The Status of Pacific Lamprey (*Entosphenus tridentatus*) in Idaho

Idaho Department of Fish and Game

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Cochnauer, T. and C. Claire. 2009. Evaluate status of Pacific lamprey in the Clearwater and Salmon River drainages, Idaho. Draft Conservation Plan. Project No. 2000-028-00, Contract No. 00000090-00001. Technical Report prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

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EXECUTIVE SUMMARY

Despite their former widespread distribution and abundance in the Columbia River basin and Pacific Northwest, Pacific lamprey *Entosphenus tridentatus* were relatively unnoticed until European settlement of the region. Pacific lamprey historically played a critical role in ecosystem energy and nutrient flow in the basins they occupied. European settlement and subsequent development of the Pacific Northwest have contributed significantly to changes in the riverine habitats occupied by Pacific lamprey. Similar to other anadromous species, these changes have altered the habitats that Pacific lamprey require to successfully complete their life cycle. In the past decade fisheries professionals have recognized the ecological importance of Pacific lamprey in the ecosystems they inhabit. Additionally, there has been recognition of the precipitous decline in Columbia and Snake River populations. This document summarizes the current available knowledge concerning the status of the species in the state of Idaho.

The major river drainages in Idaho that remain accessible to Pacific lamprey are discussed regarding their geology, hydrology, and anthropogenic changes. Based on research, historical dam counts, and best professional judgment, spawning escapement goals are defined by the Idaho Department of Fish and Game to provide reasonable assurance the population(s) in Idaho will persist. A number of management actions thought necessary to enhance persistence of the species are also presented.

GOAL

The goal of the Idaho Department of Fish and Game (IDFG) is to restore and maintain viable Pacific lamprey populations in the Clearwater River, Salmon River, and Snake River drainages. Restoration of Pacific lamprey populations will be deemed successful when monitoring and evaluation of recovery indices indicates abundance is at or near objectives addressed below.

OBJECTIVES

The purpose of this document is to:

1. Summarize available information on Pacific lamprey in Idaho.
2. Describe the Clearwater River, Salmon River, and Snake River drainages in terms of geography, hydrology, and the major anthropogenic changes.

3. Identify specific population numerical, distributional, and biological objectives that will ensure persistence of Pacific lamprey in Idaho.
4. Identify conservation actions that will ensure long term persistence and viability of Pacific lamprey populations in Idaho.

Population Objectives

I. Maintain a population of Pacific lamprey in the Clearwater River drainage with the following characteristics:
   1) Distributed throughout historically occupied habitat as is feasible excluding the North Fork Clearwater River above Dworshak Dam.
   2) An average interim annual return of 10,000 adult Pacific lamprey which is based on historic (late 1960s) counts of > 30,000 adults at Lower Snake River dams (Ecovista 2003a).
   3) Connectivity sufficient for all age classes to make normal volitional movements in historically occupied spawning and rearing habitats excluding above Dworshak Dam.

II. Maintain a population of Pacific lamprey in the Salmon River drainage with the following characteristics:
   1) Distributed throughout historically occupied habitat as is feasible.
   2) An average annual return of 21,500 adult Pacific lamprey. This is based on comparative productivity relating to escapement into the Clearwater River over Lewiston Dam, counts over Ice Harbor Dam in the 1960s, drainage area, and best professional judgment regarding productivity and known historical distribution.
   3) Natural or artificial levels of connectivity sufficient for all age classes to make volitional movements in historically occupied spawning and rearing habitats.

III. Maintain a population of Pacific lamprey in the Snake River corridor downstream of Hells Canyon Dam with the following characteristics:
   1) Distributed throughout historically occupied habitat within the mainstem corridor.

2) An average annual return of 500 adult Pacific lamprey to Idaho tributary streams in the reach.

   *Note: The importance of the Oregon tributaries (Grand Ronde, Imnaha Rivers, and others) to recovery of Pacific lamprey in the Snake River basin is noted, however, further coordination is necessary between states to determine objectives for populations under other jurisdictions).

3) Natural or artificial levels of connectivity sufficient for all age classes to make volitional movements in historically occupied spawning and rearing habitat.

INTRODUCTION

Lamprey are a unique group of fishes in the order Petromyzontiformes, first recognized by fossil records in the Carboniferous Period some 360 million years ago. Pacific lamprey *Entosphenus tridentatus* is one of several species of lamprey found in the Pacific Northwest.

The distribution of Pacific lamprey in North America is from the Alaska Aleutians to Baja California (Scott and Crossman 1998) and inland to central Idaho (Hammond 1979a). Historically they were found in all major river systems where salmon and steelhead occurred including the Snake, Salmon, and Clearwater rivers in Idaho (Simpson and Wallace 1982). The limit of upstream migration in the Snake River was documented near Lower Salmon Falls by early naturalists (Gilbert and Evermann 1894).

Life History

Pacific lamprey are anadromous and are the largest lamprey species found in the Columbia River basin. All lampreys are "eel-like" in appearance being elongated with no paired fins or scales. The lamprey skeleton is cartilaginous. They generally migrate upriver during March to October in the year prior to spawning, overwinter in deep pools, and spawn in the spring (April to July) when water temperatures reach 10^{o} to 15^{o} C in areas of fine gravel and silt by excavating shallow depressions (USACE 2009). Female Pacific lamprey can deposit from 40,000 to 238,000 eggs depending upon body size (USACE 2009). The larval (ammocoete) and juvenile (macropthalmia) life history phases reside in freshwater, prior to migration to the ocean to rear as adults, and then return to fresh water streams for spawning to complete their life history. Pacific lamprey spawn and rear in coastal and inland streams from southern California to Alaska (Hubbs and Potter 1971; Simpson and Wallace 1982).

Larval stage

Pacific lamprey have a protracted freshwater juvenile residence time in the stream benthos (Close et al. 2002). Pacific lamprey ammocoetes emerge from redds after several weeks of incubation and are eyeless upon hatching (Richards and Beamish 1981). Ammocoetes drift downstream, and settle in slow depositional areas such as pools and eddies (Pletcher 1963) occupying freshwater soft stream substrates from four to seven years (Pletcher 1963; Kan 1975; Richards 1980; Hammond 1979a and 1979b; Beamish and Northcote 1989; Creaser and Hann 1929; Richards and Beamish 1981; Beamish and Levings 1991) where they filter-feed on plant and animal detritus before undergoing transformation into macropthalmia (Creaser and Hann 1929; Richards and Beamish 1981; Beamish and Levings 1991).

Downstream migrants

During metamorphosis, the ammocoetes go through both morphological and physiological changes to prepare for a parasitic, saltwater existence. Transformation changes include formation of an oral disc with the species-specific three toothed upper disc and eyes among other morphological processes. Transformation from the larval to young adult stage generally occurs during July through November (Pletcher 1963; Hammond 1979a; Richards and Beamish 1981). Young adult lamprey may start their migration to the Pacific Ocean in the fall, however, strong pulses of migration have been documented in Idaho streams from late winter months to early summer and it is believed that in Idaho streams downstream migration primarily occurs between February and June.

Ocean phase

Within several months after completion of transformation, Pacific lamprey migrate downstream to the ocean where they grow from juveniles into adults. Parasitic feeding is thought to primarily occur in the ocean phase. The predominant growth period occurs during this period. When macropthalmia reach the ocean they are thought to range in length similarly to individuals leaving rearing streams (from 100-200 mm TL). As adults, they have a ventral mouth consisting of a circular disc set with teeth designed for their ocean phase parasitic life feeding on a wide range of aquatic marine organisms (Scott and Crossman 1998) including Pacific herring *Clupea pallasii,* Pacific hake *Merluccius productus*, walleye pollock *Theragra chalcograma*, salmon *Oncorhynchus spp.*, and steelhead trout *O. mykiss* among other prey for an estimated one to two years prior to returning to freshwater to spawn. Migration routes and or extent of migration in the ocean is unknown and the characteristics of feeding intensity, habitat depth selection, and other attributes of the ocean life history phase of Pacific lamprey are for the most part are poorly understood. The parasitic lifestyle may last for up to 3.5 years (Beamish 1980; Kan 1975).

Adult spawning migration

Returning adult Pacific lamprey enter freshwater between April and June and complete migration into freshwater streams by September (Beamish 1980). Pacific lamprey adults do not feed during the spawning migration. Once in desired freshwater habitat they overwinter and spawn the following spring. Pacific lamprey spawn along the Oregon Coast as early as May when water temperatures reach 10^{o}C to 15^{o}C and continue to spawn through July (Close et al. 2002). Post-spawn adults die soon thereafter. Counts at Columbia River and Snake River dams document Pacific lamprey adults beginning upstream migrations in large numbers during June and July. Upstream migration continues into late September when Pacific lamprey seek out boulder fields and other cover in pools in lower reaches of tributary rivers. Pacific lamprey move very little while in hiding until biological stimulus in the spring encourages them to continue migration to spawning tributaries. Historically in Idaho overwintering likely occurred to a large degree in the Snake River-Hells Canyon reach, lower Clearwater River (Kooskia, Idaho to mouth), and the Salmon River downstream of the North Fork with movement in April and May into tributaries to spawn. It is suspected that spawning in the Clearwater and Salmon River drainages of Idaho occurs from late May to early July in slow riffles or runs with adequate gravel and cobble substrates.

ECOLOGICAL SIGNIFICANCE

Larval Pacific lamprey can represent a large proportion of the biomass in streams where they are abundant, thus making them an important component in processing nutrients, nutrient storage, and nutrient cycling (Close et al. 2002). Adult Pacific lamprey carcasses are a significant contributor of marine derived nutrients to oligotrophic streams as adults (Wipfli et al. 1998; Fisher Wold and Hershey 1999).

Returning adult lamprey are an important part of the food web for many species of freshwater fishes, birds, and mammals. From the perspective of a predatory mammal the adult Pacific lamprey has at least three critical virtues: (1) it is easier to capture than an adult salmon; (2) it is higher in caloric value per unit weight than salmon and, (3) they can migrate in large schools. The lamprey is much richer in fats than salmon. Caloric values for the adult lamprey ranges from 5.92-6.34 kcal/gm wet weight (Whyte et al. 1993); whereas, Pacific salmon average 1.26-2.87 kcal/gm wet weight (Stewart et al. 1983). Similarly ammocoetes ranged from 7.44-7.46 kcal/gm from Snake River basin samples (Cochnauer et al. 2005). Adult lamprey potentially were an important buffer for upstream migrating adult salmon from predation by marine mammals (Close et al. 2002). Roffe and Mate (1984) revealed that the most abundant dietary item in the diet of sampled seals and sea lions was Pacific lamprey. As a result, marine mammal predation on salmonids may now be more significant because Pacific lamprey populations have declined (Close et al. 2002). The ammocoete stage and spawned out carcasses of Pacific lamprey are important dietary items for white sturgeon *Acipenser transmontanus* in the Snake and Fraser rivers (Semakula and Larkin 1968; Galbreath 1979). Wolf and Jones (1989) reported the great blue *heron Ardea herodias* as a predator of spawning adult Pacific lamprey, although in one case the heron died while attempting to consume the prey. The American mink *Mustela vison* are also known to prey on adult lamprey (Beamish 1980).

Larval Pacific lamprey are an important food source for a number of aquatic species as well. Juvenile and larval lamprey migrating downstream may also buffer salmonid juveniles from predation by fishes and birds. Lamprey are fed upon by northern pikeminnow *Ptychocheilus oregonensis* and channel catfish *Ictularus punctatus* in the Columbia River system (Poe et al. 1991). Juvenile lamprey may have played an important role in the diets of many freshwater fishes according to Close et al. (1995a and 1995b). Cochnauer and Claire (2006) found that ammocoetes, despite their low abundance, made up a significant proportion of the diet of northern pikeminnow sampled from the Snake River during the spring outmigration period of salmon and steelhead.

Pfeiffer and Pletcher (1964) found emergent ammocoetes and lamprey eggs were eaten by salmonid fry. Merrell (1959) found that lamprey were 71% by volume of the diet of gulls *Larus spp.* below McNary Dam during early May. River otter *Lutra canadensis* are another predator on Pacific lamprey.

CULTURAL SIGNIFICANCE

Pacific lamprey are an integral part of tribal cultures along the Pacific coast and inland (Anglin et al. 1979; Mattson 1949; Pletcher 1963). Pacific lamprey provided food sustenance, were important for ceremonies, and used for medicinal purposes. Native Americans harvested Pacific lamprey at the mouth of the Snake River and at Wallula on the Columbia River near the mouth of the Walla Walla River (Close et al. 1995b). Swindell (1941) documented testimony of Native American use of Pacific lamprey adults in the main Columbia River during the late 1800s and early 1900s. The Pacific lamprey is still significant in Native American culture (Close et al. 1995b) and they are still harvested in the Willamette and Umpqua rivers in Oregon. In the Snake River basin, Pacific lamprey were harvested by the Nez Perce people from several locations including larger rapids on the mainstem Snake River in Hells Canyon where they congregated on larger rocks. Asotin Creek named by the Nez Perce means “Place of the eel.” This stream enters the Snake River about 6 km upstream from the confluence of the Snake and Clearwater rivers.

SOCIETAL SIGNIFICANCE

Pacific lamprey were valued not only by Native Americans but European settlers as well in the Pacific Northwest. Fur trappers seeking coyote utilized lamprey as bait in the early days (Mattson 1949). In the early 1900s, the State of Oregon began developing artificial propagation of salmonids where fish culturists found that ground raw Pacific lamprey was an ideal feed for young salmon. A commercial fishery for lamprey developed and ran from 1941 through 1949 on the Willamette River at Willamette Falls. From 1943 to 1949, a total of 816 tons of lamprey were harvested (Close et al. 1995a) and estimated to be between 10 to 20 percent of the total run. The primary use of the fish was for vitamin oil, as a protein supplement for livestock and poultry, and for fish meal (Mattson 1949). Presently, Pacific lamprey are important for medicinal research, for teaching specimens, and for food for both Native Americans and non-tribal Americans.

In recent times juvenile and larval forms have been preferred bait items for sport fishermen seeking white sturgeon and other game fish species. As late as the 1980s some anglers used lamprey ammocoetes to fish for sturgeon in the Hells Canyon reach of the Snake River. However, adult Pacific lamprey in Idaho did not receive the level of harvest attention by European settlers as salmon and steelhead species partly due to their elusive nature and pattern of largely migrating at night.

DRAINAGE DESCRIPTIONS

Clearwater River Drainage

The Clearwater River drainage is located in north central Idaho and encompasses approximately 2.5 million ha (Figures 1 and 2). It is a region of mountains, plateaus, and deep canyons within the Northern Rocky Mountain geographic province. Although basalt outflow and intrusions affect the water chemistry of tributary streams in the middle and lower Clearwater River drainage, parent material in the three largest subwatersheds (Lochsa River, Selway River, and South Fork Clearwater River) is predominantly granitic geology (Ecovista 2003a) which is largely devoid of many of the primary nutrients necessary for high stream productivity. Much of the drainage is forested. Hydrology of the drainage is driven by winter snow and rain, with streamflows generally peaking in late May and early June during snowmelt. The drainage is bordered by the Salmon River drainage to the south and St. Joe River drainage to the north (Ecovista 2003a). The major tributaries which are either known or believed to have historically supported Pacific lamprey include the Potlatch, South Fork Clearwater, North Fork Clearwater, Middle Fork Clearwater, Selway, and Lochsa rivers and tributaries.

The land ownership of the Clearwater River basin is 58% federal (U. S. Forest Service, Bureau of Land Management, other), State of Idaho (6.0%), private timber company (8.0%), Nez Perce Tribe (4.0%), and private (24.0%). Land use in the Clearwater River drainage is primarily agricultural or livestock grazing in the lower and central basin and forestry related in the headwater reaches.

