next most recent sighting of adult Pacific lamprey on the spawning grounds was in the spring of 1992. Two live adults, two dead adults, and two redds were observed on the lower John Day River (RM 80), and a spawning pair of Pacific lamprey was also observed on a redd on the Middle Fork John Day River near river mile 65 (Claire, pers. comm.).

After a hydrochloric acid spill in 1990, it was estimated that 9500 Pacific lamprey (mostly ammocoetes) died in the North Fork John Day River.

In 1997, ODFW sampled 80 Pacific lamprey ammocoetes in Vincent Creek, a tributary to the Middle Fork John Day River at RM 64.0. Thirty-six Pacific lamprey ammocoetes were sampled in the upper mainstem of the John Day River (RM 273.5), and two Pacific lamprey ammocoetes were sampled in Clear Creek (RM 1.0), a tributary to Granite Creek in the upper North Fork John Day River subbasin.

The John Day Subbasin produces the largest remaining run of wild spring chinook salmon in the Columbia River Basin. Up to 4,000 wild spring chinook adults annually return to this system. Fifteen thousand to 40,000 adult wild steelhead also return to this subbasin yearly (Claire, pers. comm.). Fall chinook salmon are extinct.

Currently, the John Day River supports a token tribal spring chinook salmon fishery each year. Over the last five years in the North Fork John Day drainage, an average of 25 spring chinook salmon were annually harvested by tribal members. Currently, no known tribal harvest of Pacific lamprey occurs in this subbasin.

Presence/Absence Findings:

Presence/absence sampling was conducted at 16 sites in the John Day River subbasin in 1997. Time constraints limited the amount of sampling that staff could perform. Sampling will continue in 1998.

Six sites were sampled in Camas Creek, a tributary to the North Fork John Day River (Table B-3). Sites were located at RM 0.1, 1.2, 3.1, 4.2, 9.1, and 10.5. Temperatures for Camas Creek during electrofishing surveys (July 31-August 1, 1997) ranged from 19^{o}C to 20^{o}F. For sites sampled, an average of 1.1 fish/minute was captured. The highest density (3.4 fish/minute) was recorded at RM 10.5. The lowest density (0.0) was recorded at RM 0.1 and 4.2. A total of 221 (40 to 167mm) Pacific lamprey ammocoetes were sampled (Figure C-3). Sixty-one percent of total lamprey captured in Camas Creek was at RM 10.5. This site had heavy silt/sand substrate (6-8" deep) on right bank with slow water velocity. All lamprey captured in Camas Creek appeared to be in good condition. The largest and smallest Pacific lamprey ammocoete captured in Camas Creek was at RM 1.2. No abnormalities were found on any lamprey captured. Sampling will continue in 1998 to further document presence/absence of lamprey in the Camas Creek subbasin.

Three sites were sampled during August 25-26, 1997 in the North Fork John Day River. Sampling of more sites downstream was not possible because of instream work that was taking place during this time period creating unfavorable water conditions for sampling. Sites were located at RM 69.8 (Backwater), 75.0 (Scour Pool), and 75.8 (Lateral Pool). Water temperatures ranged from 16^{o}C to 16.5^{o}C during electrofishing surveys. An average of 6.5 fish/minute was captured for all sites sampled in the North Fork John Day River (Table B-3). The highest density (8.2 fish/minute) was recorded at RM 69.8. Silt depth at this site ranged from 6" to 8" deep with slow water velocity. A total of 178 (16 to 122mm) Pacific lamprey ammocoetes were captured (Figure C-4). All lamprey were captured in margin habitat. Based on observation, all lamprey appeared to be in good condition. No abnormalities were found on any lamprey captured.

In the mid to upper mainstem John Day River, 3 sites were sampled on August 4, 1997. Sites were located at RM 226.1, 245.5, and 257.2. Both Pacific and western brook ammocoetes were found at two of these sites (RM 226.1 and 245.5). Lamprey were found in the margin areas of sites. At RM 226.1 the ratio of Pacific lamprey to western brook lamprey was 1.3:1. At RM 245.5 the ratio of Pacific lamprey to western brook lamprey was 1.2:1. Based on observation, both species appeared to be in good condition.

Two sites were sampled in the Middle Fork John Day River on August 5, 1997. Sites were located at RM 41.5 (Glide) and 65.0 (Lateral Pool). Instream work during survey period prevented further presence/absence sampling. Water temperatures ranged from 17.5^{o}C to 19^{o}C. A total of 47 (17 to 138mm) Pacific lamprey ammocoetes were sampled. All lamprey were found in the margin areas of sites. At RM 41.5 a density of 7.5 fish/minute was recorded. At RM 65.0 a density of 5.7 fish/minute was recorded. Based on observation, all lamprey captured appeared to be in good condition.

Two sites were sampled for presence/absence in the South Fork John Day River. At RM 9.0 (Glide) a density of 3.5 fish/minute were recorded. This site had silt 1-2" deep, with a water temperature of 20^{o}C. At RM 29.1 (Lateral Pool) no lamprey were captured at this site. Site is located directly above Izee Falls, a natural passage barrier that could be impacting adult lamprey migration.

Anthropogenic Habitat Alterations:

Adult Pacific lamprey prefer low gradient stream sections, where gravel is deposited, for spawning (Kan 1975). Historically, spawning Pacific lamprey were often observed while conducting steelhead spawning ground surveys and often spawn in similar habitat (Claire, pers. comm.; Witty, pers. comm.). The ammocoetes are usually found in cold water (Mallatt 1983). It seems the habitat requirements for Pacific lamprey during most freshwater life history stages are similar to those preferred by salmonids. Thus, degradation of freshwater habitat that has affected salmonid abundance and distribution has probably affected Pacific lamprey abundance and distribution.

Historical descriptions of the John Day Subbasin indicate that the John Day River was once a relatively stable river with good summer stream flows, good water quality, and heavy riparian cover. The North Fork tributaries were well wooded with aspen, poplar, and willow; had good streamflows, and good channel structure. These conditions are common in undisturbed river systems, which have a tendency to meander and form a sequence of pools and riffles (ODFW et al. 1990).

In the late 1800's mining became a major factor in the John Day system. Placer mining channelized streams, left little shade, created high silt loads, and diverted flows. In the 1930's and 40's, dredge mining overturned the stream channels in the larger streams. This activity often changed stream courses, silted gravel, and destroyed riparian areas (ODFW et al. 1990).

Extensive timber harvest followed the discovery of gold in the John Day Subbasin. Roads were built on steep slopes, along streambanks, and across watersheds where timber was removed to supply growing communities (OWRD 1986).

Farming and ranching practices starting in the 1860's and 1870's led to loss of native riparian grasses in summer range areas in the upper watershed of the John Day Subbasin. Livestock foraged primarily on perennial grasses and shrub cover. During this time many rangelands, under grazing pressure, converted from grass-forb-browse ecosystems to weed-forb ecosystems. As grass rangelands declined in the subbasin, and wildfire suppression increased, the invasion of juniper and sage increased (ODFW et al. 1990).

Today, livestock overgrazing, water withdrawals for irrigation, landowner clearing, road building, timber harvest, and stream channelization has created further fish habitat problems by disturbing or destroying riparian vegetation and destabilizing streambanks and watersheds.

Healthy riparian areas represent a vital part of the watershed and provide multiple functions – nutrient cycling, shading, bank stabilization, water storage, filtration and retention cover, and wildlife values (Stuart et al. 1988). Riparian habitat degradation is the most serious habitat problem in the John Day River Subbasin with approximately 660 degraded stream miles identified (ODFW et al. 1990). Degradation has resulted in low summer flows, high summer and low winter water temperatures, high spring flows, depressed beaver populations, accelerated bank erosion, excessive sedimentation, and reduced cover (ODFW et al. 1990). The Oregon Water Resource Department (1986) states that "activities in the last 125 years may have had a significant impact on the basin's capacity to retain water and release it later in the season. Analysis of historical flow data suggests that more precipitation falling in the subbasin during winter now runs off immediately instead of staying in the subbasin. The use of the watershed's resources to satisfy consumer demand for forest products, grains, minerals, and other commodities probably has increased winter runoff and decreased spring runoff."

Warm water temperatures limit the downstream distribution of fingerling chinook salmon in the Middle and North Forks during the summer (ODFW 1986). Claire stated that marginal habitat suitable for rearing rainbow/steelhead during the summer months was as follows: the entire Middle Fork, North Fork from Baldy Creek to the mouth of the Middle Fork, South Fork from South Fork Falls to the mouth, and in the mainstem John Day River from the headwaters to Kimberly. Areas above the marginal areas are utilized mostly by salmonids because of the cooler water temperatures during the critical summer months. Juvenile rainbow/steelhead range further downstream in the John Day system than juvenile chinook salmon, because they have adapted to slightly higher water temperatures. The habitat available for steelhead and spring chinook salmon may also be utilized by Pacific lamprey since they prefer similar habitat and water quality as salmonids.

Claire (ODFW, pers. comm.) stated that passage barriers within the John Day Subbasin have not been and are currently not significant enough to impede Pacific lamprey.

Many chemical treatments designed to eradicate rough fish have occurred in various areas of the John Day Subbasin. From 1962 to 1982, chemical treatment projects took place in the Middle Fork John Day River as follows: the lower 42 miles were treated in 1966; the lower 3 miles were treated in 1973, the reach from Phipps Meadow to Vincent Creek was treated and the lower 64.5 miles were treated with squoxin in 1974; and, the reach from Phipps Meadow to the mouth was treated with rotenone in 1982 (ODFW 1986). Claire stated that most ammocoetes that were observed by ODFW were following chemical treatment projects. When fish kill assessments were conducted, Pacific lamprey were not enumerated separately, instead they were included in the "other" and "rough fish" columns and lumped into one numerical number with other non-salmonids. Therefore, numbers that were eradicated through chemical treatment projects are not known. Freshwater life history of larval Pacific lamprey may extend up to six years before migration to the ocean (Close et al. 1995). Therefore chemical treatment activities may have eliminated several age classes of juvenile lamprey per treatment.

In February 1990, a hydrochloric acid chemical spill occurred in the North Fork John Day River below the Camas Creek Bridge near the town of Dale. Approximately 3,500 gallons of acid spilled into the river and killed an estimated 4,000 juvenile salmon and steelhead, 300 bull trout and 9,500 Pacific lamprey. Claire (ODFW, pers. comm.) stated that most lamprey killed by the hydrochloric acid were ammocoetes and the loss of Pacific lamprey was important because it may have been a significant portion of the total outmigrant population for that year.

Discussion:

Most information gathered on Pacific lamprey in the John Day Subbasin is anecdotal. Past and current estimates of population abundance are unavailable. Historical data was reviewed from 1955 to 1995. It appears, as in other subbasins, lamprey were not specifically identified to species until recently (1995). Therefore, historical abundance data likely included western brook lamprey as well as Pacific lamprey. Reviewed data appeared to be inconsistant, and did not show evidence of annual or seasonal variation. For example, some years in various tributaries lamprey were recorded on an annual basis, but in other years for the same tributary no data was recorded for lamprey. This inconsistancy may have resulted from different personnel operating trapping devices over the 40 year span of review, or that lamprey were not enumerated with other anadramous species. ODFW screen trap technicians and area biologists state that lamprey were once very numerous in this subbasin (Claire, pers. comm.; Moulton, pers. comm.). According to Claire various agencies attempting to halt the decline of Pacific salmon and steelhead did not have time to concern themselves with the decline of Pacific lamprey. Claire stated that Pacific lamprey were very numerous in the John Day Subbasin prior to the completion of the John Day Dam in 1968. Claire also stated that lamprey populations have drastically declined possibly due to inbasin habitat degradation and passage problems in the mainstem Columbia River.

In researching recent and historical weekly screen trap reports for this subbasin, it was found that most lamprey enumerated were not keyed to species. Therefore, it is not known if the lamprey observed were Pacific lamprey. Claire stated that he felt most lamprey observed by screen trap technicians were Pacific lamprey ammocoetes. Gray and Unterwegner (ODFW, pers. comm.) stated lamprey identified by screen trap operators were keyed to species by the development of the eye, a fully developed eye was considered a western brook lamprey.

Although John Day Basin lamprey populations are probably a fraction of past abundance, the remaining population (like wild salmon and steelhead) is thought to be the most abundant today relative to other subbasins in this report. We will attempt to further document the current abundance of Pacific lamprey and investigate the feasibility of John Day Pacific lamprey as a candidate for a donor stock in subsequent years of this study.

Recommendations:

1) Request that ODFW enumerate lamprey at all trap boxes, key to species (when possible) at all trapping sites, and document capture locations and life history stage (ammocoetes vs. macrophthalmia / uneyed vs. eyed) of lamprey observed.

2) Continue to conduct random spot checks within the subbasin to determine presence/absence.

3) Request that ODFW continue to document any adult Pacific lamprey observed during stream surveys.

4) Collect Pacific lamprey ammocoetes for scientific analysis.

UMATILLA SUBBASIN

Historic Abundance:

In 1812, Wilson Price Hunt lead members of the Astor party down the Umatilla River on a voyage to the Columbia River. Wilson stated that the Indians called the river "Eo-u-tal-la (Umatilla), and it was abounded with beaver". Historically, Pacific lamprey were abundant in this subbasin (H. Campbell, pers. comm.; N. Bean, pers. comm.; D. Heckeroth, pers. comm.; E. Quaempts, pers. comm.; A. Halfmoon, pers. comm.; D. Jackson, pers. comm.). Prior to the 1900's, wild summer steelhead, chinook, coho and chum salmon were also present in the Umatilla River. Other wild salmonids historically present were as follows: bull trout, red-band trout, and mountain whitefish. The Umatilla River was primarily utilized by the Umatilla, Cayuse, Nez Perce and Columbia River Tribes (Swindell Report 1941, Lane 1979). Fishing for salmon, trout, whitefish and eels by tribal members historically occurred throughout the subbasin. Much of the eel harvesting occurred at Three Mile Falls Dam and at this site prior to construction of the dam. Harvest also occurred in the North and South Forks (Swindell 1941; Lane and Lane 1979).

Tina Jackson-Norvell and Donald Jackson, both CTUIR enrollees, remember seeing Pacific lamprey near Cayuse, Oregon in the Umatilla River prior to chemical treatment during the summer months in the late 1960's. Donald Jackson stated that he witnessed ammocoetes and adult spawning lamprey near this site.

Virgil Bronson, CTUIR enrollee, stated that "after the second treatment in 1974, the south bank of the Umatilla River near Cayuse, Oregon had thousands upon thousands of dead eels about 8" to 10" long".

Alphonse Halfmoon, CTUIR enrollee, stated that he remembers seeing ammocoetes "dying in the mud" during times of rotenone in the Umatilla River, and collected trout that had died from the effects of rotenone.

Elias Quaempts, CTUIR enrollee, also stated that they used to catch lots of eels until the fish poisonings started occurring in this subbasin. Mr. Quaempts used to fish at Three Mile Falls Dam for eels in the 1930's, and said eels were abundant at that time in the Umatilla River.

Armand Minthorn stated that Jasper Shippentower used to collect eels at the mouth of Meacham Creek. Minthorn also stated that Jasper Shippentower witnessed spawning activity at this same site.

Jimmy Clark, CTUIR enrollee, stated that he observed juvenile and adult lamprey in Buckaroo Creek in the late 1950's and early 1960's. Clark stated that tribal members occasionally collected Pacific lamprey in Buckaroo Creek, and Pacific lamprey utilized the stream for spawning and rearing.

Norman Been, former ODFW screen trap operator stated that "there were so many adult Pacific lamprey in the Umatilla River that they were a nuisance"

Weekly screen trap reports for the Umatilla River Subbasin show that lamprey were not specifically enumerated from 1960 through 1969. From 1970 through 1973 during May and June, 115 lamprey were enumerated near RM 49.5. Lamprey captured in traps were not keyed to specific species or life history stage. Information for 1974 through 1985 was not available for review.

Current Abundance:

Pacific lamprey populations in the Umatilla River Subbasin are at a very low level. Zimmerman (CTUIR, pers comm.) stated that he observed one adult Pacific lamprey at Westland Irrigation Diversion (RM 27) in July of 1996, and also observed 12 adult Pacific lamprey in the ladder at Three Mile Falls Dam during dewatering in April of 1996. Zimmerman further stated that facility operation technicians have observed one or two adult Pacific lamprey several times per year in the viewing window and ladder at Three Mile Falls Dam during spring operations.

From December 1994 to May 1996, 68 lamprey (adults and juveniles) were sampled by ODFW (Knapp, pers. comm.) at rotary screw trap sites below Three Mile Falls Dam, or at the West Extension Irrigation District canal (RM 3.7). Forty percent of the lamprey captured ranged from 130mm to 190mm. Eleven lamprey captured at West Extension Irrigation District canal ranged from 450mm to 610mm.

Hoverson (CTUIR, pers. comm.) and the CTUIR electroshocking crew observed one live, one dead, and one near dead adult Pacific lamprey below Three Mile Falls Dam in June, 1996.

The Umatilla Basin Natural Production Monitoring and Evaluation Project has operated rotary screw traps in Meacham Creek and in the mainstem Umatilla River, both above and below the Meacham Creek confluence and at Barnhart at various times during the past six years and electroshocking crews have intensively sampled many areas of the mainstem and lateral tributaries. No Pacific lamprey have ever been observed or captured above Three Mile Falls Dam.

In 1986, 1988, 1989, 1990, 1992, 1993, and 1994 records show that no juvenile lamprey were captured at any of the screen trap boxes in this subbasin. It may have been that lamprey were counted as "other fish", and combined into one numerical number. As lamprey appear in the screen trap boxes, rotary traps, and other sampling operations, ODFW will now start enumerating, and identifying each specimen captured.

Brian Kilgore, ODFW screen trap operator, stated that no lamprey were captured in 1997 in the Umatilla River Basin.

In 1997, ODFW (Kern, pers. comm.) captured 298 juvenile Pacific lamprey in rotary screw trap operations near RM 1.0. Lamprey were keyed to species and length measurements were taken. Sizes ranged from 65 to 170mm.

In 1997, CTUIR (Zimmerman, pers. comm.) did not capture any adult Pacific lamprey in the operation of Three Mile Falls Dam.

Currently, the Umatilla River Subbasin does not support a tribal harvest of Pacific lamprey.

Presence/Absence Findings:

12 sites were sampled in the Umatilla River subbasin in 1997 (Table B-3). Only at two sites, located below Three Mile Falls Dam, were lamprey found. At RM 3.6 (Isolated Pool) 4.8 fish/minute was recorded. This site had silt approximately 3" deep, and a water temperature of 24^{o}C. The next site (also RM 3.6) had a recorded density of 1.7 fish/minute. This site had silt approximately 3" deep, and a water temperature of 24.5^{o}C. Both sites lacked adequate riparian habitat. It is likely that a combination of low instream summer flows, inbasin habitat dedgradation, and passage through Three Mile Falls Dam have limited Pacific lamprey migration in this subbasin. Other sites sampled in the Umatilla River Basin had habitat that represented habitat preferred by adult and juvenile lamprey. No lamprey were found above Three Mile Falls Dam.

Extensive electroshocking was performed by the Umatilla Basin Natural Production Monitoring and Evaluation Project in 1997. This project did not capture/observe any lamprey in the Umatilla River Basin.

Anthropogenic Habitat Alterations:

Adult Pacific lamprey prefer low gradient stream sections, where gravel is deposited, for spawning (Kan 1975). The ammocoetes are usually found in cold water (Mallatt 1983). It appears that the habitat requirements for Pacific lamprey during most freshwater life history stages are somewhat similar to those preferred by salmonids. Thus, degradation of freshwater habitat that has affected salmonid abundance and distribution has probably affected Pacific lamprey abundance and distribution.

The Umatilla River begins on the west slope of the Blue Mountains and flows northwesterly across the Umatilla Plateau for about 115 miles until its confluence with the Columbia River at RM 289. Historically, the Umatilla River headwaters contained several species of trees; lodgepole pine, ponderosa pine, Douglas fir, white fir, grand fir, Engelmann spruce, and larch which provided shading in the headwaters. High elevation lands are dominated by forest with an understory of grass and brush; making watershed conditions generally good. Mid-elevation lands are characterized by strips of timber shading into brush and grass as elevation declines; large areas cleared for farming operations have created vast amounts of sediment (CTUIR et al. 1990).

Livestock grazing, road and railroad building, irrigation practices, timber harvest, and farming operations have led to the decline of adequate habitat for fish in the Umatilla River Subbasin. Riparian conditions, for the most part, are good in the upper headwaters as compared to the lower river conditions where farming operations and industries have invaded the riparian areas of the Umatilla River eliminating adequate shade in some areas (CTUIR et al. 1990).

Irrigation is the principal water use competing with fish production in the Umatilla River Subbasin. Until recent years many irrigation diversions were unscreened. Salmonids would enter these unscreened diversions and become mortalities (CTUIR et al. 1990). Pacific lamprey ammocoetes probably suffered the same fate. The lower mainstem usually is dewatered during the irrigation season, impeding emigrant juvenile and late arriving adults in the late spring, and early arriving adults in the fall (CTUIR et al. 1990). These passage problems and the dewatering process likely had a negative affect on migrating juvenile and adult lamprey.

Irrigation occurs throughout the mid to upper reaches of this subbasin. Most irrigation diversions are registered to private individuals irrigating vegetable gardens and small pastures. Small pumps are utilized to obtain water, and surveys conducted show that pumps appear to be screened. None of these irrigation diversions in the mid to upper mainstem Umatilla are believed to be passage barriers for Pacific lamprey.

If adequate instream flows are present, this subbasin has several passage barriers that Pacific lamprey may have minimal or no trouble negotiating. The major artificial passage barriers are: 1) Three Mile Falls Dam; 2) Westland irrigation diversion; 3) Feed canal; and 4) Stanfield irrigation diversion. These are passage barriers for salmonids, and were recently modified providing new fish ladders to improve salmonid passage. There are several artificial and natural passage barriers on lateral tributaries in this subbasin. These barriers would not affect lamprey passage.

Two chemical treatment projects occurred in the Umatilla River Subbasin. In 1967 and 1974, 90 and 85 miles of stream were rotenoned to eliminate targeted areas of rough fish. Norman Been, former ODFW screens operator (1964 to 1995), stated that "there were so many adult Pacific lamprey in the Umatilla River that they were a nuisance". He primarily saw adults at Westland and Three Mile Falls Dam and viewed ammocoetes near the mouth of Meacham Creek prior to chemical treatment. Been further stated that he "saw few lamprey after the chemical treatment in 1967", and that he "never saw any lamprey after the chemical treatment in 1974". The chemical treatment is also important due to the fact that larval life of lamprey may extend up to six years in freshwater before migrating to the ocean (Close et al. 1995). These chemical treatment activities likely eliminated several age classes of lamprey per treatment.

Chemical treatment projects were targeted at eliminating "rough fish", but areas that were rotenoned included areas that were known to be utilized by steelhead for spawning and juvenile rearing. These areas were also used by Pacific lamprey.

Discussion:

Several tribal members were interviewed about the decline of Pacific lamprey in the Umatilla River Subbasin. Percy Brigham, Elias Quaempts, Alphonse Halfmoon, and Armand Minthorn, all CTUIR enrollees, believe that lamprey populations drastically declined during times of fish poisonings. Most members interviewed also stated that they harvested eels at Three Mile Falls Dam as children.

As was the case for salmon, complete water withdrawal for irrigation and unscreened diversions may have been a major factor in the decline of the Pacific lamprey population.

The Umatilla Basin salmon restoration program is now a model of success in the region due to numerous efforts such as enhanced instream flows, passage improvements at ladders and screens, instream/watershed enhancements and hatchery supplementation. If common habitat factors lead to the demise of both salmon and lamprey and improvements of those factors are resulting in salmon restoration, the Umatilla Basin may be an ideal candidate for lamprey restoration. As occurred during salmon reintroduction, it may be necessary to utilize a stock from outside the subbasin due to the very low current population status. Further discussion on specific Umatilla Basin lamprey restoration plans will be forthcoming as this study continues.

Recommendations:

1) Request that ODFW enumerate lamprey at all trap boxes, key to species (when possible) at all trapping sites, and document capture locations and life history stage (ammocoetes vs. macrophthalmia / uneyed vs. eyed) of lamprey observed.

2) Request that ODFW and CTUIR document any adult Pacific lamprey observed during stream surveys.

3) Conduct random spot checks within the subbasin to determine presence/absence of Pacific lamprey.

4) Collect Pacific lamprey ammocoetes for scientific analysis.

<u>WALLA WALLA SUBBASIN</u>

Historic Abundance:

The Walla Walla River Valley Indian name is "*Wai-i-lat-pu*", the place of rye grass. The Walla Walla River once supported runs of steelhead, chinook, coho, sockeye, and chum salmon. Historic abundance estimates for Pacific lamprey are not available. Harvest information gathered from tribal informants suggests that Pacific lamprey were once abundant in the subbasin. Armand Minthorn (CTUIR, pers. comm.) stated that the North and South Forks of the Walla Walla River were utilized for eel harvesting. Eels were also collected near Skiphorton Creek on the Walla Walla River by CTUIR members (Swindell 1941). These areas where Pacific lamprey were harvested had good riparian habitat, high water quality, and low gradient for spawning and rearing, similar to spawning and rearing habitat preferred by salmon and steelhead.

Current Abundance:

Currently, no accurate numerical information is available on Pacific lamprey in the Walla Walla Subbasin. Weekly screen trap reports reviewed for the Walla Walla River indicate lamprey were enumerated at different times during the last several years. In the 1960's and from 1985 to 1990 lamprey were either not enumerated at different trap box sites, or counted as rough fish and lumped into a numerical number with other non-salmonid species. Information for 1970 through 1984, and 1991 was not available for review. From 1992 through 1995, 246 lamprey were enumerated in the Walla Walla

Subbasin trap boxes. Seventy-three percent of all lamprey were captured at the Little Walla Walla River diversion, near RM 47. Lamprey captured were not keyed to specific species, nor life history stage. Therefore it is not known whether lamprey captured were Pacific lamprey or non-anadromous western brook lamprey.

In May 1997, CTUIR sampled fifty-five lamprey from two dump truck loads of sand and sediment removed from in front of the rotary screens at the Little Walla Walla River diversion. Many more lamprey were present but impossible to access. Of the 55 sampled, 51 were western brook lamprey, and four were Pacific lamprey ammocoetes. The sediment and lamprey were returned downstream of the collection site.

In 1996, WDFW electroshocked nine lamprey in the South Fork Touchet River, five lamprey in the North Fork Touchet and three lamprey in Wolf Creek. Although lamprey captured were not keyed to species.

CTUIR electroshocked approximately 50 western brook lamprey in Mill Creek in July 1996. 15 were collected; releasing 12 upstream and sacrificing 3 for future identification purposes. The area surveyed in Walla Walla, WA, near the Wilbur Street bridge was chosen because of an oral reference stating that lamprey were once numerous at this site.

In the fall of 1993, CTUIR electroshocked 5 ammocoetes, in the South Fork Walla Walla River near RM 6. Lamprey captured were ammocoetes, but were not keyed to specific species.

James Pearman, a Walla Walla College student, noted collecting western brook lamprey in Yellowhawk and Cottonwood creeks in July, 1977. Yellowhawk Creek is a diversion of Mill Creek.

Presently, there is no harvest of adult Pacific lamprey in this subbasin.

Presence/Absence Findings:

Presence/absence sampling was conducted at eight sites in the Walla Walla River Basin. No Pacific lamprey were captured at any sites in the Walla Walla Basin for this survey. All fish sampled in the Walla Walla Basin were keyed to the western brook species. Time constraints limited the amount of sampling that could be performed. Sampling will continue in 1998.

Sampling was performed at four sites on the mainstem Walla Walla River (Table B-3). Sites were located at RM 12.2, 29.2, 38.2, and 47.0. Temperatures during the survey (August 18-20, 1997) ranged from 14°C to 25°C. Of these, lamprey were captured at only one site (RM 47.0, Little Walla Walla Diversion). 2.3 fish/minute was recorded at this site. A total of 31 (15 to 155mm) western brook lamprey were captured. This site had approximately 4” of silt in the right margin of the site. No abnormalities were observed on any lamprey sampled at site. Sampling will continue in 1998 to further document lamprey presence/absence in this subbasin.

Sampling was performed at three sites on the Touchet River, a major tributary to the lower mainstem of the Walla Walla River. Sites were located at RM 40.4, 44.3, and 51.2. Temperatures during the survey (August 21, 1997) ranged from 18°C to 19°C. Fifity-one total western brook lamprey (2.8 fish/minute) were sampled at RM 51.2. No lamprey were captured at RM 40.4, and 44.3. Fish sampled size ranged from 32 to 169mm in length. One western brook ammocoete (84mm) appeared to have and extra tail that branched off of the upper caudal area. All other lamprey sampled had no visual abnormalities. Sampling is planned for 1998 to further document lamprey populations in the subbasin.

One site (RM 2.5) was sampled on the South Fork Walla Walla River. Time constraints limited the amount of sampling that could be performed. No lamprey were captured at this site. Further sampling will need to continue in 1998 to further document lamprey abundance in this subbasin.

Anthropogenic Habitat Alterations:

The Walla Walla River originates in the Blue Mountains in northeast Oregon. The river flows west and north and meets the Columbia River, near Wallula, Washington at river mile 315. The river drains 1,785 square miles of northeastern Oregon and southeastern Washington. This subbasin lies within Walla Walla and Columbia counties in Washington and Umatilla, Wallowa, and Union counties in Oregon (CTUIR et al. 1990).

The subbasin is comprised of two major physiological regions. The Walla Walla region is characterized by rolling, treeless upland formed by deep deposits of loess overlying multiple lava flows. The Blue Mountain region consists of the long tilted plateaus formed by uplifting, folding, faulting and erosion of the Columbia River basalt and is characterized by flat-topped ridges, steep-walled canyons, and mountain slopes. Though minimal in percentage of subbasin area, the Blue Mountains are the major source for water in the subbasin (CTUIR et al. 1990).

The high elevation of the Blue Mountains are dominated with interspersed grasses. Forest species include lodgepole pine, ponderosa pine, Douglas fir, white fir, grand fir, subalpine fir, Engelmann spruce and larch. Mid elevation uplands have little or no vegetation cover due to extensive and intensive dry-farming. The river valley is suited to agriculture and extensively irrigated (CTUIR et al. 1990).

Extensive and intensive irrigation in the Walla Walla valley is the primary cause of low instream flows during critical summer months in the mid subbasin. A network of irrigation diversions within the subbasin present significant barriers to fish passage. The Little Walla Walla Diversion at river mile 47 completely dewaters the river during summer months and in the spring in years of low streamflow. This diversion impedes and/or blocks upstream migrant fish. The Touchet River had 20 unscreened diversions in 1935, the Walla Walla River diversions below "Tumalum Branch" in 1936 were screened, but none of those above had protective devices (Neilson 1950). The two major diversion on the lower mainstem Touchet, the largest tributary to the Walla Walla River, partially block adult and juvenile fish passage (USFWS 1982). Currently, one irrigation diversion has non-functional screens and one is unscreened (Mendel, pers. comm.). In Oregon, unscreened diversions on the mainstem Walla Walla River, and the North and South forks have posed "serious problems to downstream migrants" (ODFW 1987). At the same time, it is likely that lamprey were impacted as well.

Irrigation-depleted streamflows is the major factor limiting production of anadromous fish in the Walla Walla Subbasin. By May or June, the mainstem Walla Walla River is dry near the state line due to irrigation withdrawals. Irrigation-depleted streamflows in the lower reaches of the Touchet River impede fish passage at irrigation diversions and contribute to poor water quality, including elevated water temperatures.

Discussion:

Information gathered dealing with Pacific lamprey in the Walla Walla Subbasin is very limited. As in other basins, population numbers are not available. CTUIR has documented the presence of western brook lamprey and Pacific lamprey in the Walla Walla Subbasin. In February 1996, ODFW observed thousands of lamprey ammocoetes at the Little Walla Walla Diversion, but did not key them to species.

Extensive irrigation, and farming practices have had substantial impacts on Pacific lamprey populations in this subbasin. Throughout the summer months, the Walla Walla River lacks adequate flow for fish survival and migration needs below Milton-Freewater, Oregon.

Diversion of water for irrigation is the primary factor limiting lamprey survival in the Walla Walla River Subbasin. A network of irrigation diversions braid the Walla Walla River into several small, unshaded ditches and during much of the year the river is dewatered. As a result, lamprey rearing and spawning habitat have been diminished.

Prior to 1997, the Walla Walla Subbasin had received little or no mitigation for anadromous fish losses (CRITFC 1995).

A salmon and steelhead restoration program which began in 1997 includes stream habitat/watershed enhancement, passage improvements at ladders and screens, instream flow enhancement and hatchery supplementation. It is likely that some salmon and steelhead projects will also benefit lamprey. In continuing Walla Walla Basin lamprey restoration efforts, it will be critical to better determine the status (abundance and composition) of existing lamprey populations.

Recommendations:

1) Request that WDFW and ODFW enumerate lamprey at all trap boxes, key to species (when possible) at all trapping sites, and document capture locations and life history stage (ammocoetes vs. macrophthalmia / uneyed vs. eyed) of lamprey observed.

2) Request that WDFW and ODFW document any adult Pacific lamprey observed during stream surveys.

3) Conduct random spot checks within the subbasin to determine presence/absence of Pacific lamprey.

4) Collect Pacific lamprey ammocoetes for scientific analysis.

TUCANNON SUBBASIN

Historic Abundance:

This system was historically utilized by the Umatilla, Walla Walla, Nez Perce, Palouse, and Cayuse Tribes. Tribal members historically harvested eels, chinook salmon, steelhead and trout. Armand Minthorn, CTUIR enrollee, stated that his family had specific sites on the Tucannon River where his family fished for salmon, trout, and eels.

Pacific lamprey historically were common in the Tucannon Subbasin (Mendel, pers. comm.). Spring and fall chinook and coho salmon were also historically present. Other salmonids present were: mountain whitefish, rainbow and bull trout.