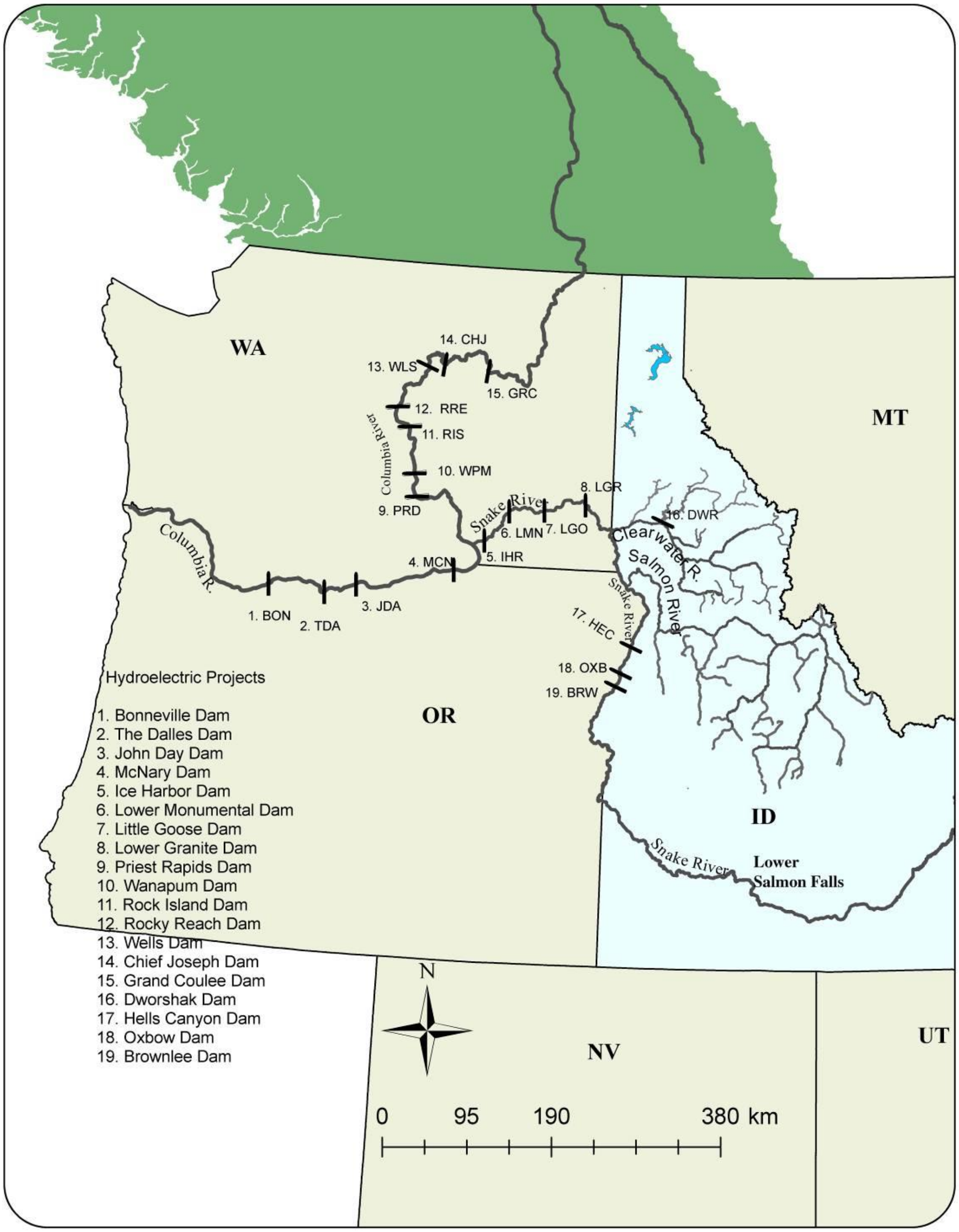

Figure 1. Salmon and Clearwater River drainages in Idaho with Lower Snake River and Columbia River basin hydroelectric facilities.

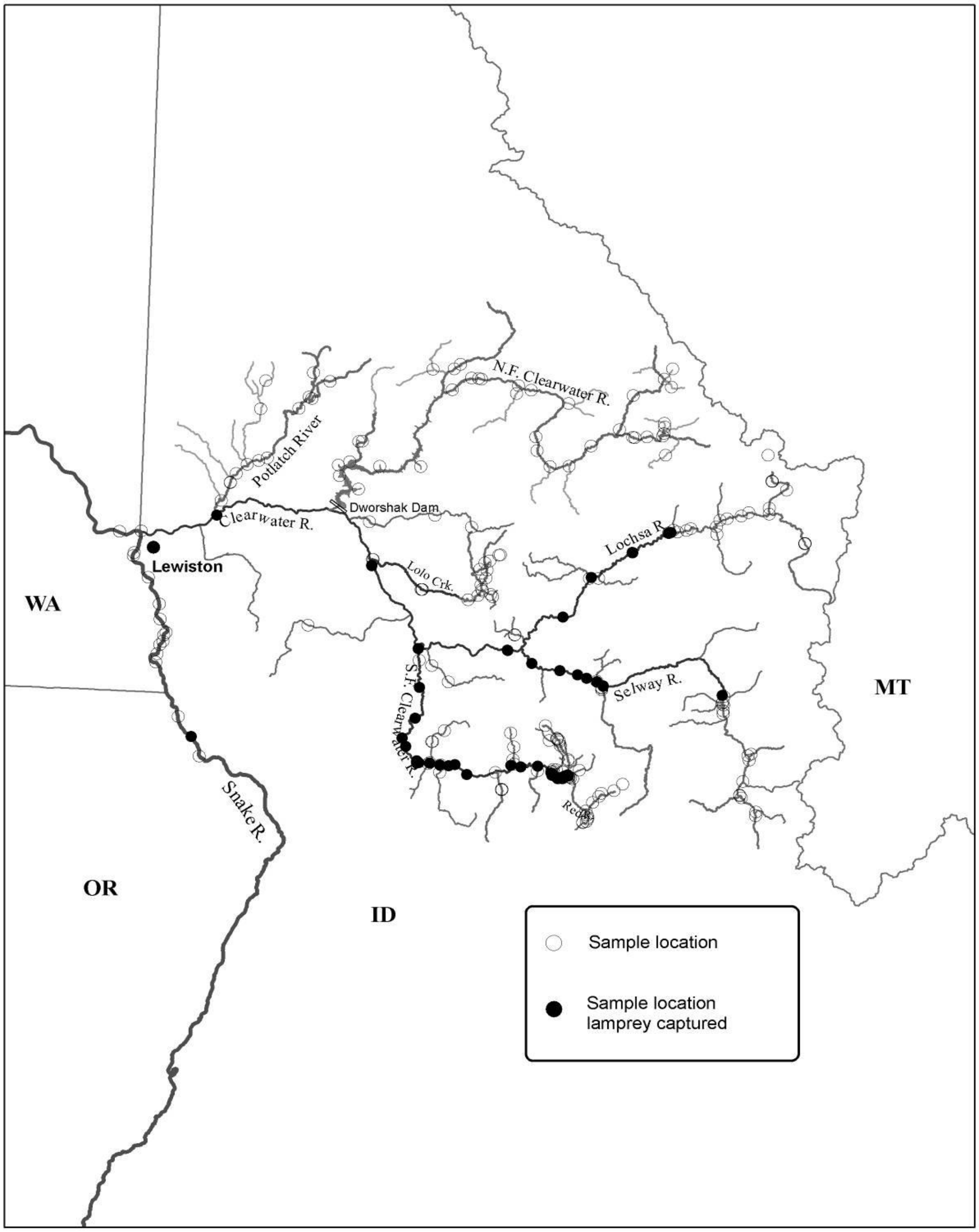

Figure 2. Locations sampled and Pacific lamprey distribution in the Clearwater River drainage, Idaho, 2000-2006. Open circles indicate sample locations and closed circles indicate sites of ammocoete observations.

The North Fork Clearwater River Drainage is 631,957 ha in size. The watershed was already actively managed for timber extraction activities when Dworshak Dam was constructed in 1972 eliminating anadromous access to the drainage. However, redd surveys documented abundant B-group annual steelhead spawning runs in the watershed prior to impoundment. Pacific lamprey were captured in the Weitas Creek watershed (Keating 1958) and Cayuse Creek prior to1972.

The South Fork Clearwater River drains into the Middle Fork Clearwater River at rkm 120.2. Extensive mining from the 1860s to the mid-1900s occurred in four South Fork Clearwater River tributaries: Crooked River, Red River, American River, and Newsome Creek (discussed in detail later). Other major South Fork Clearwater River tributaries which likely historically supported Pacific lamprey populations include Meadow Creek, Crooked River, and American River. As of 2007, Pacific lamprey were present in Red River and the South Fork Clearwater River.

The Lochsa and Selway River watersheds have had a lesser degree of anthropogenic impacts to fish habitats in comparison to the North Fork Clearwater and South Fork Clearwater River. The Selway River watershed (discussed in detail later) is largely in federally designated wilderness. Timber harvest has played a role in shaping the current hydrology of the Lochsa River watershed, but reductions in harvest on federal lands in recent years has provided for initial stages of recovery in many of the watersheds historically impacted.

Hydroelectric project development in the Clearwater River drainage impacted salmon, steelhead, and Pacific lamprey populations. The Lewiston Dam, consisting of one spillway section and the powerhouse section was constructed by Pacific Power and Light in 1927 at Clearwater River rkm 4.6 and provided power to the Potlatch Timber Corporation Mill. The dam was originally constructed with two upstream passage ladders, but due to a flawed engineering design obstructed steelhead and salmon passage. During 1927-1940, the period when the problem was detected and reconstruction efforts to the ladders corrected the problem, spring Chinook salmon and fall Chinook salmon populations were reduced to remnant numbers and subsequently never recovered to any degree (White 1954). However steelhead, likely due to their extended time in the river prior to spawning, managed to annually pass the ladder in numbers sufficient to maintain stock(s) in the Clearwater River drainage. The impacts of the Lewiston Dam to Pacific lamprey downstream migrants and upstream migrating adults are unknown. However, upstream migrant fish counts at the project documented the continued presence of adult Pacific lamprey returning to the drainage. Removal of Lewiston Dam in 1972 facilitated restoration of unobstructed upstream and downstream passage into the Clearwater River drainage.

Dworshak Dam was constructed in 1972 on the North Fork Clearwater River (rkm 3.1) without provisions for upstream passage. This dam has a height of 219 m and a crest length of 1,002 m. The hydraulic effectiveness (depth of the pool at the dam face) is 193 m. This creates a condition where water flow, even during spring periods, is relatively imperceptible throughout major sections of the 80+ km long pool, which make it unlikely juvenile anadromous fish species could have successfully migrated downstream in great enough numbers to sustain populations upstream of the project even if adults could navigate over the project and spawn in tributary streams. There have been a number of situations in the past 60 years in the Pacific Northwest where this has been the case including the Snake River following the construction of Brownlee Dam and in the Deschutes River drainage, Oregon following the construction of Round Butte Dam. Anadromous salmon, steelhead, and Pacific lamprey populations upstream of Dworshak Dam are now considered extirpated, although it is possible some degree of residualization has occurred with steelhead trout.

Harpster Dam was 10 m in height and 17 m in width, when constructed in 1910 on the South Fork Clearwater River. This project blocked upstream fish migration during 1910-1934 and 1949-1963, however, impacts relating to Pacific lamprey are unknown. Originally built without a fish ladder, wooden ladders were constructed and upstream passage was possible, although limited, over the dam from 1935 to 1949. High flows destroyed the fishway in 1949 eliminating adult salmonid passage (but likely not Pacific lamprey) until the dam was removed in 1963. Adult Pacific lamprey passage may have occurred during this entire period as the species has the ability to climb for notable distances above water surface levels on wetted generally smooth concrete. It is likely removal of Harpster Dam resulted in the recolonization of the South Fork Clearwater River drainage.

Salmon River Drainage

The Salmon River basin is the largest watershed (3,652,850 ha) in the Snake River basin without major obstruction of anadromous access to and from the Pacific Ocean (Figures 1 and 3). Similar to the Clearwater River drainage, the majority of the Salmon River drainage is comprised of relatively high mountainous landforms serrated by deep canyons. Geology is granitic, across notable portions of the drainage, which results in a number of low productivity stream systems, however, in the eastern half of the drainage, varying geologies contribute greater nutrient loading to the tributaries and mainstem Salmon River. One watershed, the Lemhi River system, is commonly considered of very high productivity and historically supported abundant spring Chinook salmon returns (Ecovista 2004). Streamflow is derived primarily from snow melt and rains, with peak flows generally in late May and early June. The largest tributary, the Middle Fork Salmon River, largely originates and flows through a portion of the Frank Church River of No Return Wilderness which is 849,858 ha in size, encompassing 23.3% of the Salmon River drainage. Other major tributaries include the Yankee Fork, South Fork, Lemhi, Pahsimeroi, Little Salmon, and East Fork. The land ownership of the Salmon River basin is 82% federal (USFS 75.6%, BLM 6.8%) 17.0% private, State of Idaho (0.5%), and 0.1% other.

The Salmon River originates in the Sawtooth Mountains near Stanley, Idaho and flows predominantly north to Salmon, Idaho and then west/northwest for a total distance of 660 km meeting the Snake River at rkm 304. Hydroelectric impoundments on major Salmon River drainage streams have been limited to two sites, the mainstem Lemhi River diversion structure near the town of Salmon, Idaho and Sunbeam Dam upstream of the Yankee Fork of the Salmon River. Although there has been offsite tributary hydropower developments on smaller streams in the drainage, these two dams currently play little role in impacting fish habitats. The Lemhi River power diversion structure constructed in 1911 was a low head structure (less than 5 m in height) with an upstream passage ladder. Although the dam had an upstream passage ladder, the project obstructed anadromous fish passage to varying degrees, for upstream migrants because of irregular dewatering downstream of the diversion. The main river flow was diverted to the location of the powerhouse which was located several kilometers to the northwest of the diversion point on the Lemhi River. There the outflow was discharged into the main

Salmon River several kilometers below the confluence of the dry Lemhi River channel and the mainstem Salmon River. Anadromous fish were attracted to the Lemhi River flow discharging from the power plant rather than continue up the main Salmon River to the dewatered Lemhi River channel. However, at the powerhouse fish were unable to move through the turbines of the powerhouse into the diversion channel above and eventually into the Lemhi River. The diversion dam was eventually removed (date unknown) and while Chinook salmon were impacted, the hydropower plant diversions affects to Pacific lamprey in the Lemhi River drainage are unknown.

In 1910 the Sunbeam Consolidated Gold Mines Company constructed a hydroelectric power plant on the mainstem Salmon River immediately upstream of the Yankee Fork of the Salmon River to supply power to the Sunbeam mine and gold ore crushing mill. The structure was 10.7 m in height and spanned 29.0 m. Construction of a wooden upstream passage ladder was completed in 1911; however, the passage efficiency of the ladder was questionable. In April 1911, the Sunbeam mine and mill were closed due to limited value of the ore extracted from the mine. In 1920 a concrete ladder was constructed and sockeye salmon *Oncorhynchus nerka* passage was documented several years during 1920-1929, but from initial construction in 1920 until 1934, salmonid passage over the structure was less than desirable and upper mainstem Salmon River anadromous stocks were impacted significantly. In 1934 the Sunbeam Dam was partially obliterated through the use of explosives to improve upstream migrant anadromous fish passage. Pacific lamprey passage likely occurred to a limited degree from 1911 to 1934 through the fishway and river tunnel that was used to facilitate dewatering of the channel during construction and reopened following use of the project.