Current Abundance:

No estimate of population size is available for this subbasin. Mendel feels the Pacific lamprey population is rapidly declining. WDFW has operated a smolt collection trap and conducted electroshocking for many years. Mendel stated that he has captured some Pacific lamprey ammocoetes in recent years in various areas of the Tucannon River by electroshocking and in downstream migrant traps. In 1995, two Pacific lamprey adults were captured at the smolt trap at RM 12.5.

In 1997, WDFW sampled 94 Pacific lamprey ammocoetes, and one dead adult Pacific lamprey in smolt trap operations. Mean lengths for the ammocoetes were 125mm. The length of the adult was 508mm.

Presently, the Tucannon supports an annual average run of 200 spring chinook, approximately 125 fall chinook, and a minimum estimate of 200 steelhead (Mendel, pers. comm.). Coho salmon are extinct.

Presence/Absence Findings:

Sampling was not performed in 1997 because ESA permits were not obatined prior to sampling. Sampling is planned for 1998.

Anthropogenic Habitat Alterations:

The Tucannon River originates in the Umatilla National Forest area of the Blue Mountains at an elevation of 6,387 feet above sea level at Oregon Butte in southeast Washington (Fuller 1986). The Tucannon drainage consists of forests, rangelands, and agricultural land (Kelley et al. 1982). The growing season in the area generally runs 110 to 140 days per year. Temperatures range from $-5^{o}C$ in the winter to $42^{o}C$ in the summer months (USDA 1984 draft).

Hecht et al. (1982) identified and evaluated changes in the riparian, channel and streambed conditions of the Tucannon River between 1937 and 1978. The changes suggested a regression in the stream's natural succession process. Thirty-three to 55 percent of riparian woodland was lost as results of major floods after 1964. Open zones replaced wooded riparian zones, shade was diminished and banks likely became less stable (Hecht et al. 1982).

The principal habitat alteration in the channel from 1937 to 1978 was the widening and straightening of the stream channel, as a result stream length decreased by seven to 20 percent (Hecht et al. 1982). Many of the bends and irregularities in the channel, which provided much of the salmonid rearing habitat, were eliminated (WDFW et al. 1990). At the same time, Pacific lamprey habitat for rearing juveniles may have been decreased.

Pataha Creek, a major tributary of the Tucannon River, has some of the poorest conditions for salmonid production. Some constraints are: 1) elevated summer water temperatures, 2) heavy sediment deposits that infiltrate gravels, 3) flash flooding events, 4) an irrigation diversion that likely impedes migrating salmonids, 5) little or no riparian vegetation, 6) channelization, 7) unstable streambanks, 8) problems with livestock management. Pataha Creek is utilized by steelhead for spawning and rearing (WDFW et al. 1990), and likely lamprey. These conditions may have effected lamprey populations too.

Fish production within the basin has been degraded as a result of human activities and catastrophic events. Degradation accelerated over the last two to three decades. Agricultural and livestock management practices have contributed to increased sedimentation and a general reduced riparian vegetation and stream shade cover. The later has likely contributed elevated stream temperatures in the lower basin. Channeling activities have reduced pool-riffle ratios and riparian vegetation (WDFW et al. 1990).

In the 1960's flood events straightened the river, eliminating streamside vegetation and instream habitat, and increasing the general gradient of the system (WDFW et al. 1990).

In the early 1970's, a group known as FURPAC (which consisted of various state and federal agencies, excluding tribes) recommended placing angle-irons in the fishways at Ice Harbor Dam (McMichael, pers. comm.). The angle-irons were placed on the sides of the fishway, preventing lamprey from passing through Ice Harbor Dam. McMichael stated that many people thought that Pacific lamprey were impacting Snake River salmon populations and further stated that the angle-iron was very effective. The angle-irons were removed six to eight years ago during dewatering.

According to Mendel, no chemical treatment projects for rough fish control have occurred in this subbasin.

Mendel stated that Starbuck Dam (Fletcher's Diversion) used to be higher than the dam's current height, and it may have limited Pacific lamprey passage upriver. In recent years, the dam was modified for salmonid passage.

Discussion:

Pacific lamprey populations in the Tucannon Subbasin are depressed. Mendel stated that lamprey population has declined rapidly since 1981. Besides instream habitat degradation, one of the major reasons for the decline of the Pacific lamprey population was the placement of angle-irons in the fish ladders at Ice Harbor Dam to preclude lamprey passage in the Snake River system.

It is hoped that ongoing salmon and steelhead restoration measures (insteam/watershed habitat enhancement and fish passage improvements) being implemented in this subbasin will also benefit lamprey. Further understanding is needed regarding current lamprey abundance and species composition before restoration planning can proceed.

Recommendations:

1) Request that WDFW enumerate lamprey at all trap boxes, key to species (when possible) at all trapping sites, and document capture locations and life history stage (ammocoetes vs. macrophthalmia / uneyed vs. eyed) of lamprey observed.

2) Request that WDFW to document any adult Pacific lamprey observed during stream surveys.

3) Conduct random spot checks within the subbasin to determine presence/absence of Pacific lamprey.

4) Collect Pacific lamprey ammocoetes for scientific analysis.

<u>GRANDE RONDE SUBBASIN</u>

Historic Abundance:

Historical estimates of the Pacific lamprey population are not available. Oral interviews with tribal members indicate that the Grande Ronde River Subbasin once supported a fishery for Pacific lamprey. This area was utilized by the Nez Perce, Cayuse, Walla Walla, Palouse, and Sho-Ban Tribes (Lane and Lane 1979; Swindell 1941). Tribal members historically harvested eels, bull trout, whitefish, chinook and sockeye salmon, and steelhead. Tribal members spoke of catching and observing lamprey in Catherine Creek, Tony Vey Meadows, Lookingglass Creek, and the upper Grande Ronde River.

Wayne Huff, former ODFW screens operator, stated that Pacific lamprey disappeared in the 1970's. He stated that the Wallowa and Imnaha rivers had thousands of Pacific lamprey prior to the 1970's.

Bob Sayre, former ODFW biologist, stated that he viewed both adults and ammocoetes in Catherine Creek in the 1950's. He stated that Pacific lamprey were abundant throughout the whole Grande Ronde system during the 1950's and 1960's.

Duane West, formerly with ODFW, stated that his crew electroshocked ammocoetes near La Grande in the mainstem Grande Ronde River in 1962.

Ken Witty, former ODFW district biologist, stated that there used to be large numbers of Pacific lamprey in the Imnaha and Wallowa systems. He stated that during his years as district biologist (from 1964 to 1990) he noticed lamprey populations were rapidly declining. Witty stated that fish agencies were too worried about declining salmon populations to worry about Pacific lamprey. The Grande Ronde Subbasin and tributaries once supported large runs of summer steelhead, sockeye (*O. nerka*), coho, and spring and fall chinook salmon (ODFW et al. 1990).

Melvin Farrow, CTUIR enrollee and CTUIR Fisheries technician, stated that he observed ammocoetes at Tony Vey Meadows in the 1960's.

Armand Minthorn, CTUIR enrollee, spoke of fishing sites on Lookingglass Creek, Catherine Creek, Grande Ronde, Minam, and Wallowa rivers. These are areas that were also likely utilized by Pacific lamprey for spawning and rearing.

Current Abundance:

The Pacific lamprey population in the Grande Ronde Subbasin and tributaries are likely near extinction. Keefe (ODFW, pers. comm.) stated that they are operating rotary traps on the Wallowa River and upper Grande Ronde and have captured no lamprey. Lofy (CTUIR, pers. comm.) stated that no lamprey have been captured in Lookingglass Creek during trapping operations.

Tim Walters, ODFW biologist, stated that no lamprey were sampled or observed in any field activities in the Grande Ronde River subbasin for 1997.

Currently, spring chinook is endangered in the Grande Ronde system. Restoration efforts are being implemented to restore spring chinook salmon and steelhead. These efforts will likely benefit lamprey populations as well.

Presence/Absence Findings:

Sampling was not performed in 1997 because ESA permits were not obtained prior to sampling. Sampling is planned for 1998.

Anthropogenic Habitat Alterations:

The Grande Ronde River originates in the Blue Mountains of northeast Oregon. It is bounded by the Blue Mountains to the west and northwest and the Wallowa Mountains in the southeast. The river enters the Snake River system at RM 168.7 in the Hells Canyon reach. The major tributaries to the system are the Wenaha, Wallowa, and Minam rivers, and Catherine and Lookingglass Creeks. The smaller tributaries are Bear, Joseph, Hurricane, Sheep, and Indian Creeks (CRITFC 1995).

The Grande Ronde River is located above eight dams in the Columbia River system, of which four are located in the Snake River Subbasin. The basin encompasses an area of about 3,950 square miles in the extreme northeast corner of Oregon. A small portion of the northern part of the basin is in Washington.

Riparian and instream habitat in parts of the Grande Ronde Subbasin have been impacted by a number of land-use activities. Pine beetles have infested some areas of this subbasin deteriorating riparian along streambanks. However, there are areas such as the Minam and Wenaha drainages that still remain pristine (ODFW et al 1990).

Rearing habitat in some parts of the subbasin is of poor quality due to land management practices and is the major inbasin factor limiting fish production. Spawning habitat is adequate to support increased escapement levels (ODFW et al 1990).

Riparian habitat degradation is the most serious habitat problem in the basin. Approximately 379 degraded stream miles have been identified (ODFW et al 1990). Several factors have contributed to the problem. Stream channelization for field development, livestock grazing, agricultural practices, poorly designed roads, and timber removal have done the most damage. Mining and recreation development have also contributed to the loss of riparian habitat.

The combination of wider and shallower stream channels, reduced streamflows, and a decrease in abundance and diversity of riparian vegetation contribute to increased water temperatures. Increased water temperature have unfavorable effects on juvenile salmonids (ODFW et al 1990), and likely impact juvenile Pacific lamprey as well.

Excessive livestock grazing has caused extensive loss of riparian vegetation along the upper Grande Ronde, Catherine Creek, Joseph Creek, and Wallowa River drainages (ODFW et al 1990).

As of 1985, unscreened or poorly screened irrigation diversions existed on the upper Grande Ronde and Wallowa Rivers, Catherine Creek, and Joseph Creek. Diversions direct migrating juvenile fish out of streams into irrigated fields (ODFW 1985). In addition, outmigrating juvenile Pacific lamprey may have also been diverted into fields because of similar outmigration timing as salmonids. An ongoing screening program, funded by the National Marine Fisheries Service and implemented by the Oregon Department of Fish and Wildlife, has corrected and will continue to correct many screening problems within the subbasin. Projects on the upper mainstem Grande Ronde and Wallowa Rivers, and Catherine Creek have the highest priority (ODFW 1985). Currently, all streams utilized by chinook salmon have been screened. Streams utilized by steelhead are now starting to be properly screened. The screening project is a voluntary program with area landowners, and will be an ongoing project until completion. No projected completion date is known (Walters, pers. comm.).

Low summer flows occur in the lower reaches of the mainstem and tributaries due to naturally low flows, extensive irrigation withdrawals, and watershed manipulation through timber harvest and agricultural practices. Extreme low flows occur generally between La Grande and Wallowa on the mainstem, Catherine Creek below Union, Joseph Creek, and the lower reaches of all Wallowa tributaries that flow through areas utilized by agricultural operations (ODFW et al 1990). These low flows and resulting high water temperatures may impede how Pacific lamprey migrate to suitable spawning areas in the upper reaches of these systems.

Water quality in the headwaters is generally good. In the lower mainstem and lower reaches of tributaries, non-point sources significantly reduce water quality by increasing turbidity, excessive water temperatures, and having low dissolved oxygen levels. Runoff from urban, agricultural, and forest areas all contribute to the non-point pollution problems (ODFW et al 1990).

Several potential point sources of pollution have been identified. Bulk gasoline, waste treatment, and chemical plants all have potential impacts on ground and surface waters within the subbasin (ODFW et al 1990).

Joe McMichael and Leonard Mayfield, US Army Corps of Engineers employees, stated that angle-iron was placed in the fishway at Ice Harbor Dam under the direction of a group known as FURPAC (which consisted of state and federal agencies, excluding tribes). The angle-iron was very effective at eliminating upstream lamprey passage. McMichael stated that Pacific lamprey were thought to be impacting Snake River salmon populations.

At the same time as Pacific lamprey populations were declining, Lower Monumental (1968), Little Goose (1970), and Lower Granite (1975) dams were all completed and operating. This may have also impacted adult Pacific lamprey and their ability to migrate upstream into suitable spawning habitat, and may have also impacted juvenile Pacific lamprey and their survivability through these dams during outmigration periods. In addition, the completion of Dworshak Dam (1972) eliminated over 600 miles of spawning and rearing habitat for lamprey. No mitigation was ever received for this loss.

Discussion:

Limited information on Pacific lamprey for the Grande Ronde Subbasin is available. It is known that Pacific lamprey were once abundant in the Grande Ronde River and tributaries, but are now likely near extinction. A combination of inbasin habitat problems and mainstem passage problems likely lead to the demise of lamprey in the Grande Ronde River and other Snake River tributaries.

Witty (ODFW, pers. comm.) stated that Pacific lamprey may have been eliminated by design. Witty stated that angle-irons were placed in the fishways at Ice Harbor Dam in the early 1970's to eliminate upstream lamprey passage.

Recommendations:

1) Request that ODFW enumerate lamprey at all trap boxes, key to species (when possible) at all trapping sites, and document capture locations and life history stage (ammocoetes vs. macrophthalmia / uneyed vs. eyed) of lamprey observed.

2) Request ODFW to document any adult Pacific lamprey observed during stream surveys.

3) Conduct random spot checks within the subbasin to determine presence/absence of Pacific lamprey.

4) Collect Pacific lamprey ammocoetes for scientific analysis.

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ACRONYMS

CRITFC	Columbia River Inter-Tribal Fish Commission
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
NPPC	Northwest Power Planning Council
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resource Department
OSU	Oregon State University
TMD	Three Mile Falls Dam
USFWS	United States Fish and Wildlife Service
USDA	United States Department of Agriculture
WDFW	Washington Department of Fish and Wildlife

APPENDIX A

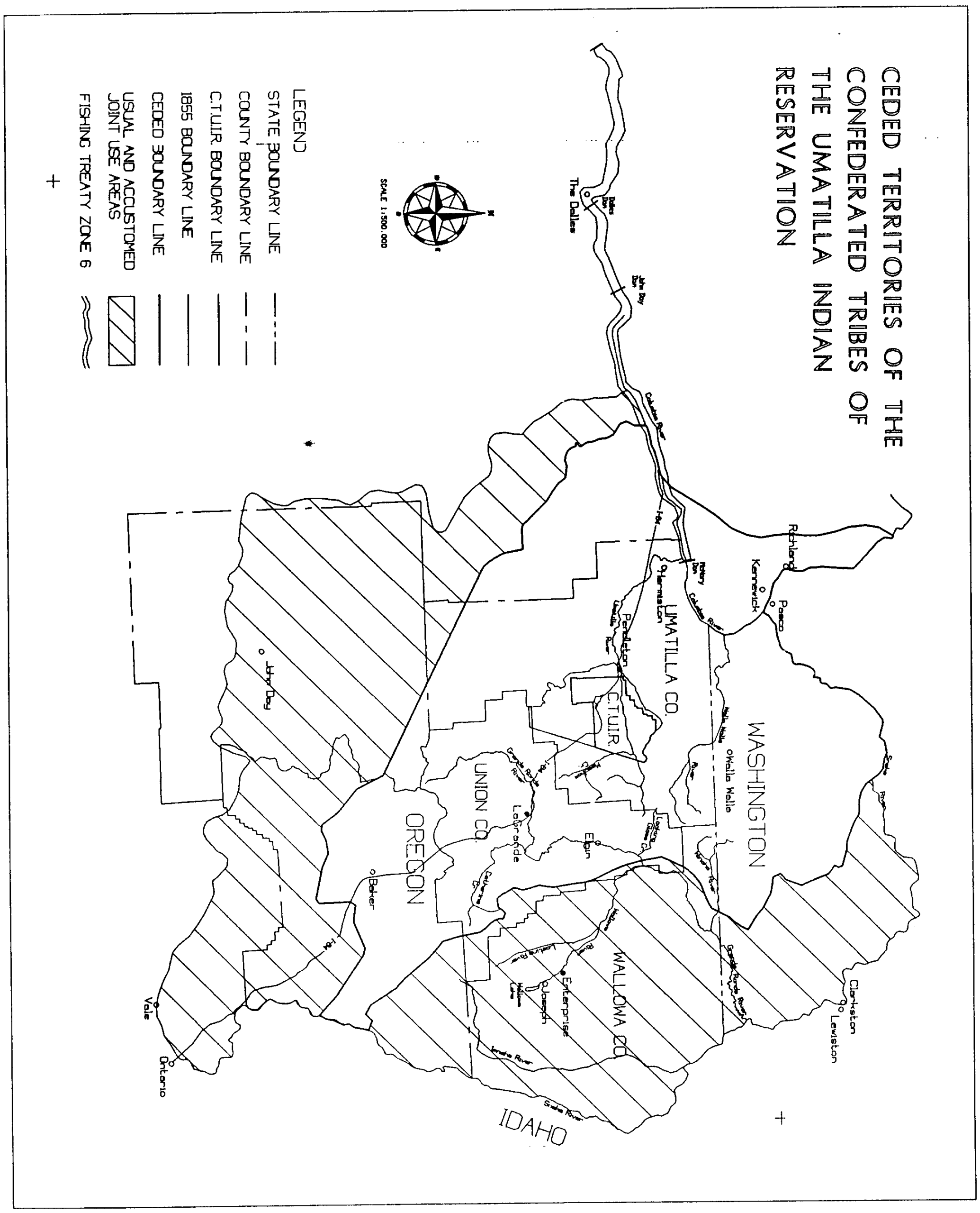

Figure A-1. Joint Use Map of the CTUIR

APPENDIX B

Table B-1. Subbasin contacts and sampling devices used in NE Oregon and SE Washington, 1997.