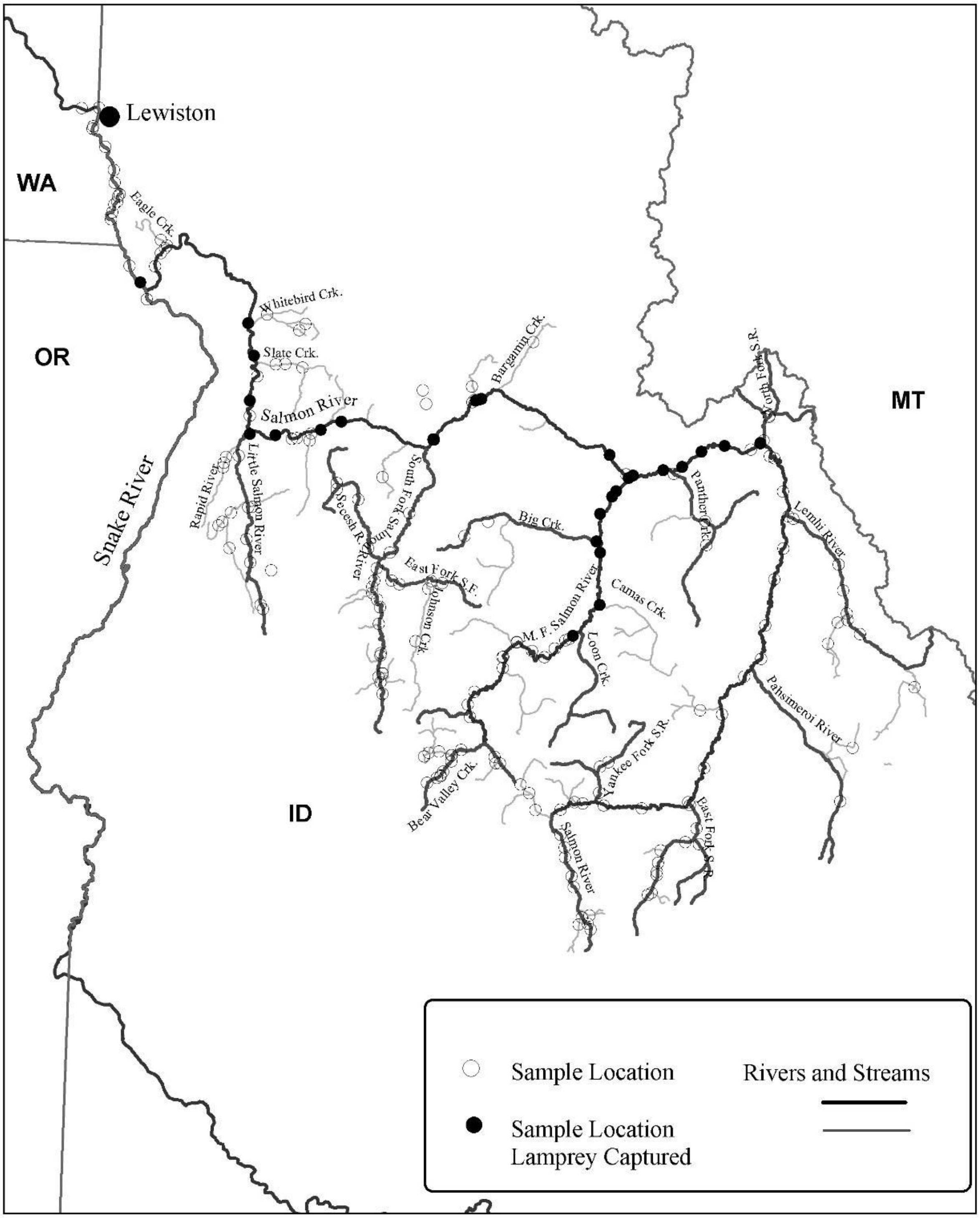

Figure 3. Locations sampled and Pacific lamprey distribution in the Salmon River drainage, Idaho, 2003-2006. Open circles indicate general sample locations and closed circles indicate sites of ammocoete observations.

Current land use activities in the Salmon River basin are predominantly livestock grazing in the lower basin, Pahsimeroi, East Fork Salmon, and Lemhi river watersheds, with forestry in the timbered habitats throughout the drainage. In the South Fork Salmon River, timber harvest, road construction, and subsequent road mass wasting failure, severely impacted production of summer Chinook salmon from 1965-1980s and the legacy effects continue today. Mining in the lower and mid-reaches of the Salmon River basin was initiated in the 1860s utilizing primarily hydraulic placer, rocker, and sluice methods. During 1920-1960 the Warren Creek and Yankee Fork Salmon River drainages were extensively mined with bucket dredges resulting in severe stream channel degradation. Large-scale open pit gold mining has also occurred in several tributaries of the headwaters of the South Fork and Middle Fork Salmon rivers.

There are more than 500 irrigation diversions located primarily in the upper Salmon River drainage upstream of the Middle Fork Salmon River. Almost half of the diversions and associated ditches have screening to prevent entrainment and allow passage of downstream salmonid migrants. Even though the construction of 'fish friendly' passage routes through or around these diversion dams and ditch networks has been focused towards salmonids, Pacific lamprey ammocoetes and macropthalmia may have benefited to varying degrees by these modifications; however, this has not been documented.

Snake River Drainage below Hells-Canyon Dam

Note: This document does not address the historical habitat area above Hells Canyon Dam. The mainstem Snake River and tributary streams above this point are no longer accessible to anadromous fish. It is recognized that the loss of these habitats reduced the available Pacific lamprey habitat in the Snake River basin by over 55% compared to historical. However, this document, while understanding the critical importance of these habitats to historical conditions in the basin, focuses on addressing conservation in the remaining accessible habitats downstream of Hells Canyon Dam.

The Snake River-Hells Canyon subbasin includes the mainstem Snake River and the tributaries of the Snake River from Hells Canyon Dam to the mouth of the Clearwater River at Lewiston, Idaho, a length of 175 km (Figure 1). The Snake River forms the border between Idaho and Oregon for 114 km and Washington and Idaho for the lower

61 km. The subbasin below the dam including the mainstem Snake River and minor tributaries incorporates 223,302 ha. Geology of the subbasin is of various forms, with largely basaltic parent material directly along the mainstem Snake River for much of the reach. Streamflow is generated predominantly from winter snowmelt and rain. About 62% of this area lies in Idaho, 31% is in Oregon, and the remaining 7% is in Washington. The Salmon, Imnaha, Grand Ronde, and Clearwater rivers, as well as Asotin Creek, are major tributaries that originate from outside the subbasin and join the Snake River in the Snake River-Hells Canyon subbasin. These rivers drain a combined area of 4,993,505 ha and the high flows, sediment transport, and nutrient loadings of these tributaries have a major influence on the water quality and hydrologic conditions in the Snake River. The Salmon River often accounts for a dominant proportion of the total water volume of the Snake River in the subbasin during April through June.

It is believed that Pacific lamprey were abundant in the Snake River basin above Hells Canyon Dam and the Snake River-Hells Canyon subbasin pre-European settlement. Based on historical distribution of the species, Ice Harbor Dam counts in the 1960s, Lewiston Dam counts, Native American accounts, and other anecdotal information, it is believed that as many as 500,000 adults annually traveled through Hells Canyon before entering spawning tributaries such as the Salmon and Grand Ronde rivers. Gilbert and Evermann (1894) documented Pacific lamprey near Shoshone Falls on the mainstem Snake River, in south central Idaho. Pacific lamprey ammocoetes were documented upstream of the Hells Canyon Hydroelectric Complex (Brownlee, Oxbow, and Hells Canyon dams) in the Owyhee, Weiser, and Boise River drainages prior to the construction of Brownlee Dam (Pratt et al. 2001). Additionally, ammocoetes collected in the Boise, Payette, and Weiser rivers prior to impoundment of the mainstem Snake River in Hells Canyon, are catalogued in the Albertsons College fish collections (Donald Zaroban, Albertson’s College Fish Collection Curator, personal communications). Construction of the Hells Canyon Hydroelectric Complex on the Snake River during the mid 1950s to late 1960s eliminated anadromous fish above Hells Canyon Dam and greatly reduced the accessible drainage area and available anadromous habitat in the Snake River basin.

STATUS

Historic Distribution

The overall distribution of Pacific lamprey in North America is from the Alaska Aleutians south to Baja California (Scott and Crossman 1998) and inland to central Idaho (Hammond 1979a). In Idaho they were found historically in all major river systems where salmon and steelhead occurred including the Snake, Salmon, and Clearwater rivers (Simpson and Wallace 1982). Upstream migration in the Snake River was documented up to Shoshone Falls (Gilbert and Evermann 1894). Pacific lamprey were abundant in the Columbia River basin historically and their use was documented by many early explorers as well as in historical accounts (Swindell 1941).

Current Distribution

Pacific lamprey are in decline in the Columbia River basin (Close et al. 1995b) and the Snake River subbasin (Hyatt et al. 2007) as evidenced by adult counts at Bonneville Dam on the Columbia River, and Ice Harbor and Lower Granite dams on the Snake River (Figures 4, 5 and 6). It is difficult to enumerate Pacific lamprey for several reasons. They tend to move at night when fish counts at dams are not conducted, they are capable of moving past or around the crowder that guides them to the fish counting window thus avoiding the count window, and they can climb vertically on smooth wetted surfaces allowing them to pass upstream undetected. Despite these issues, radio telemetry tracking of adults at both Bonneville Dam and McNary Dam and extensive review of counts by the IDFG has indicated that the same counting issues are likely present for the eight hydroelectric projects downstream of Idaho streams. Resultantly, Pacific lamprey trends show the same consistent pattern at all dams regardless of the differences in counting procedures and data processing among the different monitoring protocols (Close et al. 1995a).

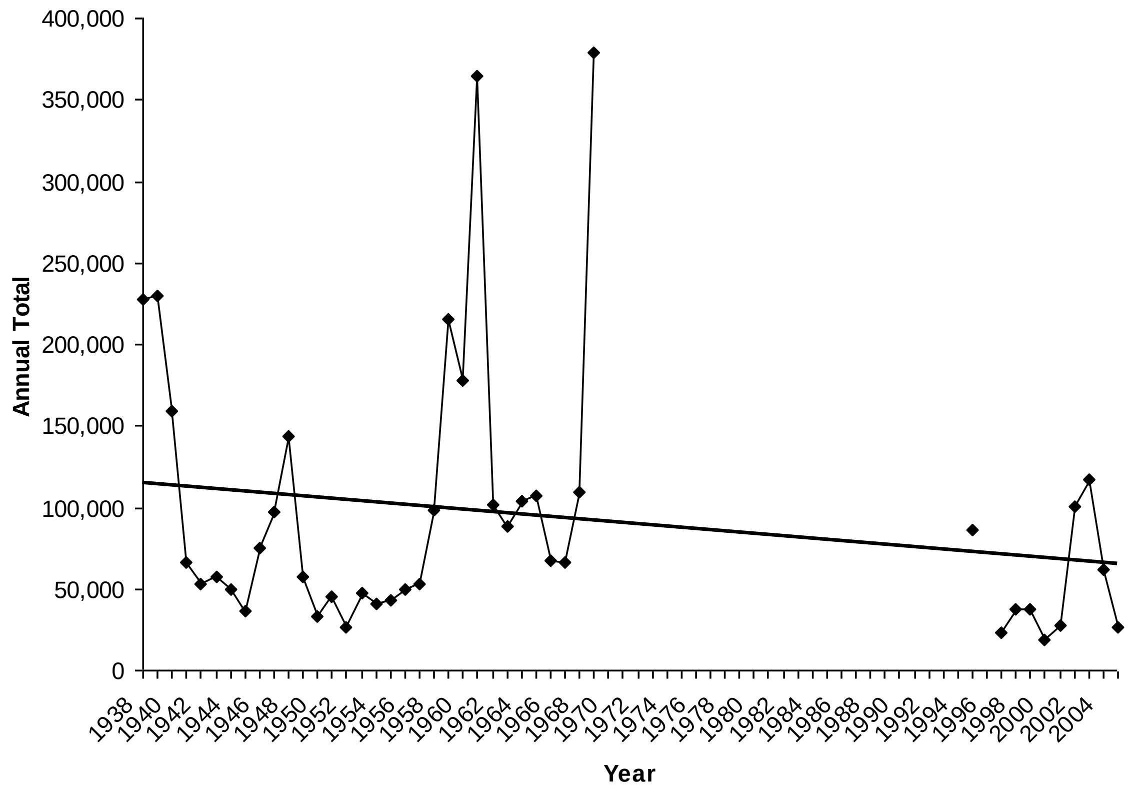

Figure 4. Pacific lamprey adult upstream passage day counts at Bonneville Dam, OR (USACE 2006). Trend line fitted through regression.

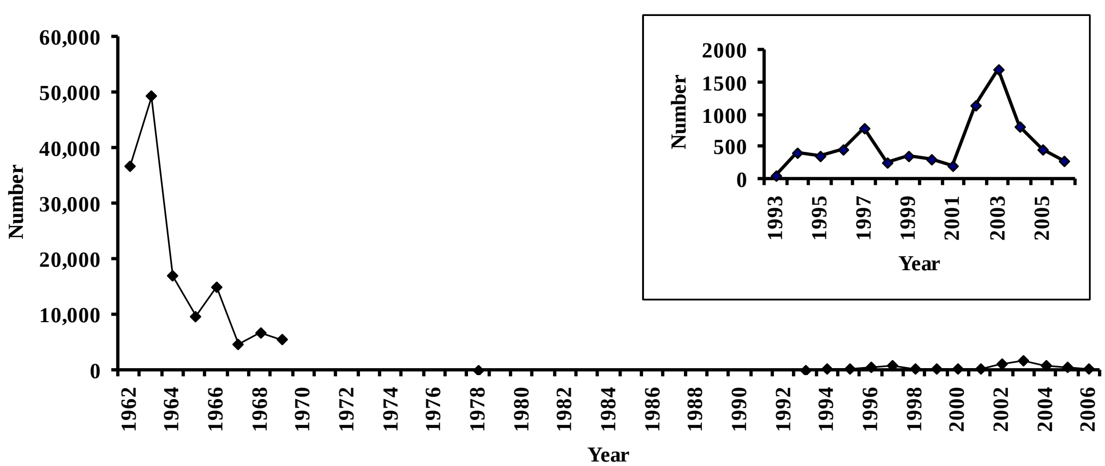

Figure 5. Pacific lamprey adult upstream passage day counts at Ice Harbor Dam, WA 1961-2006 (USACE 2006).

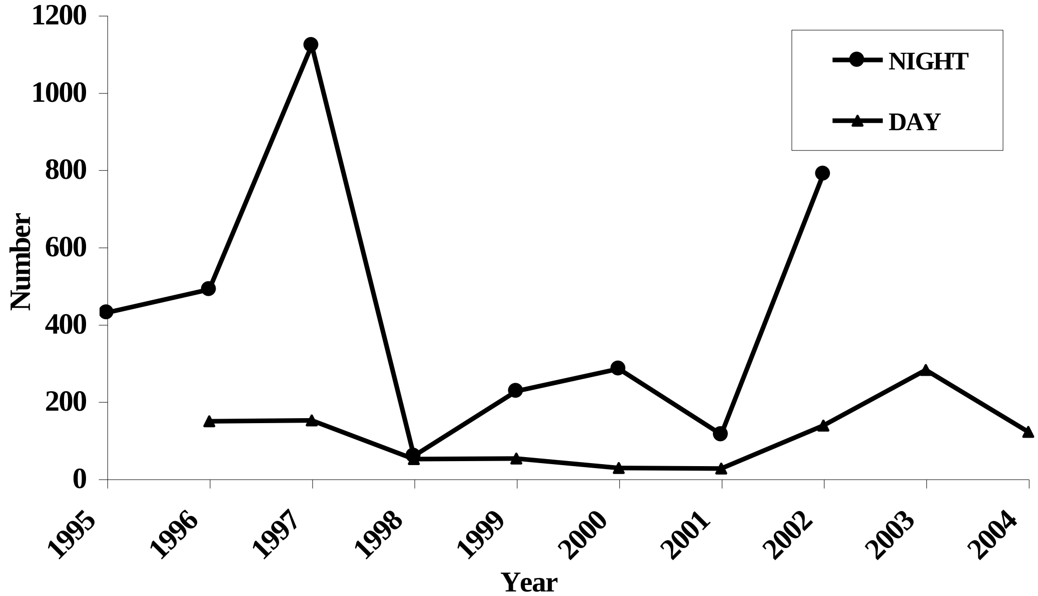

Figure 6. Day and night counts of Pacific lamprey adults passing upstream at Lower Granite Dam, WA. Night counts were discontinued after the 2002 season.

Expert opinions differ as to whether dam counts are precise enough for determining the status of the Pacific lamprey in the Columbia River basin. Close et al. (1995b) state that dam counts can be viewed as trend data, but certainly not total counts because there has been little standardized sampling across the years and counting is often restricted to only daylight hours both during and around months of the main salmonid migration period. Despite these discussions, trend and general abundance relationships correlate very closely across all eight hydroelectric projects between Idaho and the ocean. It is only rarely that an increase or decrease in the total number of upstream migrating adult Pacific lamprey counted at Bonneville Dam is not reflected similarly at the Snake River hydroelectric projects upstream.

<u>Clearwater River Drainage</u>

Potlatch River

The Potlatch River and its tributaries is historically a major producer of anadromous fish within the Clearwater River drainage (Bowersox and Brindza 2006). The river enters the mainstem Clearwater River at rkm 24.3 and the watershed is

189,859 ha in size. Since European settlement the drainage has been impacted by many land use activities including agricultural, logging, and mining practices, which have altered the hydrologic cycle, stream habitat, and riparian habitat within the drainage (Bowersox and Brindza 2006). In the 1970s, Hammond (1979a) readily captured Pacific lamprey ammocoetes in the lower mainstem and East Fork of the Potlatch River which enters the main Potlatch River upstream of Kendrick. University of Idaho staff attempted to capture lamprey in the early 1980s but they were unsuccessful using known methodology. In 2002, 15 sites were sampled by IDFG on the mainstem Potlatch River, Bear Creek, and the East Fork Potlatch River, but no Pacific lamprey were found (Cochnauer and Claire 2003). Hyatt et al. (2007) resampled sites in the mainstem Potlatch River and East Fork Potlatch River in 2005-2006 and again failed to capture any Pacific lamprey. Based on this information and recent surveys, it is believed thatPacific lamprey are extirpated from the Potlatch River watershed.

North Fork Clearwater River

Dworshak Dam was constructed on the North Fork Clearwater River (rkm 3.1) in 1972 and effectively eliminated Pacific lamprey migration into the North Fork watershed which comprised approximately 25% (631,957 ha) of the Clearwater River drainage. There has been extensive road building and logging of the North Fork Clearwater river watershed since the 1940s, but predominantly since 1960. Numerous slope failures in forest clearcuts and mass wasting road failures have occurred in the drainage and remain visible in a number of locations including the Orogrande and Rock Creek subwatersheds.

Keating (1958) documented the presence of Pacific lamprey ammocoetes in Orogrande and Weitas creeks in the North Fork drainage. While conducting research on mountain whitefish *Prosopium williamsoni* in Cayuse Creek in the 1960s, prior to construction of Dworshak Dam, ammocoetes were regularly captured from sand deposits by researchers (Steve Pettit, retired IDFG, personal communications). Wallace and Ball (1978) documented the presence of ammocoetes in Dworshak Reservoir in the 1970s during the first couple of years after the reservoir was filled. Additionally, Melo Maiolie (Idaho Department of Fish and Game, personal communications) captured six ammocoetes in Dworshak Reservoir while trawling for kokanee in 1988-1989, which is sixteen years after the construction of Dworshak Dam. Other species of lamprey have been known to persist in the ammocoete freshwater life-phase for extended periods of time. Based on the potential presence of a residualized population, Cochnauer and Claire (2006) surveyed 31 sites in tributaries of Dworshak Reservoir and 12 sites along the shoreline of Dworshak Reservoir, but failed to find any ammocoetes. Based on these more recent survey efforts, Pacific lamprey are no longer considered present in the North Fork Clearwater River above Dworshak Dam. There are no known populations of Pacific lamprey that have successfully residualized following entrapment behind impoundments in the Pacific Northwest.

Lochsa River

The Lochsa River watershed is the third largest in the Clearwater River drainage with an area of 305,619 ha. Timber harvest activities with associated road construction have impacted the northern half of the watershed since the 1960s. Major slope failures and road mass wasting events remain visible in the Squaw Creek subwatershed. Mining with sluice methods occurred only ephemerally on the banks of the mainstem Lochsa River historically and leave little trace today. Construction of U.S. Highway 12 in the 1960s resulted in the channelization and constriction of the river in a number of locations reducing the amount of pool habitat and increasing streamflow velocities through restricted reaches. Most of the southern subwatersheds in this drainage are within roadless or wilderness areas.

Although there are reports of anglers observing ammocoetes just downstream of the Lochsa River mouth, there is no historical sampling or anecdotal information pertaining to Pacific lamprey presence in the watershed. From 2002-2006, 60 sites were surveyed within the Lochsa River drainage (Cochnauer and Claire 2003, 2004, 2005, 2006; Hyatt et al. 2007) including tributary streams (Brushy Fork of the Lochsa, Crooked Fork of the Lochsa, Warmsprings, Bear, Colt Killed, Squaw, Boulder, and Pete King Creeks). Based on these surveys, the distribution of Pacific lamprey in the Lochsa River drainage is restricted to the mainstem Lochsa River below Weir Creek (rkm 47.9). The presence of smaller length groups (20-30 mm TL) representing young age classes indicate that successful spawning is occurring on an annual or semiannual basis.

Selway River

At 494,688 ha in size, the Selway River watershed is the second largest in the Clearwater River drainage. The majority of the land area resides within the Selway Bitterroot Wilderness Area. While this has provided protection from human impacts, there were several small homestead livestock operations in the watershed historically. Timber harvest activities have impacted only very limited portions of the lower watershed and around homestead sites. Mining occurred at locations throughout the system, but was nearly all small scale sluice activities with little to no legacy impacts.

There is very little historical information identifying Pacific lamprey presence in the Selway River drainage. However, IDFG fisheries personnel report observing ammocoetes in the mainstem Selway River in the late 1960s while constructing hatching channels for spring Chinook salmon near the mouth of Indian Creek. From 2002-2006, 33 sites were sampled in the mainstem Selway River and 15 sites total in the following tributaries: Bear Creek, Deep Creek, Ditch Creek, Elk Creek, Whitecap Creek, and Gedney Creek (Cochnauer and Claire 2003, 2004, 2005, 2006; Hyatt et al. 2007). Based on these efforts, the current distribution of Pacific lamprey in the Selway River drainage is assessed as being limited to the mainstem Selway River from Bear Creek (rkm 126) to the mouth. The presence of smaller length groups (20-30 mm TL) representing young age classes indicates that successful spawning is occurring on an annual or semiannual basis in the Selway River watershed.

South Fork Clearwater River

The South Fork Clearwater River watershed is 300,440 ha in size and the 4th largest in the Clearwater River drainage. Harpster Dam, constructed in 1911, just upstream from the town of Harpster, Idaho, was originally built without a fish ladder. The project eliminated steelhead and Chinook salmon runs in the watershed, but Pacific lamprey likely managed to scale over the wetted surface of the concrete spillway sill during periods of high flow. Road construction, predominantly associated with timber harvest activities in the watershed has been extensive; however, the degree of impact to anadromous production potential in the basin is unknown. Construction of the main Kooskia to Elk City highway involved the engineering of the road along the mainstem South Fork Clearwater River for nearly its entire length. The river was pushed away from the road side of the canyon wherever necessary and many miles of floodplain, pool habitat, and edge area were impacted by road fill and channelization. Gold mining occurred from 1860 to the present. In the late 1800s widespread sluice and placer mining occurred in the watershed. Large escarpments remain where tens of thousands of cubic meters of material were washed from hillsides hydraulically and run through sluice boxes to separate the gold from lighter sediments. Much of the finer material from these placer sites reached major anadromous spawning and rearing sites. In the 1930s-1960 bucket dredging occurred in the Newsome Creek, Crooked River, American River, and Red River subwatersheds. Dredge operations caused altered floodplains and stream channels through direct channelization of the stream, confinement of the stream with large extracted and redeposited tailings, and introduction of unconsolidated (free to move) material into the hydraulically active zone. Currently the productive potential of Newsome Creek, American River, but especially Crooked River remains impacted by these past bucket dredge activities. Extensive habitat improvements and mining reclamation efforts in the last 25 years by the U.S. Forest Service, BLM, and others have improved the habitat condition in Newsome Creek, Red, American, and Crooked rivers.

There is no historical information from sampling or anecdotal observations of Pacific lamprey in the South Fork Clearwater River drainage. Some Nez Perce tribal elders suggest that Pacific lamprey were present in the watershed historically. From 2000-2006, 150 sites were sampled in the South Fork Clearwater River drainage including the mainstem South Fork Clearwater River and the following tributaries: American River, Red River, Crooked River, John’s Creek, Leggett Creek, Little Elk Creek, Meadow Creek, Mill Creek, Newsome Creek, Ten Mile Creek, and West Fork American River (Cochnauer and Claire 2001, 2002, 2003, 2004; Cochnauer et al. 2005; Cochnauer and Claire 2006; Hyatt et al. 2007). Based on these surveys, the current distribution of Pacific lamprey in the South Fork Clearwater River drainage is restricted to the mainstem and the lower 7.5 km of Red River. The presence of smaller length groups (20-30 mm TL) representing young age classes indicate that successful spawning is occurring on an annual basis or every few years. However in Red River the absence of length groups less than 160 mm TL clearly indicates that spawning has been extremely limited or nonexistent for a number of years. Pacific lamprey were documented in Newsome Creek, another tributary of the South Fork Clearwater River as recently as 2002 (Sprague and Johnson 2004), but it appears this population has been extirpated as no ammocoetes or macropthalmia have been captured since 2002 and subsequent IDFG efforts (Cochnauer and Claire 2006) failed to capture any lamprey. Currently suitable habitat does not appear to be a limiting factor in the South Fork Clearwater drainage as a notable number of reaches of the American River, Red River, and Newsome Creek have fair to good quality habitat despite extensive reaches of degraded habitat.

Middle Fork Clearwater River

The Middle Fork of the Clearwater River is a mid length reach between the confluence of the Lochsa and Selway Rivers and the North Fork Clearwater River. Although extensive roading and timber harvest has occurred in the major tributaries which empty into this reach, the river itself is sparsely timbered for much of its distance and thus impacts have been due to other causes. Construction of U.S. Highway 12 caused constriction of the floodplain in some sections.

Historically the mainstem Middle Fork of the Clearwater River likely provided important rearing habitat for ammocoetes, but not critical for spawning. There are large areas of softer substrate deposits interspersed with boulders in this reach currently which provide good to excellent ammocoete rearing habitat. There are anecdotal reports from anglers documenting collection of ammocoetes for bait in this reach of river during the 1960s and 1970s. In 2002-2006, Pacific lamprey ammocoetes were collected from sites sampled in the mainstem Middle Fork Clearwater River. While, a number of tributaries (Clear, Eldorado, Lawyers, Lolo, Musselshell, and Orofino creeks) were sampled, no Pacific lamprey were collected. Based on these surveys the current distribution of Pacific lamprey in the Middle Fork Clearwater River is restricted to the mainstem. While it is unclear if lamprey spawn in the mainstem Middle Fork, it is evident that ammocoetes utilize this reach for rearing.

Lolo Creek

Lolo Creek flows into the Middle Fork Clearwater River at rkm 87.1. The watershed drains a total of 62,937 ha. Land use activities in the watershed have primarily been forestry related, with livestock grazing in the Musselshell Creek subwatershed. Pacific lamprey utilized this watershed historically as Hammond (1979b) captured lamprey in the late 1970s. Nez Perce Tribal Fisheries (NPTF) rotary screen trapping efforts captured a total of 496 Pacific lamprey ammocoetes and macropthalmia during the period 1994-2003. No Pacific lamprey were captured in 2003-2006 with electrofishing of 15 sites in Lolo Creek, Musselshell Creek, and Eldorado Creek (Cochnauer and Claire 2004, 2006). Based on the decline over time, current absence of ammocoetes and macropthalmia in NPTF's rotary screen trap, and with the failure to capture them in IDFG electrofishing surveys, there is near certainty Pacific lamprey are no longer present in the Lolo Creek watershed. Surveys by IDFG have indicated that there is abundant suitable or good quality habitat remaining in this watershed.

Mainstem Clearwater River

The mainstem Clearwater River (the reach from the North Fork to the confluence with the Snake River) was undoubtedly important for rearing ammocoetes. Although the construction of U.S. Highway 12 restricted and or partially channelized sections of this reach of river, the size of the river and channel complexity for much of its extent has remained. Timber harvest has played little role in directly impacting this reach, however, sediment inputs from logging and agriculture practices in tributary watersheds has influenced water quality. Flow management strategies at Dworshak Dam affect the streamflow and temperature regimes in the lower reach of river; however, the impacts to Pacific lamprey are currently unknown.

In 2002, a total of seven ammocoetes were collected in the mainstem Clearwater River from one location (Cochnauer and Claire 2003). The same site was sampled again in 2006 but no lamprey were captured. The mainstem Clearwater River currently serves as a primary migration route for adult Pacific lamprey to access upstream spawning areas, and as a rearing area for ammocoetes and macropthalmia. It is unclear if adults spawn in the mainstem Clearwater River or if the presence of juveniles is a result of their downstream migration from drainages upstream. As long as there is lamprey production in Clearwater River tributaries, the mainstem Clearwater River will continue to serve as a rearing area for juveniles that have migrated downstream.

Salmon River Drainage

Mainstem Salmon River

Gilbert and Evermann (1894) documented lamprey adults in the Salmon River drainage upstream to Alturas Lake. Ammocoetes were observed when the Salmon River was dewatered in the late 1970s at the town of Salmon to place a water line (Kent Ball, retired IDFG, personal communications.). Hammond (1979a) documented Pacific lamprey ammocoetes in the Salmon River at the town of Salmon, Idaho. Electrofishing surveys of 74 sites in 2004-2006 in the mainstem Salmon River and minor tributaries in the Salmon River drainage suggest Pacific lamprey are no longer present in any tributary to the Salmon River except for the Middle Fork Salmon River (Cochnauer et al. 2005; Cochnauer and Claire 2006; Hyatt et al. 2007). In 2005-2006, sampling efforts documented Pacific lamprey in the Salmon River upstream to the North Fork Salmon River at rkm 381.4 (Cochnauer and Claire 2006; Hyatt et al. 2007). The presence of smaller length groups (20-30 mm TL) representing young age classes indicates that successful spawning is occurring on an annual basis or every several years below the North Fork Salmon River.

Middle Fork Salmon River

The Middle Fork of the Salmon River is the largest tributary to the Salmon River. It drains a land area of 732,967 ha and enters the mainstem Salmon River at rkm 319.5. The majority of this land area is under wilderness management and as such has limited impacts from human activities.