SUBBASIN	CONTACT	PHONE NO.	SAMPLING DEVICE
John Day	Tim Unterwegner/Mike Gray	(541) 575-1167	Field Surveys
John Day	Coby Moulton	(541) 575-0561	Screen Traps
Umatilla	Sue Knapp	(541) 567-5318	Rotary Traps and WEID
Umatilla	Craig Contor	(541) 276-4109	Rotary Traps/Field Surveys
Walla Walla	Brian Kilgore	(541) 276-2344	Screen Traps
Walla Walla	Glen Mendel	(509) 382-1005	Field Surveys
Tucannon	Glen Mendel	(509) 382-1005	Rotary Traps/Field Surveys
Grande Ronde	Peter Lofy	(541) 962-3777	Rotary Traps
Grande Ronde	Mary Lou Keefe	(541) 962-3777	Rotary Traps
Imnaha	Don Bryson	(541) 426-0119	Rotary Traps
Yakima	Ken McDonald	(509) 662-4361	?
Bonneville Dam	Jim Kuskie	(503) 374-8375	N/A
McNary Dam	Brad Ebbie/Paul Wagner	(541) 922-3211	Smolt Collection Facility
Lower Granite Dam	Marc Peterson	(509) 332-1625	Smolt Collection Facility
Ice Harbor Dam	Steve Richards	(509) 382-1187	Count Station Manager
Little Goose Dam	Rex Baxter	(509) 399-2009	Smolt Collection Facility

Table B-2. Pacific Lamprey Status for NE Oregon, SE Washington and the Willamette Subbasin.

SUBBASIN	POPULATIONS		TRIBAL HARVEST		HABITAT FACTORS
	Historic	Current	Historic	Current	
John Day	Abundant	Remnant / Declining	Yes	No	No Artificial Passage Barriers in System.
Umatilla	Abundant	Near Extinction	Yes	No	Recently Improved Fish Ladders for Salmon.
Walla Walla	Abundant	Assumed Rapidly Declining	Yes	No	Dewatered during critical summer months.
Grande Ronde	Abundant	Near Extinction	Yes	No	Ice Harbor Angle-Iron Recently Removed.
Tucannon	Abundant	Rapidly Declining	Yes	No	Ice Harbor Angle-Iron Recently Removed.
Willamette	Abundant	Declining	Yes	Yes	Unknown at this time.

Table B-3. Lamprey Abundance Site Summary, Total Site Length, Silt Depth, Habitat Type, Discharge, Number of Lamprey Captured/Minute (Fish/Min), Seconds Electrofished, and Pacific/Western Brook Presence, 1997.

Site	Stream	RM	Date 1997	Length (m)	Silt Depth (in.)	Habitat Type	Discharge	Seconds	Fish/Min.	Pacific/Western Brook?
UMATILLA RIVER SUBBASIN										
01	Umatilla River	1.5	7-22	60	1-2"	PP	LF	1456	0.0	None observed.
02	Umatilla River	1.6	7-22	85	0"	PP/SS/SB/ RP/LP	LF	450	0.0	None observed.
03	Umatilla River	2.3	7-22	10	4"	IP w/ss	LF	353	0.0	None observed.
04	Umatilla River	3.4	7-22	10	6-8"	IP w/ss	LF	400	0.0	None observed.
05	Little Johnson Creek	1.4	7-25	3	0"	PP	LF	197	0.0	None observed.
19	Umatilla River	42.2	8-13	4	7"	LP	LF	800	0.0	None observed.
20	Umatilla River	3.6	8-14	3.5	3"	IP	LF	200	4.8	Pacific only.
21	Umatilla River	3.6	8-14	25	3"	SP	LF	650	1.7	Pacific only.
33	Umatilla River	59.9	10-1	10	3-4"	SP	MF/LF	325	0.0	None observed.
34	Umatilla River	57.4	10-1	15	2-3"	BW	MF/LF	334	0.0	None observed.
35	Umatilla River	53.0	10-1	10	7-9"	LP	MF	469	0.0	None observed.
36	Umatilla River	73.8	10-2	13	14-18"	BW	MF/LF	631	0.0	None observed.
JOHN DAY RIVER SUBBASIN										
06	Camas Creek	0.1	7-31	57	1-2"	GL/RP/LP	LF	750	0.0	None observed.
07	Camas Creek	1.2	7-31	50	3-4"	GL	LF	1900	2.5	Pacific only.
08	Camas Creek	3.1	7-31	30	3"	GL	LF	900	0.4	Pacific only
09	Camas Creek	4.2	7-31	60	4.5"	GL	LF	750	0.0	None observed.
10	Camas Creek	9.1	7-31	50	2"	LP	LF	1300	0.1	Pacific only.
11	Camas Creek	10.5	8-1	50	6-8"	LP	LF	2400	3.4	Pacific only.
30	North Fork John Day River	75.0	8-25	25	7-10"	SP	MF/LF	770	8.0	Pacific only.
31	North Fork John Day River	69.8	8-26	12	6-8"	BW	MF/LF	528	8.2	Pacific only.
32	North Fork John Day River	75.8	8-26	16	3-5"	LP	MF/LF	228	1.1	Pacific only.
12	John Day River	257.2	8-4	21	5"	LP/GL	MF/LF	1895	0.1	Western brook only.
13	John Day River	245.5	8-4	11	4-5"	BW/IP	MF/LF	980	2.4	Pacific and Western Brook.
14	John Day River	226.1	8-4	45	6"	GL	MF/LF	1300	2.4	Pacific and Western Brook.
16	Middle Fork John Day River	65.0	8-5	20	4"	LP	LF	295	5.7	Pacific only.
17	Middle Fork John Day River	41.5	8-5	10	4-5"	GL	LF	175	7.5	Pacific only.
15	South Fork John Day River	9.0	8-4	10	1-2"	GL	MF/LF	425	3.5	Pacific only.
18	South Fork John Day River	29.1	8-6	15	2-3"	LP	MF/LF	500	0.0	None observed.
WALLA WALLA RIVER SUBBASIN										
22	Walla Walla River	38.2	8-18	35	2-3"	LP	LF	800	0.0	None observed.
23	Walla Walla River	29.2	8-19	5	2-4"	LP	LF	677	0.0	None observed.
24	Walla Walla River	12.2	8-19	14	8-10"	GL	LF	900	0.0	None observed.
25	Little Walla Walla River Diversion	47.0	8-20	15	3-4"	SP	MF	797	2.3	Western brook only.
26	South Fork Walla Walla River	2.5	8-20	4	3-4"	BW	MF	1081	0.0	None observed.
27	Touchet River	40.4	8-21	19	6"	BW/LP	LF	926	0.0	None observed.
28	Touchet River	44.3	8-21	12	4"	GL	LF/MF	268	0.0	None observed.
29	Touchet River	51.2	8-21	18	6-9"	BW	LF	1092	2.8	Western brook only.

APPENDIX C

Clear (transparent-like)

Lacks dark line

Figure C-7. Characteristics of Juvenile Western Brook lamprey.

Blue-gray Color

Dark Pigment

Dark Line

Figure C-8. Characteristics of Juvenile Pacific lamprey.

Lamprey Research and Restoration Project

1997 Annual Report

Part (B) Abundance Monitoring for Columbia and Snake Rivers

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Abstract

In 1996, a field study was begun to investigate the declining population of Pacific lamprey *Lampetra tridentata* and develop appropriate restoration programs for stocks in the Columbia River. The study was headed by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in cooperation with the Columbia River Inter-Tribal Fish Commission (CRITFC) and Oregon State University (OSU). The CRITFC primarily concentrated on two objectives in 1997. The first objective was to determine abundance, passage trends, length frequencies and life phases of juvenile Pacific lamprey migrating past mainstem Columbia and Snake river dams and project tributaries. The second objective was to determine the current abundance, passage trends, and length frequency of adult Pacific lamprey crossing mainstem Columbia and Snake river dams.

Life history characteristics of transformed and untransformed juvenile Pacific lamprey were collected at Lower Granite, Little Goose, and Lower Monumental dams on the Snake River and at McNary Dam on the Columbia River during the 1997 migration season. Most outmigrant Pacific lamprey sampled were of the transformed silvery form known as macrophathalmia, although a substantial number of untransformed brown ammocoetes were also sampled. Juvenile lamprey were documented at all four dams throughout the sampling season (late March through October), although the preponderance of outmigrants passed during April through June. Similarly, lamprey passage at all projects declined sharply from July through the remainder of the passage season (November-December). This decline was most noticeable at the Snake River dams where passage from July through the end of the monitoring season was generally less than 100 outmigrants per month.

Three hundred and twenty-three adult Pacific lamprey were collected and tagged with 13 mm Petersen discs at the Bonneville Dam Fish Engineering Research Laboratory (FERL) from July through early October 1997. Forty tags were returned, all from Bonneville Reservoir or it’s tributary streams. Thirteen (33%) of the returned tags contained sufficient capture information to estimate travel time at large; stock identification was not possible since all recaptures occurred relatively soon after release and not in spawning locations. Time at large ranged from 1 to 13 d, with a mean of 3 d. Daily movements ranged from 0.2 to 65.4 Rkm/24 h period, with a mean of 15.6 Rkm/24 h. None of the tagged lamprey were captured or observed upstream of The Dalles Dam, although 69% of the 13 complete recaptures occurred within 0.5 km of The Dalles Dam.

Adult Pacific lamprey fish ladder passage estimates are presented from Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Rock Island, Rocky Reach, and Wells dams for 1997. Major decreases in dam counts of Pacific lamprey were identified as the run progressed upstream. These decreases could identify tributaries where populations are returning or could be associated with difficulties in counting Pacific lamprey. Enumerating Pacific lamprey at fish count stations is very difficult as a result of lamprey behavior in ladders designed for salmonid passage. The overall success of Pacific lamprey ascending the two fish ladders at Bonneville Dam was compared using calculations of

local efficiency. Local efficiencies differed significantly ($P = 0.028$) between Washington Shore (12.5%) and Bradford Island (32.8%) ladders. The Bradford Island estimate was similar to estimates reported in the literature for sea lamprey (35.4%). Length frequency data is presented from data gathered from video recordings and from hands-on sampling at Bonneville, Ice Harbor, Wells, and John Day Dams. A length-weight relationship was developed for Pacific lamprey sampled at Bonneville Dam over a 12 week period.

Acknowledgments

We thank the following individuals for their assistance with juvenile lamprey objectives of this project: Julie Firman, Sam Moyers, Shawn Rapp, ODFW; Todd Hilson, Paul Hoffarth, Sharon Lind, Monty Price, Doug Ross, Rosanna Tudor, Pete Verhey, and Shirley Witalis, WDFW. The following individuals assisted with the adult lamprey aspects of this report: John Loch and Steve Richards, WDFW; Chuck Pevan of Chelan County PUD; Rick Klinge of Douglas County PUD; and Mike Wakeland of the CRITFC.

Introduction

Pacific lamprey *Lampetra tridentata* is an anadromous fish endemic to the Columbia River Basin. This fish is highly prized by native Americans as a ceremonial and subsistence food item. Often found in sympatry with native anadromous salmonids *Oncorhyncus* sps., the Pacific lamprey shares similar life history needs that include pristine freshwater spawning and rearing habitat, mainstem passage corridors to the ocean and back, and productive ocean rearing habitat. Unlike anadromous salmonids, the Pacific lamprey is not highly prized or utilized by non-Indians, consequently, recent declines in Pacific lamprey abundance and distribution had gone largely unnoticed by regional fishery managers. Diligent efforts by tribal and Columbia River Inter-Tribal Fish Commission (CRITFC) staff secured funding and support to investigate the declines in distribution and abundance of Pacific lamprey. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in cooperation with the CRITFC and Oregon State University (OSU) have initiated a multi-faceted, multi-year approach to investigate and determine the mechanisms behind the declines and subsequent strategies for recovery. This report covers the second year of the CRITFC portion of this study. The main emphasis will be data summary and reporting for this second year. Detailed analysis will be completed in years when sufficient data exist for analysis. Two primary objectives in this project include:

1) Determine abundance, passage trends, length frequencies and life phases of juvenile Pacific lamprey migrating past mainstem Columbia and Snake river dams and project tributaries; and,

2) Determine the current abundance, passage trends, and length frequency of adult Pacific lamprey crossing mainstem Columbia and Snake river dams.

Methods

Juvenile Lamprey Investigations

Study Area

During April through December 1997, data were collected on juvenile lamprey from Lower Granite, Little Goose, and Lower Monumental dams on the Snake River, and from McNary Dam on the Columbia River. These locations were selected because the existing juvenile salmonid collection operations also incidentally collected an unknown segment of the juvenile Pacific lamprey outmigration.

Passage trends

Pacific lamprey juvenile passage trend information is imprecise at best. Collection of juvenile lamprey at mainstem dams is incidental to sampling juvenile salmonids. Unknown guidance efficiencies of juvenile lamprey combined with unknown spill passage to turbine passage ratios reduce our ability to precisely estimate abundance. Long (1968) showed that juvenile lamprey migrate deeper in the water column than do juvenile salmonids. In addition, juvenile lamprey often hide in various locations throughout the bypass systems. Large numbers are often found during the final cleanup and shutdown operations at the end of the migration season in the fall. These issues combined with highly variable sampling rates during periods of peak-juvenile salmonid passage confound efforts to quantitatively estimate juvenile lamprey outmigration.

Biological sampling of Juvenile Lamprey

Total lengths (mm), weight (g), and developmental stage were recorded from juvenile lamprey collected at the by-pass facilities by CRITFC and Collection Facility Staff. Developmental stages were assigned to according the physiological stage of development, either the larvae form (i.e. ammocoete) or the transformed juvenile (i.e. macrophathalmia). These forms were characterized by their coloration and physical features. The eyeless, brown-colored ammocoetes were referred to as “brown” lamprey, while the eyed, silvery macrophathalmia were referred to as “silver” lamprey. Only the silvery colored macrophthalmia were considered to be outmigrants, although high flow conditions often dislodged and transported the ammocoetes to juvenile collection sites at mainstem dams. After the collection of lengths, weights, and coloration phase, the juvenile lamprey were revived in holding troughs supplied with flow through river water. The juvenile lampreys were later released through the exit chute back into the river.

Adult Lamprey Investigations

Study Area

Data on adult lamprey fish ladder passage were obtained from all mainstem Columbia and Snake river hydroprojects that are equipped with fish counting stations. These include Bonneville, The Dalles, John Day, McNary, Rock Island, Rocky Reach, Wells, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams (Figure 1). These hydroelectric projects were chosen because fish passage is recorded on videotape at these sites and/or on-site lamprey counts are made there.

Abundance Estimates

Fish ladder counts of adult lamprey were used as an index of abundance. Fish ladder counts were obtained by reviewing time-lapse recorded videotape, or from on-site counts. On-site lamprey counts were available for the four lower Snake River dams as well as McNary, John Day, and The Dalles dams. Lamprey counts from video records were available from Wells, Rocky Reach, and Rock Island dams. At Bonneville Dam, on-site counts were available from the Corps of Engineers (COE) during times when shad passage was considered low. During periods when shad passage was considered too high for lamprey counting, video records were made. These records were reviewed by CTUIR to enumerate lamprey passage. Additionally, CTUIR performed some on-site lamprey counting during July, August, and September.

The on-site lamprey counting at Bonneville Dam conducted by the COE was based on "daytime" (between 0400 and 2000 hrs) counts. The on-site lamprey counting conducted by the CTUIR was based on a sampling scheme where lamprey passage was enumerated during many (range 5 to 45) 12 minute periods selected within each stratum (1/2 month units). This counting was performed during both daytime and nighttime periods. Passage estimates and 95% bounds were made using stratified random sampling (Scheaffer et al. 1990).

Comparisons were made between Pacific lamprey counts made by the CTUIR on-site observers and from reviewing videotape. Lamprey counts from 50 12-minute time intervals were compared using paired t-tests and paired Wilcoxon tests (Mendenhall 1983). Alpha (α) was set at 0.05. Similar to conditions in 1995 and 1996 (Jackson et al. 1997), a tremendous amount of lamprey movement (upstream and downstream) at the count station windows was observed in 1997. Therefore for statistical comparisons, we treated upstream and downstream estimates independently.

To compare overall success of Pacific lamprey ascending the two fish ladders at Bonneville Dam in 1997 we calculated local efficiency (E) values for each count station using (Haro and Kynard 1997):

where: Nu = number of fish passed upstream; and,
Nd = number of fish passed downstream.

Local efficiency values were calculated using data from the CTUIR on-site observations for daytime and nighttime periods within two-week periods (equal to the strata used for estimating abundance above). These values were compared between fish ladders using a two sample Wilcoxon test.

Length Frequency Estimates

We estimated lengths of lamprey from videotape recorded at Ice Harbor, Lower Granite, and Wells dams. First, we determined what the magnification factor was at each count station window (this was also repeated if changes were made to the camera). The magnification factor was calculated by measuring the known distance between the "jack" lines as they appeared on the video monitor. The images of individual lamprey were measured to the nearest mm with a ruler on a video monitor. These image lengths were then converted to fish lengths (in inches) by:

$$\text{Fish length} = FI / MF$$

where: FI = fish image length measured in mm; and,
MF =distance between "jack" lines (mm) on the monitor / 22.

Petersen Disc Tag Study

Lamprey collection

Adult Pacific lamprey were collected at the Fisheries Engineering and Research Laboratory (FERL) at Bonneville Dam from early July through the first week of October. Lamprey were captured a trap mounted on the side of the fishway just beneath the waters surface (Figure 2). University of Idaho (UofI) and the National Marine Fisheries Service (NMFS) staff operated the trap to collect Pacific lamprey for a radio telemetry project. Excess lampreys were given to CRITFC staff for tagging. Upon completion of the radio telemetry project, CRITFC staff assumed trap operations to provide additional lamprey for tagging. The trap was generally lowered into the fishway at dusk and pulled the following morning. The trap was generally fished inversely proportional to the catch rate to optimize our weekly catch total. Tagging goals were approximately 100 lamprey weekly, although this goal was only achieved in one of the twelve weeks of tagging.

Holding and Biological Data Collection

Once captured, lamprey were transferred from the trap to a 85 l plastic container to holding tank (aluminum 4'x 3' x 3') supplied with flow through river water. Lampreys were held from several hours to several days before tagging. Holding time was determined by the number of lamprey trapped at one time. For example, if 20 or more fish were trapped at once, they were usually tagged and released the same day. Later in the season, fish were often held several days to accumulate sufficient number for tagging and release.

Lamprey were anesthetized using MS-222 at the rate of 150 mg /l. The dosage varied somewhat depending water temperatures and number of animals. Once anesthetized, the animal was measured (nearest cm), weighed (nearest gm), and examined for marks, color shades and any other distinctive features. The tags were Petersen disc tags, 13 mm in diameter, numbered on one tag side, with the other side blank (Figure 3). A unique color combination was used for each week of the 12-week study. The tag halves were connected to each other and attached to the lamprey by a 76-mm nickel metal pin. We modified the pin slightly by bending it to a 30° angle to facilitate a parallel relationship between the tag and the tissue of the lamprey to prevent the edge of the tag wearing into the flesh of the animal. We disinfected the tags, pins, tags site on the lamprey and the technicians fingers in an iodine-based antiseptic solution prior to tag application. The number half of the tag was slide onto the pin, flush against the head of the pin, ready for application. The number of the tag was now read to the recording technician, who would then repeat it back for verification.

Tagging and Release

The point of application was on the left side of the lamprey near the dorsal surface approximately 2-4 cm anterior to the insertion of the first dorsal fin. The tag was partially assembled with the data portion of the tag placed on the tagging pin next to the pinhead. The pin was inserted into the flesh and realigned to exit at approximately the same place on the opposite side of the animal. It was necessary to do this procedure quickly as the presence of the tagging pin in the animals muscle tissue often caused the muscle fibers to contract around the pin, making it difficult to push the pin through the remaining tissue. This situation occurred several times during the initial weeks of the study, but was less of an problem as technicians became more experienced in applying the tags. Once the pin had passed through the opposite side of the lamprey, the blank half of the tag was inserted on to the pin. To complete the tag, all but 1.5-2 cm of pin next to the blank half of the tag was cut away. The remaining material was bent into a closed loop with a slight space of approximately 2mm to allow for expansion of the tag away from the side of the lamprey (Figure 3). The tag number was again confirmed and the animal was then moved to a recovery tank containing flow-through river water.

Tagged lampreys were released back into the Columbia River within 1.5 hours after the last animal was tagged. This allowed for sufficient recovery from the MS-222. All lampreys were released during the afternoon on the Washington side of the river upstream of Bonneville Dam. Except for a single release 4/10’s of a kilometer upstream of the Bridge of the Gods, all tagged lampreys were released at or near the public boat launch at Stevenson, Washington. Release areas contained large rocks, moderate currents, and adjacent deeper water.

Travel Times

Pacific lamprey migration distances were calculated to the nearest tenth of a river kilometer estimated from a NOAA navigation chart. Lamprey travel rate was estimated by the elapsed time from release to the time reported at capture divided by the total kilometers traveled. Kilometer per 24 h day estimates were also estimated if recapture data contained times that were deemed credible. In many cases, recapture information was incomplete and thus was not used to estimate travel times.

Results and Interpretation

Juvenile Lamprey Investigations

McNary Dam

Two hundred twenty-five juvenile Pacific lamprey were sampled from the 6,237 juvenile Pacific lamprey collected by the juvenile salmonid collection facility at McNary Dam from April through December 1997. Forty-five percent of the juvenile lamprey outmigration occurred during the month of May, with an additional 28% in June (Table 1). Macrophathalmia dominated the outmigration in all months, particularly in the spring and accounted for over 99% of all collected juvenile lampreys. Ammocoetes, although scarce, were collected every month but never exceeded eight per month (Table 1). Mean lengths of macrophathalmia were largest in May and June, with the smallest mean lengths in October and November. Similarly, mean weights of macrophathalmia were greatest in May and June, and lowest in October and November (Table 1). Only five ammocotes were sampled for length and weight data during the entire outmigration, all within July and August with lengths and weights similar to macrophathalmia sampled during the same period (Table 1).

Estimated passage numbers of outmigrating macrophathalmia at McNary Dam were calculated at approximately 156,479 during 1997. As discussed in the methods section of this report, the process used to estimate the abundance of these outmigrants is qualatative at best, since key variables, such as guidance efficiencies, are unknown or untested. Still, annual enumeration of outmigrating juvenile lamprey is important baseline information and is useful for monitoring trends and building long-term databases. Additionally, information from McNary Dam is particularly important as evaluating the apparent contributions of Pacific lamprey populations from the mid-Columbia River and the Snake River basins.

Lower Monumental Dam

One hundred eighteen juvenile lampreys were sampled for length, weight, and life stage information from a total of 209 juvenile lamprey collected by the juvenile salmonid collection facility, from April through November 1, 1997. Thirty-five percent of the collected juveniles were outmigrating macrophathalmia, primarily in April and May, with ammocoetes dominating the remaining months (Table 2). May was the peak outmigration month at Lower Monumental Dam, the same month as noted for McNary Dam. Unlike McNary Dam, ammocoetes collected at Lower Monumental Dam from June through August were the dominant life stage, comprising 94% of all collected juvenile lamprey. The preponderance of this life stage is somewhat puzzling, since ammocoetes are the larval form and not transformed into the migratory-eyed form. The 1997 spring runoff extended into early summer and was substantially above normal for the Snake River Basin. The propensity of juvenile lamprey to migrate downstream during high water events combined with the high spring runoff may partially explain the high proportion of ammocoetes in the collections.

Length and weight data were collected on 56% of the juvenile lamprey collected at Lower Monumental Dam. In all sample months, one of the two life stages were poorly represented in the sample, greatly reducing the ability to follow temporal changes in mean lengths and weights. Mean length and weight data for both life stages from Lower Monumental dam were generally similar to mean values for respective life stages and months at McNary Dam (Tables 1 and 2). When substantial differences were noted, one or both samples generally contained less than six samples, often only 1 or 2 juvenile lamprey represented a life stage for a particular month.

Ninety-nine percent of all estimated juvenile lamprey (macrophathalmia only) passage at Lower Monumental Dam in 1997 occurred in April and May (Table 2). The proportion of macrophathalmia outmigrants was essentially non-existent from June through the end of the passage season in October, unlike the more gradual decline observed at McNary Dam.

Little Goose Dam

Four hundred seventy-four juvenile lamprey were collected from April through November at Little Goose Dam. Macrophathalmia were the dominate life stage in the April, May, September and October collections and comprised 64% of all juvenile lamprey collected in 1997 (Table 3). The ammocoete life stage was most abundant in July, but proportionally, ammocoetes collected at Little Goose Dam was substantially less compared with Lower Monumental Dam (Table 2). Approximately 45% of the collected juvenile lamprey were measured but weight data were only collected during June (Table 3). Similar to Lower Monumental Dam samples the uneven proportions of ammocoetes and macrophathalmia in a given monthly sample reduced our ability to directly compare lengths between life stages within and between months (Table 3). A decline in the mean lengths of ammocoetes was apparent from June to July and August, a similar pattern was suggestive for macrophathalmia, although sample numbers were minimal during the previously mentioned months.

The juvenile lamprey outmigration was similar to patterns at McNary and Lower Monumental dams in 1997. Approximately 55% of the juvenile lamprey passed the project in May, with an additional 39% having migrated the previous month (Table 3). Numbers of juvenile lamprey collected from August through November at Little Goose Dam were considerable higher than those collected at Lower Monumental during the same period (Tables 2 and 3).

Lower Granite Dam

One thousand nine hundred and forty-nine juvenile lamprey were collected at Lower Granite Dam in 1997, 69% of these were collected on a single day (Table 4). This unusual event was likely due to a percentage of juvenile lampreys residing within parts of the juvenile collection system during the passage season and being forced out during the shutdown of the project. A similar increase of macrophathalmia was also noted at Little Goose Dam, although the numbers were considerable fewer (Table 3). This event may be related to the abnormally high numbers of ammocoetes that passed the project in April and May (Table 4). At the previously discussed projects, ammocoete numbers were a minor component of the April and May passage period (Tables 1, 2, and 3). It is possible that substantial numbers of these ammocoetes were somehow retained within the juvenile collection system and underwent transformation by the November 1997 project shutdown.

Five hundred thirteen juvenile lampreys were collected to sample for length, weight, and life stage information during 1997. Ammocoetes were the dominate life stage collected and sampled from April through October, with macrophathalmia being the only life stage sampled in November (Table 4). Ammocoete length and weight remained similar from May through August, with a decline in mean length noted in September sample, none were sampled in October and November. Some decline in the mean length of macrophathalmia was noted between the May and September samples although small sample sizes and the lack of samples in June and July make it difficult to ascertain if significant changes occurred.

Estimated passage of macrophathalmia at Lower Granite dam was the lowest of the 4 dams surveyed (Table 4). Unknown sampling efficiencies at all projects mask what actual migrant numbers are, although it is unusual that outmigrant estimates at Little Goose and Lower Monumental are quite similar in April and May, while those of Lower Granite are considerable lower, particularly since no apparent tributary source of Pacific lamprey exists between Little Goose and Lower Granite. The overall seasonal passage trend at Lower Granite was very similar to the other two Snake River dams (Table 4), with the exception of the passage anomaly that occurred in November.

Adult Lamprey Investigations

Abundance Estimates

At Bonneville Dam, Pacific lamprey counts were made during daytime periods by the COE observers, except in June due to high shad abundance. Pacific lamprey counts were also made by a CTUIR on-site observer between July 1 and September 30, 1997. As well, CTUIR reviewed videotapes and estimated lamprey passage during a similar timeframe. The CTUIR counts were based on 12-minute observation periods, included nighttime, and well as daytime periods. The total abundance estimate from the CTUIR on-site counting had a lower confidence limit of 63,725 and an upper confidence limit of 203,945 (Table 5). These are substantially higher estimates than the COE daytime count of 22,830. The lower and upper confidence limits for the CTUIR daytime only on-site observations were 11,624 and 110,100, which encompassed the COE estimate.

Monthly fish ladder passage counts at Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Rock Island, Rocky Reach and Wells dams for 1997 are presented in Table (6). Counts from the lower Columbia River projects Bonneville through McNary dams were based on 16 h counts and no counts were made at Bonneville in June during peak shad passage. Counts from all other projects were based on 24 h enumeration.

Based on COE fish ladder passage estimates there appears to be a 65% drop in Pacific lamprey abundance between Bonneville and The Dalles dams. This is particularly interesting since the Bonneville estimate does not include June passage (during the peak of the shad migration). Radio telemetry data shows a similar drop in abundance (66%) for this reach (Vella and Stuehrenberg 1997). These data suggest that a substantial portion of the lamprey that cross Bonneville Dam spawn in tributaries located between Bonneville and The Dalles dams. Possible streams could be the Wind, Little White Salmon, White Salmon, Klickitat, and Hood rivers, as well as several other smaller streams.

Another large drop in Pacific lamprey ladder passage estimates (72%) occurs between John Day and McNary dams suggesting that the John Day River supported a population of approximately 10,000 spawners in 1997.

Fish ladder passage counts in the lower Snake River demonstrate an unusual trend, counts were similar at Ice Harbor and Lower Granite dams, 1,454 and 1,274, however, counts at the middle projects Lower Monumental and Little Goose were much lower, 217 and 245. We suspect that Pacific lamprey are either using alternative avenues to cross these projects, such as through the locks, or are passing the count stations undetected.

In the mid-Columbia there is approximately a 40% drop in counts between Rock Island and Rocky Reach dams indicating that a sizable Pacific lamprey population may persist in the Wenatchee River. However, we have operated the fish count station at Tumwater Dam on the Wenatchee River during most of the last 10 years between May – September and have not recorded lamprey movement. The fish could over-winter in the lower river and go upstream prior to our salmon-counting season in May or spawn in Icicle Creek.

Passage over the last dams in the Snake and Columbia rivers appears to be seriously low. Only 3% of the Pacific lamprey that crossed Bonneville Dam were counted at Lower Granite Dam and approximately 6% crossed Wells Dam.

Difficulties with Counting Pacific Lamprey

Fish count stations have been designed for salmonid passage and enumeration. Lamprey requirements could be very different. Up- and downstream movement creates problems for enumerating Pacific lamprey. For example, at the Washington Shore Count Station the upstream lamprey detection's were estimated at 576,542 and downstream estimate was 542,330 for the nighttime period between July 1 and September 30, 1997, based on counts from 283 12-minute observation periods. This demonstrates that Pacific lamprey were detected and counted a total of 1,118,872 times and these detection's resulted in a net passage estimate of 34,065 fish. Based on these data, for every Pacific lamprey observation there is only a 3% chance that it will result in a net upstream count. Lamprey movement at the Bonneville count stations appears to be the most extreme, however, this phenomena is observed elsewhere. Clearly, work needs to be done at Bonneville Dam to try to correct this problem to allow more precise passage estimates to be made.

Mean local efficiency of Pacific lamprey using the Bradford Island ladder (32.8%, SE = 3.027, N = 6) was significantly higher than Washington Shore (12.5%, SE = 3.080, N=6; Wilcoxon Test P = 0.028). All local efficiency estimates for Bradford Island were significantly higher than Washington Shore (Table 7). Local efficiency calculated for Bradford Island (32.8%) is comparable to the local efficiency calculated for sea lamprey *Petromyzon marinus* (35.4%, SE = 7.94) crossing a modified Ice Harbor-type fishway (Haro and Kynard 1997). Haro and Kynard (1997) cited high water velocity, air entrainment, and turbulence within the fishway as factors inhibiting sea lamprey passage by disrupting upstream migratory motivation and visual and rheotactic orientation.

By comparing counts from 12-minute observation intervals, we found that video-based Pacific lamprey counts were significantly less than on-site counts made at Bradford Island in 1997 (Table 8). This suggests that there may be a problem with the facility that prevents some lamprey passage from being recorded at Bradford Island. This problem may be the lack of contrast between fish and the floor of the counting slot or fish may pass below the window in the rotating brush grove. It may be possible for an observer to see these fish but the video camera's resolution or the site lighting is insufficient for imaging. Modifications to the Bradford Island count station should be made to eliminate differences between video-based and on-site counts. These modifications could include moving the passing fish up higher in the water column by filling the rotating brush grove, or installing a small (4 inch high) ramp in the floor of the counting slot. Changes in lighting configuration could be made as well as contrast enhancement measures. Contrast could be improved by painting all surfaces that are in the video camera's field of view white. Using a similar approach, up- and downstream Pacific lamprey counts at the Washington Shore ladder were found to be similar (Table 8) in 1997, however net passage was much higher for the on-site enumeration's.

It appears that there may be a ladder preference by Pacific lamprey at Bonneville Dam. Pacific lamprey count data from Washington Shore and Bradford Island count stations clearly demonstrate that more fish passed the on Washington Shore. This holds when reviewing the COE counts, the CTUIR on-site counts, and the CTUIR video-based counts that showed preferences to Washington Shore of 78%, 62%, and 76%, respectively. An alternative hypothesis would be that the apparent preference is a result of lamprey being diverted around the Bradford Island count station window. Support for this explanation comes from radio tracking data that detected a tagged lamprey in the make-up water channel at the top of the Bradford Island ladder (Vella and Stuehrenberg 1997). Accessing this channel enables Pacific lamprey to bypass the fish count station window. Vella and Stuehrenberg (1997) also reported observations of other Pacific lamprey climbing the tainter gate at the upstream end of this channel which could lead fish to the forebay. No ladder preference has been demonstrated by radio tagged Pacific lamprey at Bonneville Dams in 1996 and 1997 based on 66 ladder exit detections (Vella and Stuehrenberg 1997).