There is some historical anecdotal information from various agency and non-agency sources (rafting outfitters) documenting the presence of lamprey ammocoetes in this watershed upstream as far as Marsh Creek. In 2004-2006 47 sites in the Middle Fork Salmon River and its tributaries (Bear Skin, Bear Valley, Big, Cache, Camas, Cape Horn, Elk, Marsh, North Fork Elk, and Pistol creeks) were sampled (Cochnauer and Claire 2006; Hyatt et al. 2007). Based on these efforts, the current distribution of Pacific lamprey in the Middle Fork Salmon River watershed is restricted to the mainstem from the mouth upstream to rkm 78.7, which is just upstream of Loon Creek. The length frequency analysis of individuals captured in the Middle Fork Salmon River has shown an incremental increase in length of minimum length groups from 2005 to 2006; however, only future sampling will confirm any shift to older age groups, which would indicate a lack of spawning. Habitat conditions in the Middle Fork Salmon River watershed remain in the good to excellent range for lamprey production.

South Fork Salmon River

The South Fork Salmon River originates just to the southwest of Warm Lake. Running north into the mainstem Salmon River at rkm 225.1, it drains 336,699 ha. A notable portion of the northern drainage is under wilderness designation or relatively uninhabited; however, summer home/resort development is fairly widespread around Warm Lake in the headwaters of the South Fork Salmon River. Placer and sluice mining has occurred in a number of locations throughout this watershed including notably the Yellowpine area and along the mainstem South Fork Salmon River. Open pit mining has occurred in the East Fork South Fork Salmon River headwaters and historically transport of sediments from these operations to the East Fork South Fork Salmon River was commonly observed. Timber harvest has only occurred in a relatively limited section of the South Fork Salmon River watershed; however, several large slope failures associated with road construction resulted in deposition of substantial volumes of sediment in the mainstem in the 1960s. The potential impact of this sediment deposition to lamprey is unknown. Hammond (1979b) captured Pacific lamprey ammocoetes in the Stolle Meadows reach of the South Fork Salmon River in 1979 and Forest Service fisheries personnel documented Pacific lamprey ammocoetes as recently as the mid- or late- 1980s while attempting to dredge sediments deposited from road failures out of the mainstem South Fork Salmon River channel. In 2004 and 2006, IDFG sampled 28 total sites in the South Fork Salmon River, Secesh River, East Fork South Fork Salmon River and tributaries (Buckhorn, Trail, Warm Lake, Cabin, and Johnson creeks) and did not capture any lamprey. Based on sampling efforts in 2003-2006, Pacific lamprey are probably no longer present in the South Fork Salmon River or at extremely low densities. There is a large amount of fair to good quality habitat remaining in the South Fork Salmon River watershed for lamprey production.

Little Salmon River

The Little Salmon River originates immediately south of New Meadows, Idaho. The watershed is 149,183 ha in size and the river drains north to join the mainstem Salmon River at rkm 139.5. The two most significant human-related impacts on this system have been livestock grazing and construction of U.S. Highway 95/55. The upper basin exhibits numerous miles of degraded stream channel associated with impacts to the riparian community from livestock use since the late 1800s. Engineering of Idaho State Highway 95/55 resulted in construction of the road immediately adjacent to the stream for much of the lower river. The stream channel was constricted or channelized extensively, but perhaps the greatest impact has been the steady annual recruitment of material from cut slopes into the main channel. During flood stage events, sediment recruitment is maximized and the resultant deposition and scour changes the channel morphology of the Little Salmon River regularly.

The IDFG has no information documenting Pacific lamprey utilization of the Little Salmon River watershed historically. There is a series of barrier waterfalls approximately 7 km upstream of Hazard Creek which are sufficient to block salmon and steelhead passage, although there are differing reports on whether or not they prevented salmon and steelhead from reaching the upper basin historically. These waterfalls would pose little if any barrier to Pacific lamprey.

In 2003-2006 12 sites were sampled in the Little Salmon River and the major tributaries including Hard Creek, Hazard Creek, Mud Creek, Big Creek, Rapid River, and Goose Creek. No lamprey were collected or observed through these efforts (Cochnauer and Claire 2004, 2005, 2006; Hyatt et al. 2007). There is sufficient fair quality habitat in the upper basin of the Little Salmon River for Pacific lamprey production, however, the reaches below Hazard Creek are considered poor quality habitat due to channel instability and the lack of pools.

North Fork Salmon River

The North Fork Salmon River runs into the mainstem Salmon River at rkm 381.6. With a drainage area of 55,426 ha, it is one of the smaller drainages of the Salmon River basin. Timber harvest, livestock grazing, and mining have all played some role in altering the habitat in the North Fork Salmon River; however, it retains a significant amount of intact habitat suitable for Pacific lamprey.

Historical documentation of Pacific lamprey in the watershed is limited to reports from IDFG that indicate lamprey ammocoetes were routinely observed in large numbers in front of irrigation diversion screens (Kent Ball, IDFG retired, personal communications). The IDFG sampled three locations in the drainage in 2005 and did not capture or observe any lamprey. Pacific lamprey are considered extirpated from this drainage.

Lemhi River

The Lemhi River is largely a spring fed stream that runs northwest in the valley between the Beaverhead and Lemhi mountains. The Lemhi River enters the mainstem Salmon River at the town of Salmon, Idaho at Salmon River rkm 416.0 and has a drainage area of 328,929 ha. The primary land usage in the Lemhi River drainage is livestock grazing and irrigated agriculture. Water rights for the mainstem Lemhi River exceed the baseflow of the stream and historically the lower reaches of the river were nearly or completely dried up in the late summer. Changes in irrigation practices (conversion to sprinkler systems), actions to consolidate diversions, and better water management have ameliorated low flow conditions somewhat. Major tributary streams feeding the Lemhi River are dewatered during summer months upstream of their confluence with the Lemhi River with the lone exception being Hayden Creek.

Historically the Lemhi River was one of the most productive Chinook salmon streams in the Salmon River drainage. The Lemhi River dam had a major impact on spring Chinook salmon attempting to enter the river, however, the dam was a low-head diversion structure with a passage ladder and the main impact to both salmon and lamprey was dewatering of the stream channel downstream of the project. Timber management and mining have played only very limited roles in impacting the habitat of the Lemhi River. Currently a major factor impacting Chinook salmon is the irrigation season utilization of the peak flows during the spring high flow period, which effectively prevents above bank full flows (high flows) in the upper Lemhi River reaches where spawning occurs. The result is that essentially since the 1950s sediments that historically were flushed out of the system have not been removed from the stream channel and are now embedded into streambed gravels impacting redd construction and egg survival (Thomas Curet, IDFG, personal communications). It is unknown if this has contributed to the current status of Pacific lamprey in the watershed. Direct removal of riparian forests and grazing impacts to the riparian communities over the long-term in the watershed have reduced streambank stability, contributed to increased stream temperatures, and resulted in increased sediment loads.

Historically, Pacific lamprey were very abundant in the Lemhi River system. Thousands of ammocoetes were observed at irrigation diversion screens where water was diverted into ditch systems in the late 1950s. The IDFG sampled 10 sites in 2005-

2006 in the mainstem Lemhi River and tributaries, but were unable to capture any lamprey ammocoetes or macropthalmia. Additionally, it has been a number of years since lamprey ammocoetes have been observed in the 60+ irrigation diversion screening systems along the mainstem Lemhi River. Pacific lamprey are considered extirpated from the Lemhi River drainage. Improvements in irrigation management in the watershed are currently beginning to benefit spring Chinook salmon. Suitable habitat in fair to good condition for lamprey production remains in many reaches of the mainstem Lemhi River and Hayden Creek.

Pahsimeroi River

Like the Lemhi River, the Pahsimeroi River is a predominantly spring fed stream running northwest between two fault block mountain ranges. It flows into the Salmon River at rkm 489.2 and drains 218,854 ha. The IDFG could not find information identifying Pacific lamprey use of this watershed historically, however, the system is one of the more productive Chinook salmon streams in the Salmon River drainage and there is little reason to suspect that Pacific lamprey were not abundant. Irrigation associated with agriculture and livestock grazing are two of the major factors impacting salmonid production in this watershed. It is also likely that long term alteration of the hydrograph (elimination of very high flows) due to early season irrigation withdrawal has reduced the ability of the system to flush out sediments and clean spawning gravels.

The IDFG sampled this watershed in 2005 and did not capture lamprey. Although there are numerous irrigation diversions on the Pahsimeroi River, there have been no reports from the IDFG screen tending technicians identifying lamprey. It is likely Pacific lamprey are extirpated from the Pahsimeroi River drainage.

East Fork Salmon River

The East Fork Salmon River is a predominantly snowmelt-fed stream entering the Salmon River at rkm 552.0 and draining a land area of 139,859 ha. The major land use in this watershed is livestock grazing. Production of hay for livestock is the primary use of the meadows along the mainstem. The East Fork Salmon River is impacted by the clearing of riparian vegetation and irrigation withdrawals. Spring Chinook salmon continue to utilize this watershed in low numbers. There is no historical information pertaining to Pacific lamprey in this watershed that IDFG has identified. The IDFG sampled 10 locations in this system during 2005 and 2006, but failed to capture any lamprey. Most likely, the East Fork Salmon River supported Pacific lamprey historically and there is relatively abundant habitat for this species remaining in the watershed, primarily in the mainstem East Fork Salmon River but also Reeds Creek. However, Pacific lamprey are believed to be extirpated from the East Fork Salmon River.

Yankee Fork Salmon River

This watershed originates from the Salmon River Mountains and runs into the mainstem Salmon River at rkm 591.1, draining 50,505 ha. There is no documentation of Pacific lamprey having used this watershed historically, however, lamprey were likely present in the mainstem Salmon River in this reach. Although timber management, livestock grazing, and agricultural activities have played only minor roles in impacting the anadromous habitat in this watershed, mining has been the major activity impacting habitat. Placer mining occurred in tributary watersheds in the late 1800s continuing until ore deposits were exhausted in these locations. Beginning in the late 1930s bucket dredge gold mining operations in the watershed were initiated and subsequently excavated the entire stream meadow habitat adjacent to the mainstem Yankee Fork. The substrate under these meadows was especially large and following excavation and deposition into tailings piles the stream has been unable to move and redistribute this material. Currently, the amount of pool habitat is less than desirable and the channel is constricted greatly with little meander. Despite this condition the stream is in secondary stages of recovering from mining and has relatively abundant fair quality habitat available for Pacific lamprey. IDFG sampled six sites in this watershed during 2005-2006, however, no lamprey were captured. Therefore, Pacific lamprey are considered extirpated from the Yankee Fork Salmon River.

Snake River Drainage—Downstream of Hells Canyon Dam

In the late 1800s, Gilbert and Everman (1894) documented Pacific lamprey adults in the Shoshone Falls reach of the Snake River. In the 1950s, IDFG documented lamprey ammocoetes in Brownlee Reservoir. Otherwise, there is little information documenting Pacific lamprey in the Hells Canyon reach of the mainstem Snake River historically. There has been one report of historical tribal harvest of Pacific lamprey adults at the base of one of the major rapids in this section of river, but the exact source of the information is unknown. There have been notable changes in the river flow dynamics including load following flows and instream habitat since the construction of the Hells Canyon hydroelectric complex. Historically this reach of river was utilized by larger ammocoetes (age 3+) for completion of rearing (Claire 2003). The presence of ammocoetes here and their importance to the white sturgeon population likely contributed historically to the overall productivity of the white sturgeon population that was observed when European settlement of the region occurred. In 2002, Pacific lamprey were documented in the Snake River downstream of the mouth of the Salmon River (Cochnauer and Claire 2002). It is likely, however, Pacific lamprey are currently extirpated upstream of the Salmon River, although there are a few minor accessible spawning tributaries to contribute to rearing. IDFG sampled one site upstream of the mouth of the Salmon River in 2002 and did not capture or observe any lamprey; however, further sampling is needed. Between 2002 and 2006 the IDFG sampled 12 locations downstream of the mouth of the Salmon River and captured one ammocoete. Currently the population of Pacific lamprey below the Salmon River likely consists primarily of ammocoetes and macropthalmia migrating from the Salmon River and utilizing the Snake River as rearing habitat. There currently remains usable fair quality habitat in this reach of the Snake River, but the potential for Pacific lamprey is unknown.

Three major factors associated with the Hells Canyon Project potentially impact the quantity and quality of available Pacific lamprey habitat in the Snake River from Hells Canyon Dam to Lewiston, Idaho. These are: 1) the presence of large migration barriers; 2) flow-related alterations in shoreline habitats from project operations; and 3) alteration of the natural hydrograph.

Impoundment of the Snake River has resulted in retention of bedload and finer-sized sediments upstream and within the Hells Canyon Complex reservoirs (Brownlee, Oxbow, and Hells Canyon). Retention of sediment has altered the sediment transport regimes in the Hells Canyon reach contributing to the reduction of finer substrate (sand, silt) deposits upstream of the Salmon River confluence, which Pacific lamprey ammocoetes prefer (Cochnauer and Claire 2001, 2002, 2003; Hammond 1979b; Scott and Crossman 1998). Downstream of the Salmon River, this limiting condition is somewhat ameliorated by Salmon River sediment transport and input. Nevertheless, rearing habitat in this reach is degraded as well.

In Snake River Basin streams exhibiting natural flow regimes, rearing Pacific lamprey ammocoetes are commonly present in shoreline zone habitats with depths of 0.10 m to 1.0 m (e.g., Red River, South Fork Clearwater River, Salmon River)(Cochnauer and Claire 2000, 2001, 2002, 2003). Pacific lamprey ammocoetes rear in stream habitats with depths exceeding 1.0 m, but the rearing patterns in these depths are generally impacted due to the increased streamflow velocity relationships in the deeper zones of stream pools. Shoreline habitats are considered critical for maximum habitat production. Downriver of Hells Canyon Dam, daily peaking operations (load following) commonly dewater 10-20 m horizontally of strategic rearing niches. Generally power peaking operations are considered detrimental to Pacific lamprey rearing habitat and potentially result in increased predation of displaced lamprey attempting to rear in substrates undergoing daily dewatering. The repeated dewatering patterns flush important fine sediments and detritus away from these habitats and render affected substrates uninhabitable.

Downstream movements of Pacific lamprey ammocoetes and macropthalmia primarily occur in the spring months during elevated streamflow and outmigration of macropthalmia to the Pacific Ocean peaks during maximum runoff conditions (Cochnauer and Claire 2003). Reservoir storage and hydropower project operations alter the natural hydrograph of the Snake River by moderating maximum streamflow. The cumulative impacts of impoundments in the Snake River Basin result in significantly reduced spring flows and velocities. As a result, outmigration may be compromised.

Pacific Lamprey Administrative Status

Federal

The Northern Region (R1) of the U. S. Forest Service lists Pacific lamprey as a sensitive species (S) which is defined as “a species for which population viability is of concern as evidenced by significant current or predicted downward trends in population numbers or significant current or predicted downward trends in habitat capability that would reduce a species’ existing distribution”.

The Bureau of Land Management lists Pacific lamprey as a ‘Type 2’ species which is defined as a “species that are experiencing significant declines throughout their range with a high likelihood of being listed in the foreseeable future due to their rarity and/or significant endangerment factors".

The decline of Pacific lamprey has caused significant regional concern regarding the long-term viability and persistence of the species in the Columbia basin. In 1993, the Oregon Department of Fish and Wildlife designated Pacific lamprey at risk of being listed as threatened or endangered. Regionally, the tribes have voiced concern about the decline of Pacific lamprey. In January 2003, the Pacific lamprey was petitioned for listing under the Endangered Species Act. However, no funds were committed in 2003 or 2004 to make a status determination. Subsequently an "intent to sue" was filed in March 2004 for failing to act on the petition and in June 2004 the suit was filed. In January 2005, a "finding of insufficient information to evaluate status" was determined by the Service.

Idaho

In Idaho, Pacific lamprey are considered an S1 species (denoted in the State of Idaho State Wildlife Action Plan as critically imperiled: at high risk because of extreme rarity; often 5 or fewer occurrences; rapidly declining numbers, or other factors that make it particularly vulnerable to range-wide extinction or extirpation) and as such, are listed endangered (IDFG 2006). According to Idaho rules, endangered is defined as any native species in danger of extinction throughout all or a significant portion of its Idaho range. As a state defined endangered species, Pacific lamprey are afforded the following protection: no person shall take or possess those species of wildlife classified as Protected Nongame, or Threatened or Endangered at any time or in any manner.

Nez Perce Tribe

Under TITLE 3, Natural Resources and Environment, Chapter 3-1, Fish and Wildlife of the Nez Perce Tribal code, Pacific lamprey are not listed as either a game fish or threatened or endangered wildlife, so thusly, are termed "unprotected wildlife".

REASONS FOR DECLINE

Since the 1960s, Pacific lamprey numbers have been declining in the Columbia Basin (USACE 2009). There are a number of reasons contributing to the decline of Pacific lamprey in the Pacific Northwest and Idaho. Scientists have attributed the decline to a number of causes including pollution, habitat loss, irrigation, intentional removal, ocean conditions, dredging, chemical poisoning, disease, non-native fishes, predation, and dam passage (Luzier et al. 2009; USACE 2009). Idaho populations of Pacific lamprey must pass eight hydroelectric facilities on the Columbia River and lower Snake River as juveniles migrating downstream to the Pacific Ocean and again as adults migrating upstream to their spawning grounds. Flow velocities in dam passage structures designed for salmonids inhibit the passage of Pacific lamprey adults. Flow regulation with associated annual fluctuations and daily power peaking affects larvae by the dewatering of rearing habitat (Close et al. 2002). Additionally there is increased outmigration time of travel and exposure to predators caused by reduced flows in large reservoir pools. The number of adult Pacific lamprey annually entering the Columbia River (Figure 4) and Snake River basin as counted at Ice Harbor Dam has declined from an average of just over 18,000 per year in 1962-1969, to fewer than 600 per year during 1997-2006 (Figure 5). Lower Granite Dam adult passage counts have dropped from approximately 1,200 in 1994 to less than 250 annually in 2005 and 2006 (Figure 6) (U.S. Army Corps of Engineers 2006). Migration corridor impacts of hydroelectric facilities are considered the primary factors contributing to declines of Pacific lamprey. Dam construction in the Snake River basin reduced habitat accessible to anadromous fish by about 59%. The current distribution of Pacific lamprey in the Clearwater and Salmon River drainages is 40% and 22%, respectively, of the estimated historical distribution documented in 1960.

Pacific lamprey are adept at moving through high velocity reaches of stream. They are able to surmount passage obstacles, such as low waterfalls that often obstruct salmonid passage. The mechanics with which Pacific lamprey navigate through turbulent/high velocity reaches of stream; however, is significantly different from salmon and steelhead. Pacific lamprey use a pattern of attaching to smooth wetted surfaces with their suctorial disc combined with burst swimming and reattachment to move through high velocity reaches. Often movements are at or near the surface of the water and the organisms body is left “surfing” during this burst and reattachment process. In order to attach, burst swim, and reattach, lamprey require smooth, wetted modestly rounded or relatively flat surfaces. At hydroelectric projects, upstream passage ladders and fishways are constructed with 90° corners for most of the ladder flow baffles. This creates a condition where Pacific lamprey must move through high velocity reaches without a flat surface or rounded corner on which to burst from and reattach.

Moser et al. (2002) examined the passage efficiency of adult Pacific lamprey at hydropower dams on the lower Columbia River. In an effort to identify obstacles to migration, they documented the movements of radio-tagged adult Pacific lamprey in specific areas of fishways (entrances, collection channels, transition areas, ladders, and counting stations) at the first three dams lamprey encounter as they move upstream (Bonneville, The Dalles, John Day). Moser et al. (2002) determined that lamprey passage at the lower Columbia River fishways in all four years of the study was consistently low relative to salmonid passage and took over four times longer. In 1996, 96% of the 837 adult spring and summer Chinook salmon radio-tagged by Bjornn et al. (2000b) passed over Bonneville Dam, and their median passage time was one day. In contrast, Moser et al. (2002) found that lamprey passage efficiency at Bonneville Dam never exceeded 50% and that the median passage times each year were 4.4-5.7 days.

Moser et al. (2002) concluded that after entering the fishways, lamprey had the greatest difficulty (1) negotiating collection channels and transition areas that lacked attachment sites and (2) passing through the Bonneville Dam counting stations. On average only 3% of the lamprey they tagged each year were detected upstream from the three lowest dams in the Columbia River. Moser et al. (2002) contend that if passage success is similar at other dams in the Columbia River basin, only a fraction of a percent of the upstream migrants would be able to get above the eight dams encountered along their migration to spawning areas in the Snake River basin above Lower Granite Dam. This small number corresponds to the low annual counts documented since 2000 that have been reported at Lower Granite Dam, the most upstream dam on the Snake River that provides fish passage (Figure 1).

Investigations identifying the habitat needs of Pacific lamprey in the Pacific Northwest (Pletcher 1963; Hammond 1979a; Claire 2003; Stone and Brandt 2002) have documented lamprey utilizing habitat attributes which are generally only abundant in streams with high habitat complexity. This generally includes leaf litter, woody debris of all sizes distributed in pool habitats, intact and well distributed pool habitat, well sorted finer substrates including fine sand, silt, and organic debris. Based on this, Pacific lamprey and other lamprey species likely benefit from increased stream habitat complexity (greater channel sinuosity, large woody debris, fine woody debris, etc.). Generally, stream habitat complexity decreases with human manipulation of stream habitats, while conversely stream and aquatic species productivity increases with increasing stream habitat complexity.

Although hydropower development impacts in the Columbia and Snake River basins are considered the primary contributor to the decline of Pacific lamprey, other habitat alterations cannot be ignored. Habitat alterations from human development in the Snake River basin including road construction, urban development, timber harvest activities, livestock grazing, mining, and other activities have negatively impacted habitat complexity and hydrologic regimes significantly impacting hundreds of miles of rearing stream habitats in the Snake River basin. Activities such as mining and livestock grazing also affected habitat by reducing riparian canopy shade, altering sediment transport processes, and affecting nutrient movement into streams and rivers. Other potential factors that may have led to declines in lamprey abundance include commercial and subsistence fishing.

MANAGEMENT ACTIONS

The IDFG objectives for distribution, abundance, and connectivity are largely unmet (Table 1). Improvements in upstream passage are necessary for any chance of recovering Pacific lamprey populations in Idaho. The reasons for not attaining IDFG management objectives are found in Table 2. Direct actions to facilitate improvement of downstream and upstream passage at mainstem lower Snake and Columbia River hydroelectric facilities are outside the regulatory purview of the IDFG. However, the IDFG can support and promote modifications and improvements at the Federal Columbia River Power System hydroelectric facilities so that objectives for Idaho populations of Pacific lamprey can be realized. More directly, the IDFG is actively pursuing and implementing fish habitat restoration throughout the Clearwater and Salmon River basins for the benefit of salmon and steelhead. These projects also generally benefit native resident species including cutthroat trout and bull trout. The IDFG and its partners will need to give additional consideration to accommodate Pacific lamprey passage at these project sites.

Table 1. Status of Idaho Department of Fish and Game management objectives by drainage basin.

Drainage Basin	Objective	Status of Objective	Discussion
Clearwater River Drainage	Distribution: Establish and maintain Pacific lamprey in accessible streams within the drainage that historically supported other anadromous fish species such as Chinook salmon.	Not Met	Sampling conducted during the 2000-2006 period indicates that Pacific lamprey ammocoetes or macropthalmia are present in the Lochsa River downstream of Weir Creek (rkm 47.9), in the Selway River downstream of Bear Creek (rkm 82.0), in the Red River downstream of rkm 7.5, in the S.F. Clearwater River throughout its length, and the mainstems M.F. Clearwater and Clearwater rivers throughout their lengths. Pacific lamprey were not found in any other locations.
	Abundance: Establish and maintain at least 10,000 Pacific lamprey adults in the drainage with a minimum of 100 adults in each potentially accessible stream.	Not Met	Based on prorated adult passage counts at Lower Granite Dam, an estimated 200 adults enter the Clearwater River drainage.
	Connectivity: Establish and maintain connectivity sufficient for all age classes and life history phases to make natural movements in historically occupied habitats, except the N.F. Clearwater River above Dworshak Dam.	Unknown	Connectivity issues are probably associated with culvert or bridge placement on smaller tributaries. Additional assessment is needed.
Salmon River Drainage	Distribution: Establish and maintain Pacific lamprey in accessible streams within the drainage that historically supported other anadromous fish species such as Chinook salmon.	Not Met	Sampling conducted during the 2004-2006 period indicates that Pacific lamprey ammocoetes or macropthalmia are present only in the mainstem Salmon River downstream of N.F. Salmon River at rkm 381.4 and in the M.F. Salmon River downstream of rkm 78.7. Pacific lamprey were not found in any other locations.
	Abundance: Establish and maintain at least 21,500 Pacific lamprey adults in the drainage with a minimum of 100 adults in each potentially accessible stream.	Not Met	Based on prorated adult passage counts at Lower Granite Dam, an estimated 200 adults enter the Salmon River drainage.
	Connectivity: Establish and maintain connectivity sufficient for all age classes and life history phases to make natural movements in historically occupied habitats.	Not Met	Irrigation diversions in the upper Salmon River drainage have presented passage issues for other anadromous fish. The expectation is that the same issues apply to Pacific lamprey during upstream adult migrations and

Table 1. Continued.

Drainage Basin	Objective	Status of Objective	Discussion
			downstream ammocoete and macropthalmia migrations. Research is needed to determine the extent that diversions impact Pacific lamprey and what actions may be necessary to alleviate the problem so that objectives can be met.
Snake River-Lewiston upstream to Hells Canyon Dam	Distribution: Maintain suitable migratory habitat throughout the river corridor downstream of the Salmon River.	Met	The Snake River itself probably provides no suitable spawning habitat for Pacific lamprey, but does provides rearing habitat for ammocoetes and macropthalmia and a passage corridor for migration. Hells Canyon Dam at rkm 399.0 is a total barrier to access historical habitats in the middle Snake River. In Oregon, Asotin Creek, the Grande Ronde River, and Imnaha River enter the Snake River downstream of Hells Canyon Dam and have historically supported Pacific lamprey populations. Several small tributaries (Rush Creek, Deep Creek) offer suitable spawning habitat in their lower reaches.
	Abundance: Because there are few suitable tributary streams for Pacific lamprey spawning on the Idaho side, the adult abundance goals for the Snake River management unit are set at a very conservative 500.	Unknown	see above
	Connectivity: Establish and maintain natural connectivity sufficient for all age classes and life history phases.	Met	Flows for the Salmon River and releases from Hells Canyon Dam are adequate to provide suitable flows for passage and maintenance of rearing habitat for ammocoetes and macropothalmia.

Table 2. Potential reasons for not attaining management objectives by drainage and management action needed to achieve objectives.

Drainage Basins	Potential Reasons for Not Meeting Objectives	Management Actions
Clearwater River Drainage	1. Passage through hydroelectric facilities on the Columbia River and lower Snake River dams. 2. Habitat alteration 3. Impacts from non-native fish species 4. Disease	• Management actions addressing this issue are outside the direct authority of the Idaho Department of Fish and Game. The Department will provide support and technical expertise in developing best management practices to be undertaken by the appropriate governmental agencies. Some proposed actions developed by IDFG and with information from the Columbia River Basin Lamprey Technical Work Group are presented in Appendix A. • Work with appropriate state and governmental agencies to ensure appropriate Best Management Practices are implemented to reduce and prevent habitat degradation due to improper grazing practices. • Work with appropriate state and governmental agencies to ensure appropriate Best Management Practices are implemented to reduce and prevent habitat degradation due to timber management practices. • Work with state and governmental agencies to identify locations where suction dredge mining activities may be harmful to existing and potential Pacific lamprey rearing and spawning habitats. • Evaluate effect of heavy metals (by-products of mining activities) on productivity and survival of juvenile lamprey. • Evaluate effect of predation from non-native fish species, and if necessary develop and implement measures to reduce or eliminate impacts. • Evaluate potential effects of known parasites and potential diseases on Pacific lamprey populations.
Salmon River Drainage	1. Passage through hydroelectric facilities on the Columbia River and lower Snake River dams. 2. Habitat alteration 3. Impacts from non-native fish species 4. Disease 5. Migration barriers at irrigation diversions	• Management actions addressing this issue are outside the direct authority of the Idaho Department of Fish and Game. The Department will provide support and technical expertise in developing best management practices to be undertaken by the appropriate governmental agencies. Some proposed actions developed by IDFG and utilizing information from the Columbia River Basin Lamprey Technical Work Group are presented in Appendix A • Work with appropriate state and governmental agencies to ensure appropriate Best Management Practices are implemented to reduce and prevent habitat degradation due to improper grazing practices. • Work with appropriate state and governmental agencies to ensure appropriate Best Management Practices are implemented to reduce and prevent habitat degradation due to timber management practices. • Work with state and governmental agencies to identify locations where suction dredge mining activities may be harmful to existing and potential Pacific lamprey rearing and spawning habitats. • Evaluate effects of heavy metals (by-products of mining activities) on

Table 2. Continued.

Drainage Basins	Potential Reasons for Not Meeting Objectives	Management Actions
	6. Entrainment in irrigation canals	productivity and survival of juvenile lamprey. • Evaluate effect of predation from non-native fish species, and if necessary develop and implement measures to reduce or eliminate impacts. • Evaluate potential effects of known parasites and potential diseases on Pacific lamprey populations. • Evaluate potential migration barriers at irrigation diversions. If necessary develop and implement actions to reduce or eliminate obstructions to downstream and upstream migration. • Evaluate entrainment at diversions, and if necessary develop and implement corrective measures to reduce or eliminate entrainment.
Snake River Drainage	1. Passage through hydroelectric facilities on the Columbia River and lower Snake River dams. 2. Habitat alteration 3. Impacts from non-native fish species 4. Disease 5. Entrainment in irrigation canals	• Management actions addressing this issue are outside the direct authority of the Idaho Department of Fish and Game. The Department will provide support and technical expertise in developing best management practices to be undertaken by the appropriate governmental agencies. Some proposed actions developed by IDFG and information from the Columbia River Basin Lamprey Technical Work Group are presented in Appendix A • Work with appropriate state and governmental agencies to ensure appropriate Best Management Practices are implemented to reduce and prevent habitat degradation due to improper grazing practices. • Work with appropriate state and governmental agencies to ensure appropriate Best Management Practices are implemented to reduce and prevent habitat degradation due to timber management practices. • Work with state and governmental agencies to identify locations where suction dredge mining activities may be harmful to existing and potential Pacific lamprey rearing and spawning habitats. • Evaluate effect of heavy metals (by-products of mining activities) on productivity and survival of juvenile lamprey. • Evaluate effect of predation from non-native fish species, and if necessary develop and implement measures to reduce or eliminate impacts. • Evaluate potential effects of known parasites and potential diseases on Pacific lamprey populations.

The U.S. Army Corps of Engineers has ongoing efforts to improve passage conditions for adult Pacific lamprey at Columbia River dams (Clabough et al. 2011a), and is actively assessing general passage and fishway use at its projects on the Columbia River mainstem (Clabough et al. 2011b). Additionally, the U.S. Army Corps of Engineers issued a 10-year (2008 - 2018) implementation plan for passage improvements targeted at Pacific lamprey (U.S. Army Corps of Engineers 2009). The goal of this implementation plan is "...to improve both juvenile and adult lamprey passage and survival through the FCRPS as a part of a regional effort to immediately arrest the decline of Pacific lamprey populations within the Columbia basin and to quickly and substantially contribute towards rebuilding these populations to sustainable, harvestable levels throughout their historic range." The plan provides a proposed funding stream and total cost of implementing improvements, and identifies specific actions for consideration to improve lamprey passage and survival.