If a large portion of Pacific lamprey using the Bradford Island ladder are in fact bypassing the count station window using the make-up water channel, the viability of successful lamprey passage through this avenue needs to be addressed. If it is determined that this passageway is not harming lamprey alternative methods of indexing abundance in it must be investigated.

Lamprey activity in the Bonneville Dam fish count station windows was least between 0600 and 1900 hours in 1997 (Figure 4), similar to the two previous years (Jackson et al. 1997). The period of greatest activity was between 2000 and 0400 hours.

Length Frequency Estimates

A total of 991 lamprey images were measured from video recordings, 253 from Ice Harbor, 614 from Bonneville, and 124 from Wells dam recordings. The relative frequency of these data was computed and plotted as a function of one-inch length classes (Figure 5). The modes from the Wells and Ice Harbor dam's data were 23 inches, which is the same as in 1997 (Jackson et al. 1997). The mean lengths were 22.9, 22.9, and 22.7 inches for Ice Harbor, Bonneville, and Wells dam's respectively.

We participated in a lamprey salvage operation at John Day Dam on 1/8/98. These fish were trapped in the fish ladder during dewatering. Prior to releasing these fish upstream, we anesthetized and 120 of them. The length frequency plot from these data is presented in Figure (6). The length groups were near-normally distributed with a mode of 25 inches. The mean length was 24.5 inches from a sample size of 120 fish. A length-weight relationship was developed from this sample of fish and is presented in Figure (7).

During the Petersen Disc Tag experiment, we collected additional length and weight data from Pacific lamprey trapped on a weekly basis at Bonneville Dam. A total 323 fish were measured, over the 12 weeks of study. The length frequency distribution had a single mode at the 27 inch group (Figure 8). Pacific lamprey lengths did not vary among sample weeks ($P = 0.269$; $F = 1.241$). Pacific lamprey weights were highly correlated with length (Pearson $r = 0.844$) and did not vary among sample weeks ($P = 0.183$; $F = 1.429$).

Petersen Disc Tag Study

The intent of this experiment was to mark a number of adult Pacific lamprey as they crossed Bonneville Dam and follow those fish through the upstream migration by using observations of tagged fish as they passed fish counting stations.

First, we tested two marking techniques. One technique was freeze branding a ¾" number on the side of a lamprey and the other technique utilized a 13 mm Petersen disc tag. Freeze brands became indiscernible after only a few days and retention of the Petersen disc was 100% after 2 weeks. Therefore, we used individually numbered Petersen discs with 15 different color combinations to differentiate sample weeks.

Second, we tagged captured lamprey for 12 weeks and released each group above Bonneville Dam. Groups of tags with similar color combinations could be followed through the Columbia Basin fish passage facilities (i.e. fish count stations) as they moved through the system. No tagged lamprey were observed or recorded at any fish counting station operated by the Army Corps of Engineers (COE) or the various Public Utility Districts (PUD's) in the Columbia and Snake rivers. In addition, fish salvage operations at lower Columbia River COE dams routinely salvage hundreds of Pacific lamprey that remain in the fish passage systems during the winter months. Salvage personnel were alerted to the presence of tagged lamprey in the Columbia River and asked to record data if encountered any marked fish. No tagged lamprey were observed during the salvage operations.

Tags of 40 recaptured lamprey were returned to CRITFC project staff. Based on discussions with tribal fishers who returned lamprey tags, the number of recaptured lamprey likely exceeded the 40 that were reported. Due to incomplete or delayed returns, data from only 13 of the returned tags were considered suitable for analysis. The most common problem was the failure on the part of the individual who captured the tagged lamprey to record the date, time and location of capture. Project staff placed "reward" posters in areas frequented by tribal fishers in an effort to increase the number and quality of the returns.

Tag returns came from two general areas. The first area was the scaffold fishery near The Dalles Dam, known locally as "Lone Pine". Most returns in this area (Rkm 309.3) occurred prior to the fall commercial salmon season that began in September (Table 9). In this location, tagged lampreys were incidentally captured in the monofilament nylon mesh of hoop nets fished from scaffolds. In addition to hoop net recaptures in the "Lone Pine" area, two tagged lamprey were recaptured in Fifteen Mile Creek. This tributary joins the Columbia River in the "Lone Pine" area and is a traditional place to gather Pacific lamprey. Unlike the incidental catches in the hoop nets, these tagged lamprey were intentionally taken by tribal fishers for subsistence.

The second area of tag returns occurred when tagged lamprey were captured incidentially in gillnets during the fall commercial salmon season. Several tagged Pacific lamprey were captured in gillnets near the point of release, Rkm 243 (Figure 9). Returned tags with data useable for analysis do not accurately reflect the increased numbers of tagged lamprey captured during the fall commercial salmon season; since many tags were turned in days or weeks after capture. Tagged lamprey captured by tribal fishers were usually kept and eaten, although at least one tribal fisher was known to have released five tagged lamprey from a single net.

Recaptures of tagged lamprey demonstrate that lamprey are capable of migrating at rates that far exceed those reported in the literature (Table 9). Kan (1975) reported that Pacific lamprey in Clear Creek of the John Day River system could travel an estimated 4.5 km per day. Wigley (1959) reported sea lamprey (*Petromyzon marinus*) range an average of 3.2 km per day. The similarity of median and mean daily and total travel times clearly shows that Pacific lamprey are capable of considerable movement. The ranges exhibited from the recaptures clearly demonstrates that in reservoir habitat, Pacific lamprey can migrate substantial distances in a 24 h period.

We received and paid rewards on forty tags. Assuming a moderate 50% non-compliance rate, approximately 60 tagged lamprey were recaptured from the pool of 323 tagged lamprey, leaving 263 tagged lamprey in the Columbia River. At the time of report preparation, we have not received any additional tags or information regarding tagged lamprey upstream of The Dalles Dam. By mid-summer 1998, all of the tagged lamprey from the 1997 investigation will have completed spawning and died. The permanency of the tags combined with their bright coloration may result in latent returns from spawning areas, adding to our information base regarding migratory timing and stock specificity.

Recommendations

Juvenile Lamprey Investigations

1. Require comprehensive testing and monitoring of fixed bar screens to determine impingement rates of juvenile lamprey prior to system-wide implementation of this guidance equipment.

2. Maintain data collection (e.g. length, weight, maturation level, condition, etc.) on juvenile lamprey at all juvenile collection facilities.

3. Attempt the development of passage indices for lamprey at selected projects using existing data.

4. Attempt to quantify the survival curves for juvenile lamprey using pressure chamber tests to simulate draft tube pressure extremes.

5. Develop proposals for funding of juvenile lamprey mainstem passage studies, addressing losses at mainstem hyropower dams from juvenile salmonid bypass structures (e.g. fixed bar and extended fixed bar screens).

6. Require that the number data from the incidentially collected juvenile lamprey be submitted to and reported annually by the Fish Passage Center (FPC) to monitor changes in juvenile lamprey outmigrations over time.

Adult Lamprey Investigations

1. Continue to estimate lamprey passage and length frequency at Bonneville, Ice Harbor, Lower Granite, Rock Island, and Wells dams using on-site counts or videography.

2. Modify fish counting stations to improve lamprey-counting precision.

3. Identify lamprey migration routes through dams that enable them to bypass count station windows.

4. Request that adult lamprey count numbers be submitted annually to the Fish Passage Center for inclusion within its annual fish passage reports.

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Table 1. Life history and passage data for juvenile Pacific lamprey sampled at the McNary Dam juvenile salmonid collection facility from May through December 1997. The 24-hour sampling rate of the juvenile salmonid bypass flow varied often within a month. Monthly passage estimates are sums of the daily estimates. Juvenile lamprey were recorded as “browns” or “silvers”, referring to ammocoetes or macrophathalmia, respectively.

Month	Sample size (N)	Mean length in mm (SE)	Mean weight in g (SE)	Life stage	Total number collected	24 h sampling rate (range)	Minimum juvenile lamprey passage estimate (“silvers only”) (daily counts X 24 h sampling rate)
April	-	-	-	Silver	2,823	0.033-0.166	26,[illegible]
	-	-	-	Brown	6		
May	16	153.6(2.86)	4.3(0.29)	Silver	1,766	0.013-0.033	97,[illegible]
	-	-	-	Brown	5		
June	*4*	*155.8(5.95)*	*4.5(0.87)*	*Silver*	*743*	*0.006-0.066*	*19,[illegible]*
	-	-	-	*Brown*	*6*		
July	*19*	*143.6(2.68)*	*3.9(0.13)*	*Silver*	*62*	*0.067-0.033*	*5,[illegible]*
	2	146.0(5.00)	4.0(0.00)	Brown	8		
August	*64*	*144.8(1.23)*	*3.8(0.11)*	*Silver*	*151*	*0.010-0.066*	*4,[illegible]*
	3	137.6(4.97)	4.0(1.00)	Brown	3		
September	*96*	*144.8(0.89)*	*4.3(0.80)*	*Silver*	*254*	*0.066-0.250*	*1,[illegible]*
	-	-	-	Brown	1		
October	*4*	*138.0(3.49)*	*3.7(0.21)*	*Silver*	*196*	*0.166-0.250*	[illegible]
	-	-	-	Brown	0		
November	*4*	*137.8(3.52)*	*3.3(0.05)*	*Silver*	*158*	*0.250*	[illegible]
	-	-	-	Brown	1		
December	*12*	*140.8(2.61)*	*4.0(0.17)*	*Silver*	*56*	*0.250*	[illegible]
	-	-	-	Brown	0		

Table 2. Life history and passage data for juvenile Pacific lamprey sampled at the Lower Monumental Dam juvenile salmonid collection facility from May through November 1, 1997. The 24-hour sampling rate of the juvenile salmonid bypass flow varied often within a month. Monthly passage estimates are sums of the daily estimates. Juvenile lamprey were recorded as “browns” or “silvers”, referring to ammocoetes or macrophathalmia, respectively.

Month	Sample *size (N)*	Mean length in mm *(SE)*	Mean weight in g *(SE)*	Life *stage*	Total number *collected*	Minimum 24 h sampling *rate (range)*	juvenile lamprey passage estimate (“silvers only”) *(daily counts X 24 h sampling rate)*
April	28	146.3(1.96)	-	Silver	39	0.01-0.25	1,[illegible]
	2	147.5(2.5)	-	Brown	3		
May	6	156.6(5.85)	4.3(0.29)	Silver	21	0.007-0.033	2,[illegible]
	1	160.0	-	Brown	1		
June	*1*	*160*	*-*	*Silver*	*1*	*0.02-0.25*	
	38	*151.0(1.35)*	*4.6(0.29)*	*Brown*	*38*		
July	*3*	*155.8(7.64)*	*3.0(0.00)*	*Silver*	*6*	*0.033-1.00*	
	26	146.3(2.10)	4.9(0.30)	Brown	79		
August	*1*	*145.0*	*3.0*	*Silver*	*1*	*1.00*	*1*
	6	140.8(3.96)	-	Brown	6		
September	-	-	-	*Silver*	*0*	*1.00*	
	1	150.0	-	Brown	1		
October	*1*	*155.0*	-	*Silver*	*1*	*1.00*	
	-	-	-	Brown	0		
November[1]	*4*	*138.8(4.27)*	*4.0(0.40)*	*Silver*	*4*	*1.00*	
	-	-	-	Brown	8		
December[2]							

[1] The November sample is a one day sample, since the facility shutdown occurred on November 1st 1997.
[2] No sampling conducted during December 1997.

Table 3. Life history and passage data for juvenile Pacific lamprey sampled at the Little Goose Dam juvenile salmonid collection facility from May through November 1, 1997. The 24-hour sampling rate of the juvenile salmonid bypass flow varied often within a month. Monthly passage estimates are sums of the daily estimates. Juvenile lamprey were recorded as “browns” or “silvers”, referring to ammocoetes or macrophathalmia, respectively.

Month	Sample *size (N)*	Mean length in mm *(SE)*	Mean weight in g *(SE)*	Life *stage*	Total number *collected*	24 h sampling *rate (range)*	Minimum juvenile lamprey passage estimate (“silvers only”) *(daily counts X 24 h sampling rate)*
April	4	158.8(3.14)	-	Silver	51	0.006-0.250	2,[illegible]
	-	-	-	Brown	3		
May	10	148.5(2.24)	-	Silver	47	0.006-0.250	2,[illegible]
	-	-	-	Brown	2		
June	*7*	*146.1(3.08)*	*3.6(0.29)*	*Silver*	*18*	*0.006-0.185*	
	24	*153.8(1.82)*	*5.6(0.28)*	*Brown*	*46*		
July	*3*	*148.3(7.26)*	-	*Silver*	*5*	*0.025-0.250*	
	82	145.4(1.23)	-	Brown	83		
August	*1*	*140.0*	-	*Silver*	*3*	*0.25-1.006*	
	13	145.0(0.98)	-	Brown	28		
September	*44*	*141.7(1.46)*	-	*Silver*	*53*	*1.00*	
	1	150.0(6.01)	-	Brown	1		
October	*17*	*141.3(1.39)*	-	*Silver*	*22*	*1.00*	
	2	157.5(12.5)	-	Brown	2		
November[1]	-	-	-	*Silver*	*103*	*1.00*	-
	-	-	-	Brown	5		
December[2]							

[1] The November count was a one day sample, during project shutdown. The high numbers were probably from an accumulation of juvenile lamprey residing in the juvenile fish collection system over an unknown period of time.
[2] No sampling conducted after November 1, 1997.

Table 4. Life history and passage data for juvenile Pacific lamprey sampled at the Lower Granite Dam juvenile salmonid collection facility from May through November 1, 1997. The 24-hour sampling rate of the juvenile salmonid bypass flow varied often within a month. Monthly passage estimates are sums of the daily estimates. Juvenile lamprey were recorded as “browns” or “silvers”, referring to ammocoetes or macrophathalmia, respectively.

Month	Sample *size (N)*	Mean length in mm *(SE)*	Mean weight in g *(SE)*	Life *stage*	Total number *collected*	24 h sampling *rate (range)*	Minimum juvenile lamprey passage estimate (“silvers only”) *(daily counts X 24 h sampling rate)*
April	-	-	-	Silver	20	0.010-0.100	1,(
	-	-	-	Brown	15		
May	6	147.8(5.79)	-	Silver	7	0.006-0.05	1,(
	24	156.3(1.46)	-	Brown	39		
June	*0*	*-*	*-*	*Silver*	*0*	*0.04-0.160*	
	130	*-*	*-*	*Brown*	*136*		
July	*0*	*-*	*-*	*Silver*	*0*	*0.16-0.25*	
	294	152.3(0.59)	7.5(0.08)	Brown	354		
August	*1*	*150.0*	*7.3*	*Silver*	*1*	*0.25-1.001*	
	8	153.6(3.04)	8.2(0.63)	Brown	9		
September	*13*	*142.2(1.73)*	*7.0(0.38)*	*Silver*	*13*	*1.00*	
	4	144.8(6.44)	7.2(1.07)	Brown	4		
October	-	-	-	*Silver*	*1*	*1.00*	
	-	-	-	*Brown*	*0*		
November[1]	*33*	*154.3(1.15)*	*6.9(0.190)*	*Silver*	*1,350*	*1.00*	1,:
	0	-	-	Brown	0		
December[2]							

[1] High numbers from this one-day system shutdown sample were likely due to juvenile lamprey accumulating and residing in the collection system over a period of time.
[2] No sampling conducted after November 1, 1997.

Table 5. Pacific lamprey passage estimates (95% bound) derived from CTUIR on-site observations at Bonneville Dam in 1997.

	Bradford Island				Washington Shore			
Strata	Daytime	(+/-)	Nighttime	(+/-)	Daytime	(+/-)	Nighttime	(+/-)
7/1-15	0	0	25,212	4,324	18,800	30,802	-16,077	14,826
7/16-31	4,867	3,322	7,934	2,049	11,874	7,213	17,336	6,019
8/1-15	3,600	2,980	2,813	2,000	6,057	2,662	3,147	2,031
8/16-31	2,238	1,063	1,176	565	3,287	1,034	7,236	2,218
9/1-15	384	422	1,080	580	10,585	5,316	17,895	4,053
9/16-30	747	411	692	475	-1,575	7,571	4,528	1,904
Total	11,835	22,532	38,908	4,766	49,027	26,706	34,065	16,106

Table 6. Estimated total adult Pacific lamprey passage by month at Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Rock Island, Rocky Reach and Wells dams in 1997.

	Bonneville COE	The Dalles	John Day	McNary	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Rock Island	Rocky Reach	Wells
January											
February											
March											
April	4		1								
May	1,691	4	216		7			1	2		
June	-	392	114	35	19	4	2	2	12		8
July	1,939	8,377	5,493	897	340	61	49	78	26	16	6
August	9,783	3,374	5,518	2,343	796	124	162	924	1,154	761	91
September	8,643	2,469	2,807	882	267	27	35	247	1,008	598	547
October	770	219	696	56	25	1	-3	22	114	30	121
November	0	0	0						5		
December	0	0	0								
Total	22,830	14,835	14,845	4,213	1,454	217	245	1,274	2,321	1,405	773

Table 7. Pacific lamprey ladder ascending efficiency and (SE) at Bonneville Dam in 1997. All comparisons (daytime, nighttime, and total) between Bradford Island and Washington Shore were significantly different (P = 0.028) using a two-sample Wilcoxon Test.