The U.S. Fish and Wildlife Service (USFWS) hosted the Pacific Lamprey Conservation Initiative Work Session on October 28-29, 2008 in Portland, Oregon. The purpose of the gathering was to bring managers and scientists with various skills and expertise together to facilitate communication on the current status and ongoing efforts to conserve Pacific lamprey and to begin development of a collaborative, range-wide Conservation Plan. In late 2010, the Service released the Pacific Lamprey Draft Assessment and Template for Conservation Measures (formerly Conservation Plan). The Service also released Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (USFWS 2010). In July 2008, the four treaty tribes within the Columbia River Basin (Umatilla, Warm Springs, Nez Perce, and Yakama Nation) released a Final Draft of the Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin (Nez Perce, Umatilla, Yakama and Warm Springs Tribes 2008). This plan describes a ten-year (2008 – 2018) path including specific actions that can be taken for both the Columbia/Snake Rivers and associated tributaries. The ultimate goal is restoration of Pacific lamprey to levels supportive of their unique cultural and ecosystem values.

Hydroelectric Facility Impacts

A detailed discussion regarding the effects of hydroelectric project operations to upstream migrating adults and downstream migrating juvenile lamprey is found in Appendix A.

Moser et al. 2002 documented the impact of hydroelectric project passage structures to upstream passage of adult Pacific lamprey. The IDFG estimates that an approximate 50% passage rate per project has resulted in annual escapement levels that are several magnitudes below that needed to seed unoccupied rearing habitats in the Snake River basin (Figure 7). Table 3 reflects the number of Pacific lamprey adults that would pass Lower Granite Dam with 50% passage efficiency, 80% passage efficiency, and 95% passage efficiency. The IDFG modeled based on the assumption that a portion of the Pacific lamprey adults approaching the base of Bonneville Dam will ultimately be bound for the Snake River basin and further assuming that no immigration of Pacific lamprey bound for the Snake River basin into tributary streams occurs. If passage efficiency improves by 30% over the current 50% passage efficiency (to 80%) at the eight hydroelectric projects downstream of Lewiston, Idaho, the IDFG determined Pacific lamprey adult escapement to Lower Granite Dam could improve dramatically (Table 3). The IDFG recognizes this is a modeling exercise and that there is normal attrition, predation, and straying, however, the potential improvement for returns to the Snake River basin and Idaho tributaries is significant and the calculations mirror current poor returns to the Snake River basin very closely.

Juvenile downstream migration is currently considered impeded by the slackwater pools created behind reservoirs. The degree of impact to populations in the Snake River basin related to this is unknown; however, actions to increase flow velocities currently aimed at helping salmonids will likely benefit juvenile lamprey as well. Additional efforts to increase flow velocities through reservoir pools in the downstream migratory period (March-July; Figure 8) will likely benefit Pacific lamprey. Slackwater pools also create an environment where natural and introduced predators have access to juvenile lamprey. While historical free-flowing conditions provided for reduced exposure time and greater escape capability compared to current conditions, it is unknown to what degree this affects predation rates for Pacific lamprey. Stresses and direct damage of downstream migrating juvenile lamprey during passage at hydroelectric projects has been studied to some degree (Moursund et al. 2001; see Appendix A), and disorientation of lamprey in turbine outflow may result in high vulnerability to both avian and aquatic predators, which has been documented at Mid Columbia River P.U.D. Dams. Spillway route of passage has been considered the optimum pathway for salmon and steelhead and is presumed to be the best migration pathway for Pacific lamprey downstream migrants as well (see Appendix A).

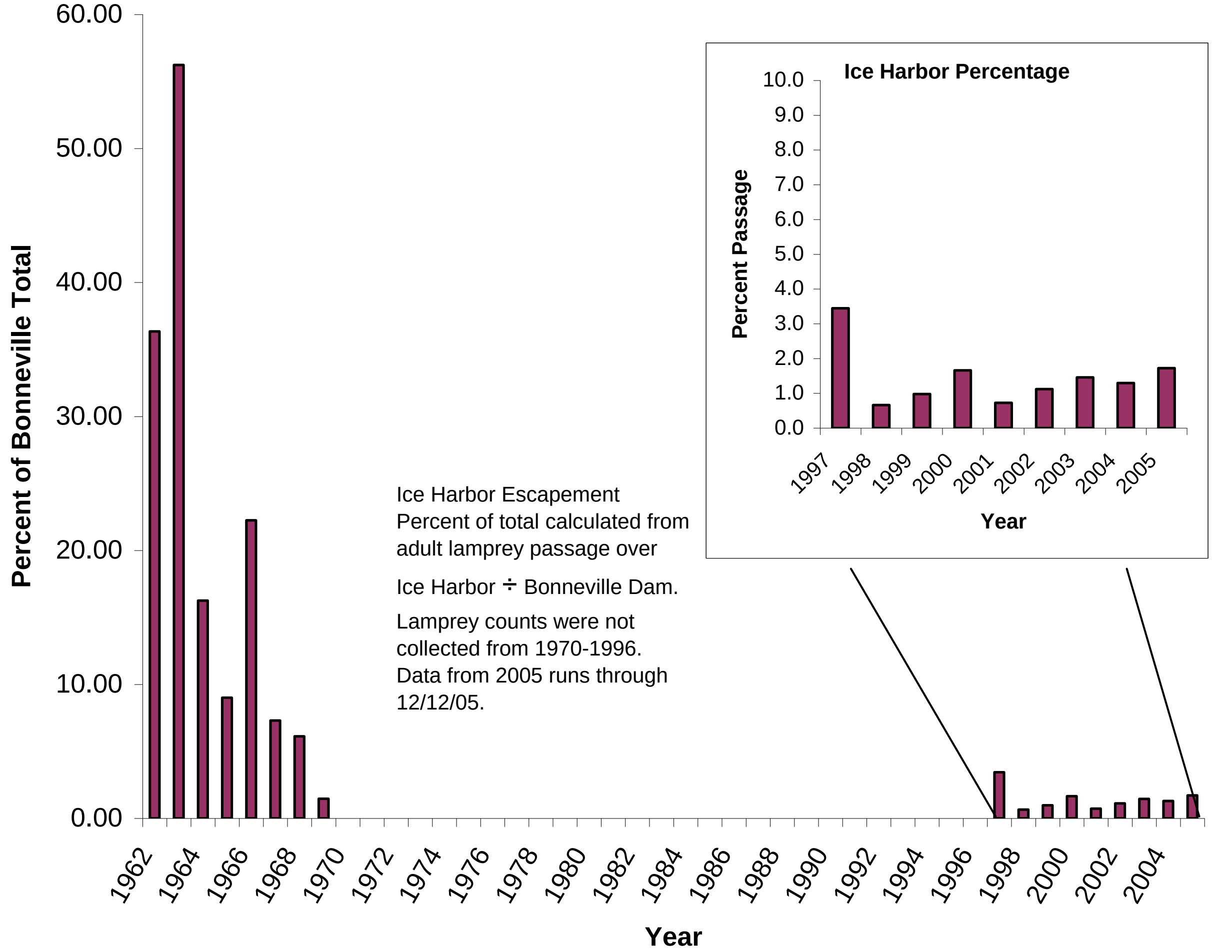

Figure 7. Pacific Lamprey adult upstream passage over Ice Harbor Dam as percent of total Bonneville Dam passage 1962-1969 and 1997-2005.

Table 3. Columbia River Basin Pacific Lamprey Hydroelectric Project Passage Assessment. Modeling of number of adult Pacific lamprey that would reach and pass Columbia River and Snake River Hydroelectric Projects with different passage efficiencies. Current passage efficiency at Columbia River Basin hydroelectric projects estimated at 50% based on Moser et al. (2002).

Loc./Project	Number with 50% Passage Efficiency	Number with 80% Passage Efficiency	Percent Improvement 80% pass.	Number with 95% Passage Efficiency	Percent Improvement 95% pass.
Estuary	300,000	300,000		300,000	
Bonneville	250,000	250,000		250,000	
(Snake R. # @ base of dam)	100,000	100,000		100,000	
Bonneville*	50,000	80,000	60	95,000	90
The Dalles*	25,000	64,000	156	90,250	261
John Day*	12,500	51,200	310	85,738	586
McNary*	6,250	40,960	555	81,451	1,203
Ice Harbor*	3,125	32,768	949	77,378	2,376
Lower Mnmntl.*	1,563	26,214	1,578	73,509	4,605
Little Goose*	781	20,972	2,584	69,834	8,839
Lower Granite*	391	16,777	4,195	66,342	16,884

*Number is lamprey bound for the Snake River basin to end point of at least Lower Granite Dam. Also assumes no migration of Snake River-bound lamprey into tributaries downstream of Lower Granite Dam.

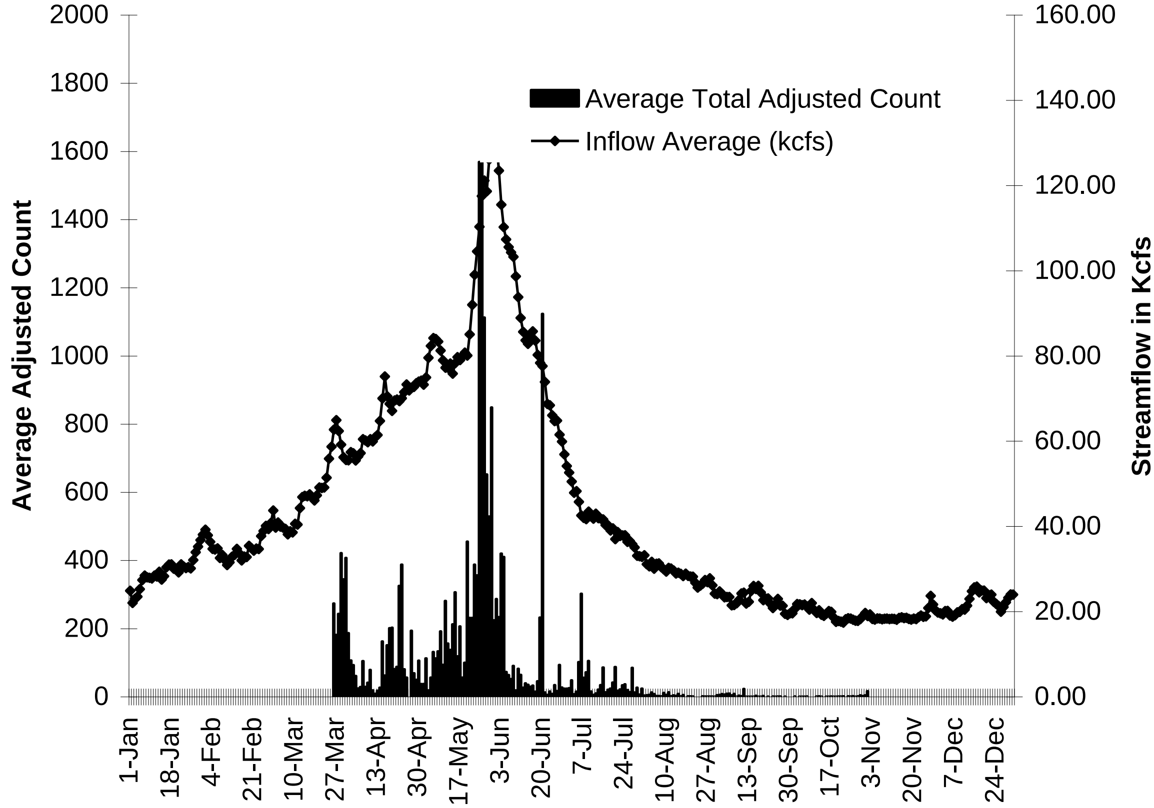

Figure 8. Daily streamflow in Kcfs and average adjusted total juvenile/ammocoete lamprey count from the downstream migrant collection and sampling facility by day at Lower Granite Dam facility 1996-2005.

Population Recovery Goals

Clearwater River Drainage: The IDFG establishes an annual average escapement goal of 10,000 Pacific lamprey spawners returning to the Clearwater River drainage. This escapement goal is based on two factors: 1. Historical accounts of abundance; and 2. historically occupied but currently vacant or under-seeded habitats.

In the early 1960s, Pacific lamprey adult counts at Ice Harbor Dam reached as high as 49,000. With three dams already in place on the Columbia River downstream of Ice Harbor (Bonneville, The Dalles, McNary), the number of lamprey bound for the

Snake River basin had already been reduced dramatically. Salmon River Drainage: The Salmon River is the longest un-dammed river in the state of Idaho running over 660 km prior to emptying into the Snake River in Hells Canyon. The overall size of the Salmon River drainage and the numerous tributaries with high water quality historically provided excellent habitat for Pacific lamprey. Currently the habitat in the largest tributaries (South Fork Salmon River, Middle Fork Salmon River) is in fair to excellent condition, much of it in federally designated wilderness. Additionally, other than smaller tributaries with irrigation dewatering issues, all of the major tributaries in the Salmon River drainage retain habitat capable of producing Pacific lamprey, with much of this habitat in good to excellent condition. Based on the size of the drainage, large number of tributaries, and productivity levels likely greater than the Clearwater River drainage, an average annual adult spawning escapement goal of 21,500 is considered conservative.

Population goals for abundance of Pacific lamprey in the Clearwater and Salmon River drainages are defined by the IDFG as 10,000 and 21,500 adults annually returning, respectively on average. The IDFG suggests a critical minimum threshold escapement level for adult lamprey over Lower Granite Dam into Snake River tributaries is necessary to prevent extinction. Overall it is suggested that an annual escapement of 4,000 lamprey adults on average passing Lower Granite Dam is necessary to offset continued declines and that returns greater in size are needed for recovery of populations in the Snake River basin. This critical minimum threshold level of escapement for adult Pacific lamprey is based on three factors: 1. Adult escapement to the Clearwater River basin in the 1950s observed over Lewiston Dam, 2. Escapement levels over Ice Harbor Dam during 1961-1969 and Lower Granite Dam 1993-2007, and 3. assessment of the quantity and quality of surveyed available habitat in Idaho.

Habitat Conditions and Management Implications

Although additional study may refine information pertaining to the life history requirements of Pacific lamprey, several efforts have documented the primary needs of the species (Hammond 1979a; Pletcher 1963; Claire 2003; Cochnauer and Claire 2006). Pool habitat is a dominant factor in predicting the capability of a stream to produce Pacific lamprey. The ammocoetes, though elusive and difficult to capture when disturbed, are not powerful swimmers and seek out slower water habitats for rearing.

Ammocoetes prefer fine sand or silt substrates when available, but are capable of living in cobble substrates with limited organics present. Elevated sediment loads above historical background levels are considered detrimental to rearing Pacific lamprey. Although further study is needed to better understand the relationship of Pacific lamprey production relating to sedimentation rates, correlative relationship in Idaho has suggested water quality is related to persistence of the species (Cochnauer and Claire 2006). Pacific lamprey ammocoetes are found rearing in fairly dense mudbeds at times. Sedimentation of redds following spawning is considered an undesirable condition.

It is believed that Pacific lamprey ammocoetes have thermal preferences similar to steelhead trout, seeking out cold water (9-18°C), but not necessarily the coldest. Although laboratory work has shown tolerances above this range, the long term impacts of this exposure are unknown. Claire (2003) found that ammocoete abundance in Red River, Idaho was positively correlated with stream riparian canopy shading, however, it is unknown if this is related to seeking out thermal refuge or avoidance of direct sunlight (lamprey ammocoetes are highly photophobic).