	Bradford Island			Washington Shore		
Strata	Daytime Efficiency	Nighttime Efficiency	Total Efficiency	Daytime Efficiency	Nighttime Efficiency	Total Efficiency
7/1-15/97	35.1	21.5	27.0	8.1	-8.2	0.6
7/16-31/97	34.4	19.0	22.9	19.3	11.0	13.3
8/1-15/97	57.1	20.1	31.6	37.1	7.1	15.4
8/16-31/97	54.3	30.1	41.8	32.1	13.9	16.9
9/1-15/97	50.0	38.1	40.6	28.1	19.3	21.8
9/16-30/97	68.4	21.0	33.0	-28.7	14.4	7.2
Mean	49.9 (5.39)	25.0 (3.09)	32.8 (3.03)	16.0 (9.87)	9.6 (3.92)	12.5 (3.08)

Table 8. Summary of lamprey passage counts made at the Bradford Island and Washington Shore count stations at Bonneville Dam in 1997. On-site counts were observations recorded over 12 minute intervals and video-based counts were made from recordings made during the same 12 minute intervals. A total of 50 intervals (34 at Bradford Island and 16 at Washington Shore) were included in the analysis. Significant differences (in italics) were based on paired Wilcoxon tests with α=0.05.

		On-site Count	Video Count	P value
Bradford Island	Upstream	96	45	*<0.01*
“ “	Downstream	82	49	*0.01*
Washington Shore	Upstream	177	1430.10	
“	“Downstream	126	141	0.67
Total Dam	Upstream	273	188	*<0.01*
	Downstream	208	190	0.05

Table. 9 Length, weight, and migration data on recaptured Pacific lamprey disk tagged at Bonneville Dam, and released at Stevenson, Washington in 1997. Pacific lamprey were released at river kilometers 243.3, and 243.4.

Length (mm)	Weight (g)	Tag no.	Date tagged	Recapture date	Recapture location(Rkm)	Days at large	Total distance traveled(Rkm)	Travel (Rkm/day)
680.0	443.0	1366	7/14/98	7/24/97	309.3	10.0	66.0	6.6
731.0	597.0	1313	7/14/98	7/16/97	309.3	2.0	66.0	33.0
656.0	462.0	1384	7/16/98	7/18/97	309.3	2.0	66.0	33.0
712.0	547.0	409	7/24/98	8/06/98	309.6	13.0	66.3	5.2
630.0	435.0	1014	8/14/98	8/16/97	309.3	2.0	66.0	33.0
615.0	367.0	1006	8/12/98	8/17/97	309.9	5.0	66.7	13.4
662.0	412.0	1211	9/11/98	9/12/97	309.3	1.0	65.8	65.8
652.0	413.0	1233	9/11/98	9/12/97	309.3	1.0	65.8	65.8
740.0	640.0	305	9/18/98	9/19/97	243.8	1.0	0.32	0.32
668.0	454.0	805	8/28/98	8/30/97	243.8	2.0	0.32	0.16
634.0	410.0	652	9/04/98	9/06/97	243.8	2.0	0.32	0.16
650.0	413.0	637	9/04/98	9/07/97	308.0	3.0	64.6	21.6
706.0	540.0	614	9/04/98	9/05/97	292.2	1.0	48.3	48.8
Mean								
672.0	471.8				292.9	5.6	49.4	25.1
Median								
662.0	443.0				309.3	3.2	65.8	21.6
C.I								
(651.4-692.6)	(428.6-515.0)				(278.1-307.7)	(2.4-8.8)	(34.6-64.2)	(12.7-37.5)

Figure 7. Length and weight relationship of 120 Pacific lamprey sampled at John Day Dam on 1/8/98 (R^2 = 0.846).

Appendix A.

Daily Counts

Month	Day	Dalles Dam	John Day Dam	McNary Dam	Ice Harbor Dam	Little Goose Dam	Lower Monumental Dam	Lower Granite Dam	Rock Island Dam	Rocky Reach Dam	Wells Dam
April	1			0	0	0	0	0			
April	2			0	0	0	0	0			
April	3			0	0	0	0	0			
April	4			0	0	0	0	0			
April	5			0	0	0	0	0			
April	6			0	0	0	0	0			
April	7			0	0	0	0	0			
April	8			0	0	0	0	0			
April	9			0	0	0	0	0			
April	10			0	0	0	0	0			
April	11			0	0	0	0	0			
April	12			0	0	0	0	0			
April	13			0	0	0	0	0			
April	14			0	0	0	0	0			
April	15			0	0	0	0	0	0	0	
April	16			0	0	0	0	0	0	0	
April	17			0	0	0	0	0	0	0	
April	18			0	0	0	0	0	0	0	
April	19			0	0	0	0	0	0	0	
April	20			0	0	0	0	0	0	0	
April	21			0	0	0	0	0	0	0	
April	22			0	0	0	0	0	0	0	
April	23			0	0	0	0	0	0	0	
April	24			0	0	0	0	0	0	0	
April	25			0	0	0	0	0	0	0	
April	26			0	0	0	0	0	0	0	
April	27			0	0	0	0	0	0	0	
April	28			0	0	0	0	1	0	0	
April	29			0	0	0	0	0	0	0	
April	30			0	0	0	0	-1	0	0	
May	1			0	0	0	0	0	0	0	0
May	2			0	0	0	0	0	0	0	0
May	3			0	0	0	0	0	0	0	0
May	4			0	0	0	0	0	0	0	0
May	5			0	0	0	0	0	0	0	0
May	6			0	0	0	0	0	0	0	0
May	7			0	0	0	0	0	0	0	0
May	8			0	0	0	0	0	0	0	0
May	9			0	0	0	0	0	0	0	0
May	10			0	4	0	0	0	0	0	0
May	11			0	0	0	0	0	0	0	0

May	12	0	0	0	0	0	0	0	0
May	13	0	0	0	0	0	0	0	0
May	14	0	0	0	0	0	0	0	0
May	15	0	2	0	0	0	0	0	0
May	16	0	0	0	0	0	0	0	0
May	17	0	0	0	0	0	0	0	0
May	18	0	0	0	0	0	0	0	0
May	19	0	0	0	0	0	0	0	0
May	20	0	0	0	0	0	0	0	0
May	21	0	0	0	0	0	0	0	0
May	22	0	0	0	0	0	0	0	0
May	23	0	0	0	0	0	1	0	0
May	24	0	0	0	0	0	1	0	0
May	25	0	0	0	0	0	0	0	0
May	26	0	0	0	0	0	0	0	0
May	27	0	0	0	0	0	0	0	0
May	28	0	0	0	0	0	0	0	0
May	29	0	0	0	0	0	0	0	0
May	30	0	0	0	0	0	0	0	0
May	31	0	1	0	0	1	0	0	0
June	1	0	0	0	1	0	0	0	0
June	2	0	1	0	0	0	0	0	0
June	3	0	1	0	0	0	0	0	0
June	4	1	1	0	0	0	0	0	0
June	5	0	0	0	0	0	0	0	0
June	6	0	0	0	0	0	0	0	0
June	7	0	0	0	0	0	0	0	0
June	8	1	0	0	0	0	0	0	4
June	9	0	1	0	0	1	0	0	0
June	10	2	0	0	0	0	2	0	0
June	11	0	0	0	0	0	0	0	0
June	12	0	0	0	1	0	0	0	0
June	13	0	0	0	0	0	1	0	1
June	14	2	0	0	1	0	1	0	1
June	15	1	2	0	1	0	0	0	0
June	16	1	0	0	0	0	0	0	0
June	17	0	0	0	0	0	0	0	0
June	18	2	1	0	0	0	0	0	1
June	19	0	2	0	0	0	0	0	1
June	20	2	0	0	0	0	1	0	0
June	21	1	0	0	0	0	0	0	0
June	22	1	0	0	0	0	1	0	0
June	23	1	0	0	0	0	1	0	0
June	24	2	5	1	0	0	0	0	0
June	25	1	3	0	0	0	2	0	0
June	26	3	1	1	0	1	1	0	0
June	27	4	1	0	0	0	0	0	0
June	28	2	0	0	0	0	0	0	0
June	29	6	0	0	0	0	2	0	0
June	30	2	0	0	0	0	0	0	0
July	1	0	1	0	0	0	2	0	0
July	2	1	0	0	0	2	0	0	0
July	3	2	1	0	0	0	2	0	0
July	4	2	1	0	0	0	2	0	0
July	5	0	0	0	0	0	2	0	0
July	6	3	2	0	0	0	1	0	0
July	7	3	1	0	0	0	1	1	0
July	8	5	0	0	0	0	1	0	0
July	9	9	0	0	1	0	0	2	0
July	10	3	0	0	0	0	0	0	0
July	11	4	1	0	0	0	0	0	0
July	12	14	1	0	0	0	0	0	0
July	13	13	4	0	0	0	0	1	3
July	14	15	3	0	0	0	0	0	1
July	15	10	2	0	1	1	1	0	0
July	16	20	11	-1	0	0	0	0	0
July	17	24	8	0	1	0	0	1	0
July	18	25	16	1	4	0	0	1	0
July	19	50	13	1	1	0	0	0	0
July	20	52	22	0	2	0	0	4	0
July	21	79	18	1	1	2	0	0	0
July	22	69	14	0	6	1	0	1	0
July	23	40	16	1	4	0	0	0	0
July	24	34	31	3	6	2	2	2	0
July	25	28	25	5	5	2	2	0	0
July	26	33	23	5	9	1	0	1	0
July	27	61	7	7	6	15	1	0	0
July	28	36	29	9	3	11	1	1	1
July	29	60	37	4	0	12	1	0	1
July	30	102	26	8	4	21	2	0	0
July	31	100	27	5	7	8	5	1	0
August	1	141	29	10	10	15	5	1	3
August	2	97	76	3	10	12	2	2	1
August	3	83	61	3	4	21	5	4	0
August	4	60	37	10	5	23	2	2	0

August	5	76	44	7	9	35	7	2	0
August	6	46	49	2	4	29	8	4	1
August	7	70	30	7	5	17	10	6	0
August	8	121	31	4	3	5	15	13	0
August	9	76	20	7	2	51	6	18	1
August	10	54	15	6	2	29	18	11	4
August	11	116	39	5	5	23	14	2	2
August	12	95	10	9	5	26	19	3	1
August	13	108	21	5	6	35	30	5	0
August	14	96	7	8	3	31	17	12	0
August	15	78	31	2	3	32	30	19	0
August	16	109	9	4	5	35	39	21	0
August	17	47	29	5	3	38	41	35	1
August	18	56	14	2	4	26	54	7	1
August	19	99	15	5	2	34	50	10	1
August	20	82	22	6	5	33	35	44	1
August	21	68	16	1	1	34	46	6	5
August	22	42	25	5	3	38	55	8	6
August	23	42	26	6	6	17	74	26	5
August	24	61	21	7	3	50	62	66	6
August	25	80	21	5	4	30	49	60	7
August	26	91	31	4	6	46	80	45	7
August	27	74	11	4	1	46	69	75	6
August	28	53	12	4	2	26	163	57	12
August	29	56	18	6	2	33	56	56	7
August	30	51	10	6	1	25	49	85	7
August	31	15	16	4	1	29	44	56	6
September	1	37	21	5	2	17	64	8	4
September	2	45	36	1	0	9	88	10	18
September	3	52	17	3	0	19	81	11	7
September	4	57	12	1	0	25	59	42	15
September	5	53	15	0	4	18	43	57	6
September	6	38	22	0	5	13	44	79	15
September	7	40	13	0	1	23	47	36	27
September	8	27	11	0	1	10	65	32	20
September	9	32	4	2	0	6	55	54	39
September	10	42	12	1	1	7	32	42	38
September	11	38	11	1	1	5	48	18	27
September	12	47	9	0	0	6	19	9	30
September	13	33	4	1	0	4	26	3	26
September	14	31	4	4	1	8	22	4	13
September	15	45	7	1	0	6	11	11	13
September	16	29	14	3	1	13	17	8	30
September	17	20	12	3	4	7	20	20	15
September	18	19	3	2	1	9	12	10	11
September	19	13	9	1	0	4	14	24	31
September	20	7	4	0	0	4	50	9	14
September	21	24	1	-1	1	0	7	14	13
September	22	15	7	1	2	1	23	15	21
September	23	14	2	1	0	1	23	18	23
September	24	19	2	0	0	3	14	9	22
September	25	19	0	1	1	2	18	9	18
September	26	24	3	0	0	1	27	15	3
September	27	17	3	2	0	8	23	5	3
September	28	14	3	3	0	9	30	5	5
September	29	18	2	-1	0	5	17	15	24
September	30	13	4	0	1	4	9	6	16
October	1	8	0	-1	0	2	16	3	8
October	2	8	5	0	0	4	3	10	12
October	3	8	2	0	1	6	9	2	13
October	4	7	1	0	1	0	12	0	8
October	5	4	2	0	1	1	10	5	5
October	6	1	0	-1	0	3	11	1	6
October	7	5	2	-1	0	1	12	0	12
October	8	5	4	0	0	1	4	1	7
October	9	2	2	0	0	1	1	1	2
October	10	2	0	0	0	0	7	1	8
October	11	1	1	0	0	0	5	1	7
October	12	0	3	2	0	0	3	0	5
October	13	1	0	0	0	0	1	0	1
October	14	0	1	0	0	1	2	0	9
October	15	0	0	0	-1	0	5	0	4
October	16	0	0	0	-1	0	2	0	8
October	17	1	1	0	0	0	2	0	1
October	18	2	0	0	0	0	1	2	1
October	19	1	0	-1	0	1	2	0	3
October	20	0	0	-2	0	1	1	0	0
October	21	0	1	0	0	0	2	2	0
October	22	0	0	0	0	0	0	0	0
October	23	0	0	0	0	0	0	1	0
October	24	0	0	0	0	0	0	0	0
October	25	0	0	0	0	0	0	0	1
October	26	0	0	0	0	0	0	0	0
October	27	0	0	0	0	0	0	0	0
October	28	0	0	0	0	0	0	0	0
October	29	0	0	1	0	0	0	0	0

October	30	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	3	0	0
November	1						0	0	0
November	2						0	0	0
November	3						1	0	0
November	4						0	0	0
November	5						2	0	0
November	6						1	0	0
November	7						1	0	0
November	8						0	0	0
November	9						0	0	0
November	10						0	0	0
November	11						0	0	0
November	12						0	0	0
November	13						0	0	0
November	14						0	0	0
November	15						0		0
November	16								0
November	17								
November	18								
November	19								
November	20								
November	21								
November	22								
November	23								
November	24								
November	25								
November	26								
November	27								
November	28								
November	29								
November	30								

ANNUAL REPORT

for

Pacific Lamprey Research and Restoration Project

Part (C) Adult Passage Research

by

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Year ending 31 December 1997

Abstract

To study the potential impact of dam passage on the reproductive success of adult Pacific lamprey (*Lampetra tridentata*), methods such as radio-tracking are being used by biologists in the Columbia River Basin. However, the key assumption in studies that employ radio tags is that tagged animals are representative in performance of untagged animals. To test this assumption, 7.4 g radio tagged adult Pacific lamprey were assessed for physiological recovery and swimming performance after the stress of a tagging procedure. Plasma glucose levels in radio tagged animals were significantly elevated until day four and seven. Plasma glucose levels in radio tagged animals were significantly lower than control animals by 30, 60, and 90 days after surgery. Swimming performance decreased significantly between control and tagged lamprey one hour after surgery. However, swimming time was not different between control and tagged fish at 24 and 168 hours after surgery. Oxygen consumption differed significantly between control and tagged fish in the one-hour group, however there was no difference at 24 and 168 hours. The results suggest that 7.4 g radio tagged lamprey should be held a minimum of 24 hours before release. The lower glucose levels at 30, 60, and 90 days in tagged fish suggest possible chronic stress.

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Introduction

The reasons for the decline of Pacific lamprey populations throughout the Columbia River Basin remain unknown. Many factors may have contributed to the decline of Pacific lamprey including hydroelectric projects. Hydroelectric projects may be causing migration delay and possibly impeding passage of lamprey to spawning areas in the interior basin. In order to assess the role of hydroelectric project impacts on migration of lamprey, methods need to be developed to examine the behavior of lamprey passing through the dams. In 1996, the National Marine Fisheries Service (NMFS) started using radiotelemetry to follow movement around the Columbia River dams. One of the assumptions of a radiotelemetry study is that the radio-tagged individuals represent the free-swimming fish; however this assumption must be verified for lamprey. The first part of the verification process is to examine if radio-tagged lamprey recover from the stress of surgical implantation of radio tags. The second part of the evaluation is to determine if radio tagged lamprey have reduced swimming performance.

Methods

Animals: Adult Pacific lamprey were collected at Willamette Falls, Oregon during July 1997 and transported to the Fish Performance and Genetics Laboratory at Corvallis, Oregon. Lamprey were treated with oxytetricycline at a dose of .5 ml per kg of fish for bacterial infections and treated with formaldehyde 37% (formalin) for external parasites. Fish were maintained in flow through 0.9 m diameter tanks supplied by well water at a temperature of 12-13°C. Adult lampreys do not feed during the freshwater phase, therefore, the fish were not fed during the study.

Experimental Design: The first experiment was designed to determine time to recovery from stress after tag implantation. In experiment 1A, fish were anesthetized in MS-222 buffered with sodium bicarbonate and injected with pit tags (passive integrated transponder). Lamprey were distributed to holding tanks to acclimate for 2 weeks (n=10/tank; 2 tanks/sampling time). Each tank was randomly assigned a treatment control or tagged (i.e. no individual fish was sampled more than once). Lamprey were anesthetized and implanted with a 7.4 g tag into the body cavity. Control fish were treated the same as tagged fish, except for no surgery or tag implantation was performed. At 3, 24, 96, and 168 hours after completion of surgery, the fish were anesthetized and sampled for blood. The second experiment (1B) was designed to examine the chronic effects of surgical implantation of radio tags. Lamprey from experiment 1A were maintained in tanks and sampled for blood at 30, 60, and 90 days after surgery. Lamprey were sampled the same as the previous experiment excluding the 168 hour fish. In experiment 2A, swimming performance of radio-tagged individuals were tested at 1, 24, and 168 hours after surgery. Eight controls and tagged lamprey at each time were tested individually. Adult lamprey were anesthetized in MS-222 buffered with sodium bicarbonate and then surgically implanted with the 7.4 g tag. Fish were acclimated in the flume one-hour before starting the flow. Ventilation rate was counted (beats/min.) at 5, 30, and 60 minutes after placement in the flume. The flume was lined with a high-density polyethylene aqua-net grid. The lining in the flume prevented the lamprey from attaching on the walls of the flume. After an hour, the flow was turned on and the lamprey were acclimated to swimming for 10 minutes (5 minutes for both 20 and 30 cm/sec). After swimming acclimation, the flow was increased to 40 cm/sec. An electrical current (12-volt lantern battery) was applied to keep the lamprey off the back screen. The lamprey were considered exhausted when the animal could not get off the back screen. After one hour of swimming the test was ended. The lamprey were then taken out of the flume and placed into a respirometer. The dissolved oxygen levels were recorded at 5 and 30 minutes after swimming exhaustion.

Sampling. Lampreys were anesthetized in tricane methansulfonate (MS-222) .08 g/L buffered with sodium bicarbonate and then a blood sample was collected from the caudal vein with a vacutainer needle. The plasma was separated by centrifugation and stored for analysis at -80°C. In experiment 2A, ventilation rate was recorded during the hour acclimation in the flume. Swimming performance was measured by time to exhaustion. Lamprey unable to push themselves off the back screen were considered exhausted and time was recorded. Water samples were collected from the respirometer into a graduated cylinder and dissolved oxygen levels measured.

Plasma samples were analyzed for glucose by colorometric assay (Wedemeyer and Yasutake 1977). Observation of ventilation rate (beats/min) was recorded during the acclimation in flume. Time to swimming exhaustion was recorded by use of stopwatch. Time spent on the back screen was subtracted from total swimming time. Oxygen consumption after swimming performance was determined by containing fish in a respirometer and measuring dissolved oxygen with a meter (Cech 1990).

Statistical analysis. Plasma levels of glucose, and ventilation rate were compared by ANOVA followed by multiple range testing by use of Duncan's LSD method.. The significance levels were set at $p \leq 0.05$. Ventilation rates were compared by repeated measure ANOVA. Swim time was compared by the nonparametric tool Mann-Whitney U test. The significance level was set at $p \leq 0.05$. Oxygen consumption was compared by unpaired t-test ($p \leq 0.05$).

Results

In experiment 1A, plasma glucose levels at 3 and 24 hours did differ significantly between control and tagged lamprey, However, by 96 and 168 hours glucose levels in tagged fish were not significantly different ($p > 0.05$) than controls (Fig. 1). In experiment 1B, plasma glucose levels at 30, 60, and 90 days were significantly different ($p < 0.05$) between control and tagged adult lamprey through time (Fig. 1).

In experiment 2A, ventilation rate at 1, 24, and 168 hours did not differ significantly ($p > 0.05$) between control and tagged lamprey (Fig. 2). Ventilation rate did decrease significantly ($p < 0.05$) from 5 to 30 minutes in both control and tagged fish at 1, 24, and 168 hours after tagging. Ventilation rate did not differ significantly ($p > 0.05$) from 30 to 60 minutes between control and tagged fish. In experiment 2B, Swimming time was significantly different ($p < 0.05$) between control and tagged lamprey at 1 hour after surgery. Swimming time was not significantly different between control and tagged lamprey at 24 and 168 hours (7 days), after surgery (Fig. 3). In experiment 2C, Oxygen consumption was significantly different ($p<0.05$) between control and tagged lamprey 1 hour after surgery, however there was not a difference between control and tagged lamprey after 24 and 168 hours (Fig. 4).

Discussion

Plasma glucose becomes elevated after stress in many species of fish, including lamprey. The first experiment indicated that radio tagged lamprey did not recover from the stress of surgery and surgical implantation until day 4. The results of experiment 1B, suggest that radio tagged lamprey are physiologically different than control fish. The radio tags may have changed the metabolic rate in radio tagged lamprey.

Swimming performance of radio tagged lamprey was significantly different than controls immediately after surgery; however, fish tested at one day and seven days after tag implantation indicated no difference. Oxygen consumption between control and tagged fish was significantly different one hour after surgery. The recovery was faster in control compared to tagged lamprey. There was no difference in oxygen consumption between control and tagged lamprey at 24 and 168 hours after surgery. The performance tests of adult radio tagged lamprey suggest that recovery after being surgically implanted radio tags takes a minimum of 24 hours. These results suggest that 7.4 g tags do have an immediate impact on Pacific lamprey, but the effects are reduced by 24 hours. However, glucose did recover to control levels by day four. The results suggest holding tagged lamprey a minimum of 24 hours before release; however, the conservative amount of time as indicated by glucose would be 4 days. The results of the long-term effects of radio tags on adult lamprey suggest there is a difference between tagged and untagged fish. This may be due to a change in metabolic rate in the fish. Caution should be excersized in making inferences to the larger population of lamprey.

Acknowledgments

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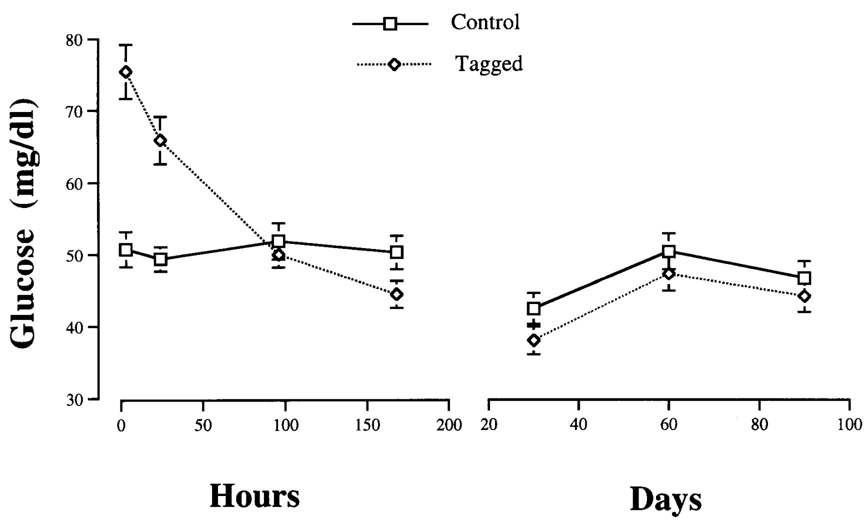

Fig. 1 Plasma levels of glucose in adult Pacific lamprey after surgical implantation of 7.4 g Radiotags. Each point is the mean (+SE) for 20 fish. At 30, 60, and 90 days each point is the mean for 59 (control) and 60 (tagged) fish. Control fish were handled and anesthetized, but no surgery was performed.

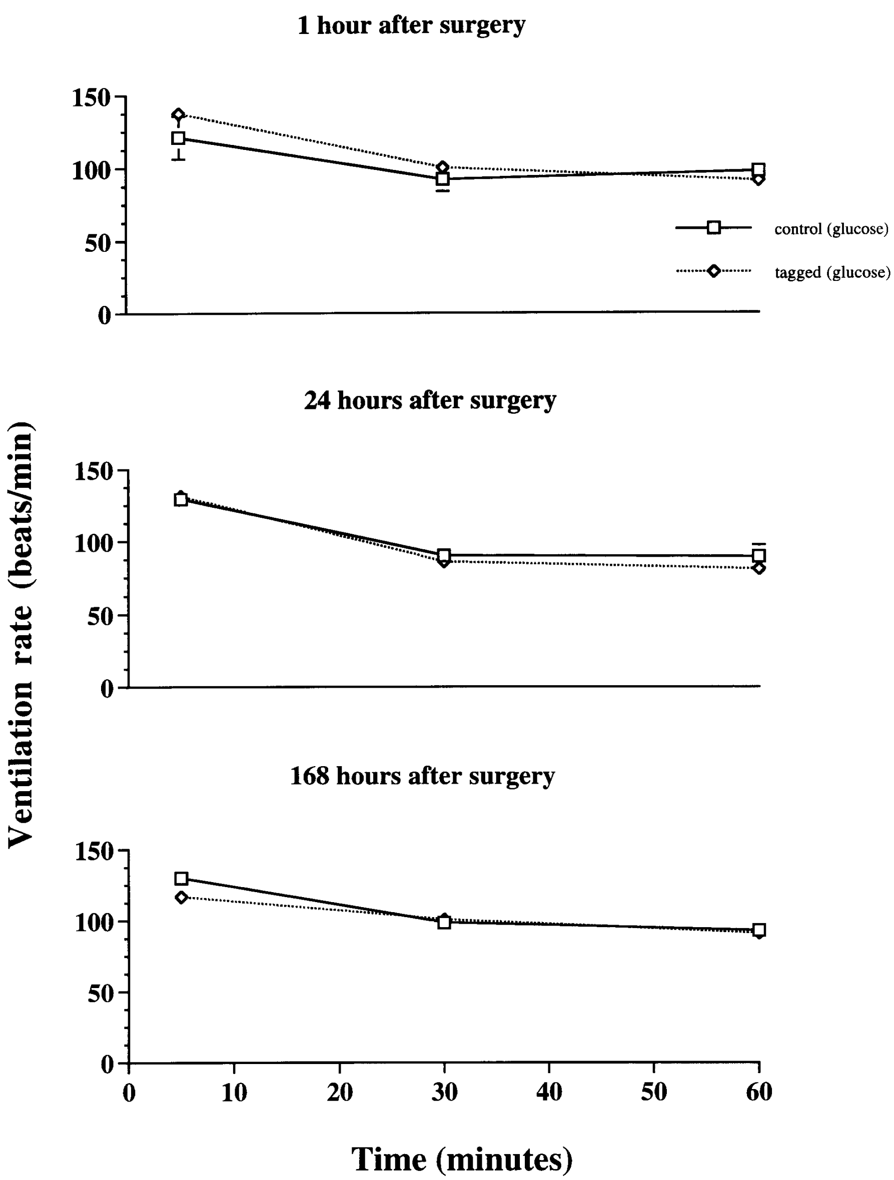

Fig. 2 Ventilation rates of adult Pacific lamprey after 7.4 gram tag implantation. Each point is the mean (+SE) for 8 fish.

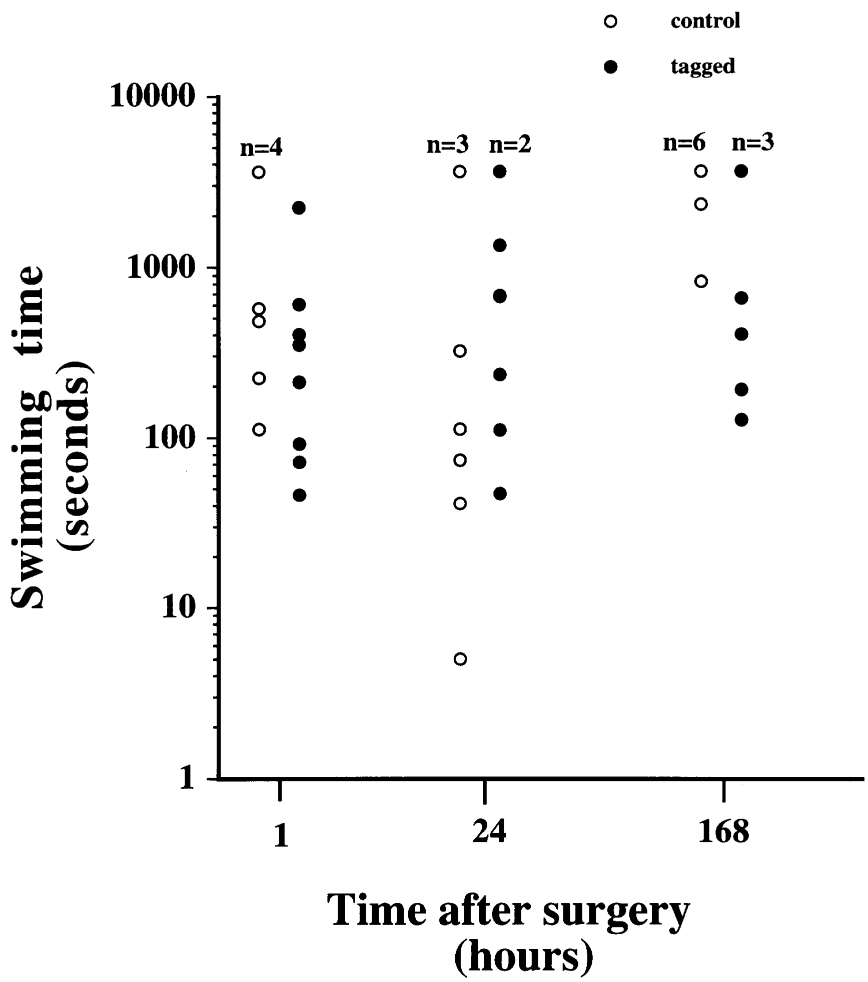

Fig. 3 Swimming time of adult lamprey after 7.4 g tag implantation.

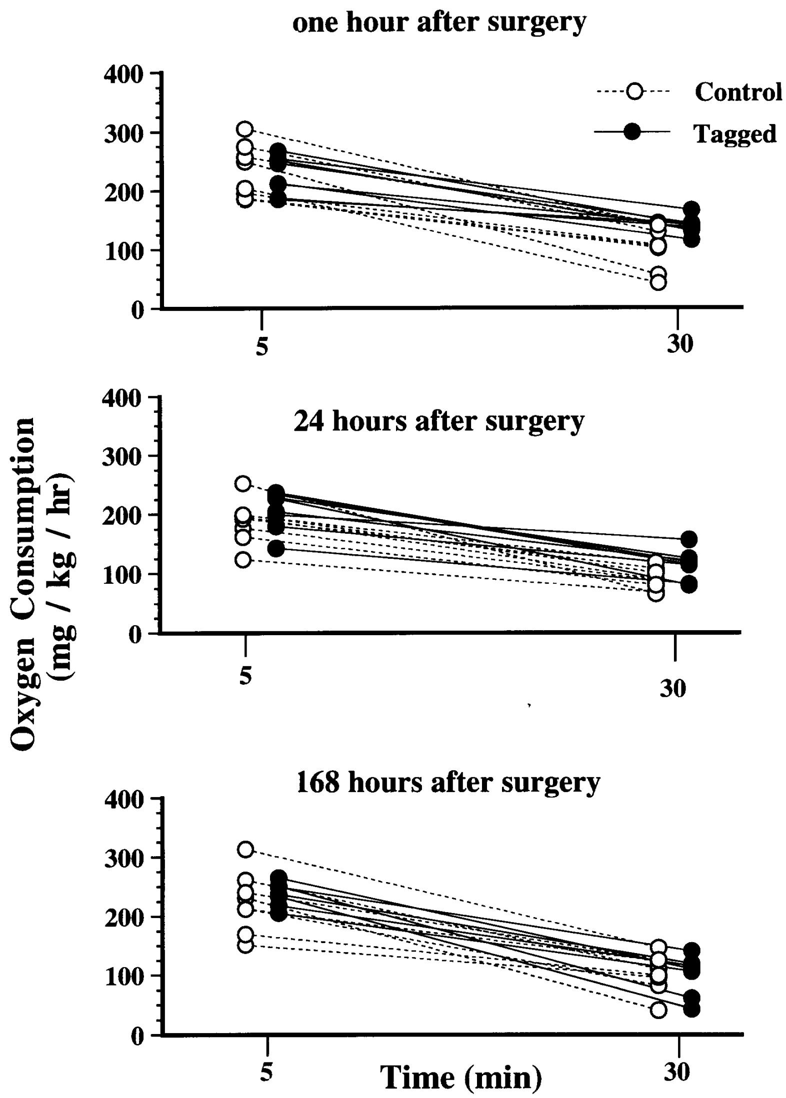

Fig. 4 Oxygen consumption of adult lamprey after swimming exhaustion.