Pacific lamprey, like other anadromous species in Idaho, must deal with changes in flow volume in streams. Conditions like those which currently exist in the Lemhi River watershed where most of the tributaries and much of the mainstem are partially or completely dewatered on an annual basis inhibit lamprey production. Ammocoetes are less capable of exiting dewatering substrates and locating new refuge than salmonids due to their different swimming ability and lack of vision. Therefore they are much more vulnerable to dewatering events. Additionally dewatering and subsequent movement out of substrates into the open water column while attempting to find new suitable habitat increases their risk of predation. This condition exists in the Snake River Hells Canyon reach below Hells Canyon Dam where power peaking increases and decreases river volume rapidly, dewatering and rehydrating shoreline substrates daily or weekly in the zone where younger ammocoetes often rear (see Appendix B for detailed discussion).

Clearwater River Drainage Current Condition, Quantity, and Availability of Habitat: The general condition of habitat for the individual major Clearwater River drainage watersheds was discussed in the STATUS section. Overall when compared to historical conditions the ability of the Clearwater River drainage to support Pacific lamprey is considered reduced, but good. There are degraded watersheds in the drainage including the Potlatch River and Lapwai Creek, however, these are exceptions. Several tributary streams in the Potlatch River watershed (East Fork, Boulder Creek) remain in relatively fair shape despite poor habitat conditions in the majority of tributaries largely due to altered hydrologic conditions and elevated sediment loads. Dworshak Dam has eliminated access to ~25% of the anadromous habitat in the Clearwater River drainage. No other major passage impediments currently exist on major tributaries. However, the overall potential of the Clearwater River drainage to produce Pacific lamprey is enhanced by the largely intact habitat conditions in the Lochsa and Selway River watersheds.

The South Fork Clearwater River watershed is in a state of recovery (American River, Newsome Creek, Crooked River) following major mining operations and large-scale timber harvest. However, there is abundant fair quality habitat in many reaches of mining impacted tributaries and good habitat in a number of sections upstream of mining impacted habitat.

The Lochsa River drainage has experienced increased sedimentation following extensive roading and logging operations in the northern portions of the watershed. Sedimentation above historic background levels is considered undesirable for rearing Pacific lamprey, but lamprey continue to utilize the mainstem Lochsa River, although lamprey are currently extirpated in the Potlatch River system and considered near extirpation in the South Fork Clearwater River watersheds where sediment loads are greater. A major portion of the Lochsa River watershed is within wilderness or roadless area and thus in good to excellent habitat condition.

The Selway River watershed is currently managed under wilderness designation for much of its land area and has retained most of the intact habitat attributes present pre-European settlement. This river drainage is considered to have good to excellent quality habitat to support Pacific lamprey.

Salmon River Drainage Current Condition, Quantity, and Availability of Habitat: There are a number of major tributary streams in the Salmon River basin that have been degraded in relation to Pacific lamprey production. The habitat conditions in the Lemhi River, Pahsimeroi River, East Fork Salmon River, and Yankee Fork Salmon River were discussed in the STATUS section individually. Despite major impacts restricting Pacific lamprey production capability in these drainages, some of them continued to produce lamprey well after impacts were first documented (Lemhi River) and most stream habitats in these watersheds are currently in a stable state or recovering incrementally.

The largest watershed in the Salmon River drainage is the Middle Fork Salmon River. The mainstem and majority of tributary reaches are under wilderness designation, which has provided for a high degree of protection. Livestock grazing activities in Marsh Creek and Bear Valley Creek watersheds, the major tributaries that join to form the Middle Fork, has impacted the habitats there, however, they continue to be productive Chinook salmon streams, which indicates water quality and habitat conditions are likely suitable for Pacific lamprey. Approximately 120,000 acres of the Bear Valley Creek watershed was permanently retired to livestock grazing by the U.S. Forest Service in the 1990s to protect anadromous fish habitat (Scott Grunder, IDFG, personal communication). The condition of the Middle Fork Salmon River overall including the tributaries has been commonly considered in good to excellent condition for Chinook salmon production and likewise is considered fully adequate or better (mostly good to excellent condition) for production of Pacific lamprey.

It is possible the Middle Fork Salmon River, including the tributaries, and subsequent utilization of the mainstem Salmon River downstream to the Snake River could provide sufficient habitat to reach the production goal of 21,500 spawning adults for the entire Salmon River drainage. However, a number of other streams with largely intact habitat conditions including Bargamin, Smiley, Valley, Reeds Creeks, and the upper mainstem Salmon River in combination with the other major tributaries (Middle Fork Salmon River, Little Salmon, North Fork, Lemhi, Pahsimeroi, East Fork, and Yankee Fork Rivers) provide habitat likely capable of producing 3-5 times (64,500-107,500) as many spawners as the Salmon River drainage production goal.

Measures Suggested to Protect or Enhance Habitat; Land use activities that contribute to reducing the quantity and quality of stream pool habitat need to be monitored. Best management practices should be implemented in land management activities to protect habitat for Pacific lamprey and other native fishes including steelhead trout, Chinook salmon, cutthroat trout, and bull trout.

Sedimentation loads above background levels are considered deleterious to Pacific lamprey spawning and rearing environments. In this context, land management actions which tend to increase sedimentation loading should receive careful scrutiny prior to implementation.

Riparian vegetation with the associated rooting structure and canopy is considered important for not only maintaining the bank stability, complexity of stream channels, but also providing relief from solar heating. Consideration should be given to improving management practices to enhance stream-riparian plant communities adjacent to Pacific lamprey spawning and rearing streams.

Irrigation practices in the Salmon River drainage provide for the production of livestock and a limited number of crops. Current screening devices when installed on irrigation diversion ditches, are thought to protect to at least some degree against entrainment of most age classes of ammocoetes (except age-0) into ditch networks. However, the total dewatering of spawning and rearing streams is considered deleterious to Pacific lamprey production. Minimum stream flows should be considered in major tributary streams such as the Lemhi River, East Fork Salmon River, and Pole Creek in order to protect rearing capability of these streams.

Predation

Clearwater and Salmon River drainages: Although pikeminnow, smallmouth bass *Micropterus dolomieu,* and white sturgeon are predators on Pacific lamprey ammocoetes, their impacts on Pacific lamprey populations within the Clearwater and Salmon River drainages is not considered a major factor contributing to their current status. Pacific lamprey rear for several years in many cases in tributary streams prior to drifting downstream into lower watersheds where thermal conditions allow for the proliferation of warm water species. There is, however, a notable drop in densities of Pacific lamprey rearing in the substrates in the Salmon River below Riggins, Idaho, but the reason for this decrease is unknown.

Snake and Columbia River Corridors: Pacific lamprey are a favorite food of not only white sturgeon, but pikeminnow, smallmouth bass, and a host of other aquatic predators. Historically lamprey ammocoetes likely were a significant prey item for Snake River white sturgeon. Pikeminnow and other site feeding predators continue to capture

Pacific lamprey moving downstream in the Snake River system (Cochnauer and Claire 2006). Currently predation impacts to larval and juvenile lamprey outmigrants is not seen as the predominant factor restricting recovery of the species in Idaho streams.

It is has been documented that avian predators consume large numbers of Pacific lamprey ammocoetes and juveniles in the turbine outflow upwelling areas at Columbia River basin dams. While this is not a desirable condition, it undoubtedly occurred historically in turbulent reaches of stream. Undoubtedly hydroelectric facilities have exacerbated this impact to outmigrant Pacific lamprey ammocoetes and macropthalmia. The exact magnitude of the impact is unknown. Further study is needed to determine the degree of predation. Current efforts to inhibit avian predation of salmonids at the base of Columbia River and Snake River dams will undoubtedly benefit Pacific lamprey.

Population Monitoring and Assessment

Research and assessment efforts in recent years have increased the basic understanding of the life history, ecology, population dynamics, and habitat relationships of Pacific lamprey in Idaho. However, the life history of Pacific lamprey is complex and additional research and monitoring must occur over the long-term. Table 4 identifies critical assessments, monitoring, and research actions needed to better prioritize and implement management actions to meet stated objectives

The multiple year study done by IDFG identified 327 field sites for survey that are strategic for assisting in defining the status of Pacific lamprey in Idaho (Appendix C). These sites are situated within three IDFG administrative regions: Clearwater, Southwest, and Salmon. The identified sites are are hierarchically ordered based on a two year (where the sites are all sampled within two years) sampling rotation for sites ranked (1), four year rotation for sites ranked (2) and whenever personnel and time allow for sites ranked (3). Presence- absence survey data combined with subsequent analysis of population structure when compared to recent past data will provide an overall future assessment of the status of Pacific lamprey. Methodology for sampling techniques are found in Appendix D.

Population Supplementation

A proposed action to achieve restoration of Pacific lamprey in Idaho is the translocation of adult fish collected at one location for reintroduction purposes elsewhere. Translocation should be viewed as an interim measure while primary limiting factors are addressed in the long term. The Columbia River Basin Lamprey Technical Work Group (CRBLTW) issued a draft report about the state of the science regarding translocating adult Pacific lamprey (CRBLTW 2011). The paper provides a review of translocation programs carried out in the Columbia River basin to date. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) drafted guidelines for Pacific lamprey translocation when the Northwest Power and Conservation Council required a Umatilla Lamprey Restoration Plan prior to initiating translocations in the Umatilla Subbasin. These guidelines were adopted for the Columbia Basin Fish and Wildlife Authority by the Columbia River Basin Lamprey Technical Work Group (1999). The guidelines have been further revised and adopted by the Nez Perce, Umatilla, Yakama, and Warm Springs Tribes for inclusion into the Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin (Nez Perce, Umatilla, Yakama, and Warm Springs Tribes 2008).

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APPENDICES

Appendix A. Discussion of the impacts of the hydroelectric system in the Snake and Columbia Rivers to Pacific lamprey upstream and downstream passage.

OPERATION AND MANAGEMENT OF HYDROELECTIC FACILITIES

Note: This section was developed by IDFG fisheries personnel in 2005 in response to a request by several agencies, internally, and the U.S. Fish and Wildlife Service to provide guidance to address issues impacting recovery of Pacific lamprey in Idaho and the Columbia River basin. It contains perspectives from interaction with the Columbia River Basin Lamprey Technical Workgroup, but is solely a product of IDFG and is considered a foundation for discussion to address issues inhibiting recovery.

Upstream Passage

The design of fish ladders at hydroelectric projects is perhaps the most significant factor affecting the persistence of Pacific lamprey in the Columbia River basin upstream of Bonneville Dam. Upstream migrant adult passage conditions are believed to have played a large role in the demise of river lamprey in the Columbia River basin. Pacific lamprey utilize their suctoral disc in combination with burst swim performance to navigate reaches of stream and passage ladders with velocities exceeding their maximum swimming potential. Moser et al. (2002) and Vella et al. (1997) outline difficulties Pacific lamprey experience navigating sections of upstream passage ladders where velocities are high and few attachment sites exist. Ninety degree corners are a structural design which presents a non-attachable point. Passage ladder entrances where the ladder flow enters the river are especially troublesome. These sites usually have ninety degree corners or slotted bulkheads which prevent lamprey from attaching, burst swimming and reattaching along the wall. Diffuser gratings in the floor of ladders additionally result in a limited number of attachment points in critical sections of the ladder. The Bonneville Dam serpentine weir sections utilized to reduce flow velocities in ladders, are an extensive reach of repeated 90° baffling combined with elevated flow velocities which make upstream passage past the dam difficult for Pacific lamprey. To improve upstream passage of Pacific lamprey the following actions or similar actions are recommended:

- Round bulkhead 90° corners along wall of the entrances to ladders sufficiently to allow Pacific lamprey to attach and move at the water surface or below the surface.

- Round upstream passage ladder 90° baffle angles (corners) in sections with velocity exceeding 1.0 ft/sec. at the mainstem Columbia and Snake River hydroelectric projects.
- Install flat plate (aluminum or polycarbonate) to provide Pacific lamprey attachment points along upstream passage ladder sections with extensive diffuser grating at mainstem Columbia and Snake River hydroelectric projects.
- Redesign and modify existing upstream passage ladders to increase Pacific and River lamprey upstream migrant passage efficiency setting a goal of 95%+. Replace serpentine weirs at Bonneville Dam and other mainstem Columbia and Snake River hydroelectric projects with passage ladder stream flow control structures which are navigable to the complement of anadromous species.
- Design and implement tests of new "lamprey" upstream passage mechanisms such as the lamprey ladder currently in the test phase, however, with priority on completion of actions listed above.

Downstream Passage

The impingement of ammocoetes and macropthalmia in hydroelectric project turbine bypass structures combined with the potential difficulty of ammocoete and macropthalmia navigation through extensive slackwater pools behind hydroelectric projects is likely as great a negative impact to Columbia River basin and Snake River subbasin Pacific lamprey populations as upstream passage impediments. The potential associated increases in predation and reduction in energy reserves due to lengthened migration durations through reservoirs, likely contributes to decline of Pacific lamprey in the Snake River basin. To improve downstream passage of Pacific lamprey, the following actions are recommended.

- Install the new design of hydroelectric project turbine bypass screens with reduced screen widths in order to reduce impingement of ammocoetes in screens.
- Maintain spring period (April-July) Snake River Columbia River stream flows as close to historically natural conditions as is possible to increase river current velocities through pools.
- Maintain or increase Columbia and Snake River hydroelectric project stream flow spring/early summer (April 1 to July 31) spill levels through traditional gates in

addition to removable spillway weirs (Pacific lamprey ammocoetes travel deeper in the water column compared to salmonids) to maximize instream passage. Bypass collection and subsequent transport of Pacific lamprey ammocoete and macropthalmia downstream migrants is considered detrimental. Maintenance of current river flow spill levels should occur at the complement of mainstem Columbia and Snake River hydroelectric projects downstream of spawning and rearing tributaries.

Transportation Issues

Transportation of salmonids is commonly known to cause stress to those species. It is currently thought extended (longer than several hours) retention of Pacific lamprey ammocoetes and macropthalmia in raceways and barge holds likely results in elevated stress response. This assessment is based on behavior of the species observed in Lower Granite hydroelectric project collection raceways and is supported by observations in the field (Christopher Claire, personal observation 2000, 2001, 2002, 2003). When retained in holding structures, Pacific lamprey ammocoetes and macropthalmia swim non-stop to exhaustion attempting to locate sites in which to burrow into the substrate.

In the spring migration year of 2001 the Columbia Basin Bulletin presented a document identifying issues involving the transportation of Pacific lamprey ammocoetes and macropthalmia. A barge load of salmon, steelhead trout, and lamprey ammocoetes and macropthalmia enroute to the Columbia River below Bonneville hydroelectric project was released prior to reaching Ice Harbor hydroelectric project when hundreds (perhaps several thousand) of lamprey ammocoetes inserted themselves irremovably into the exchange screens between holding divisions on the transport barge. The lamprey ammocoetes were embedded into the screens in great enough numbers to reduce flow exchange to the point where the holding water levels rose onto the deck of the barge. The imbedding of ammocoetes into the screens on transport barges is a common event.

Steelhead trout are commonly observed regurgitating Pacific lamprey ammocoetes in the Snake River basin during hydroelectric project bypass/collection sampling operations. The total number of Pacific lamprey ammocoetes and macropthalmia which is consumed by steelhead trout during spring outmigration is unknown; however, they are considered a potential predator of Pacific lamprey ammocoetes and macropthalmia. Snake River subbasin hydroelectric project bypass collection and subsequent transportation of steelhead trout and Pacific lamprey ammocoetes and macropthalmia in the same holding tank places the lamprey at high risk of predation.

Appendix B. Pacific lamprey trend monitoring sites in the Salmon and Clearwater drainages, Idaho.

Clearwater River Drainage **Status 2006**

River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
		Clearwater River				
Clearwater River	1	Gibbs Eddy (20m downstream of boat launch	11T	519030	5147114	P
		Lochsa River				
Lochsa River	1	0.85 km below Fire Creek	11T	620114	5120423	P
Lochsa River	1	2.0 km above Squaw Creek	11T	666308	5151606	A
Lochsa River	1	1 km above Castle Creek	11T	639437	5140452	P
Lochsa River	1	1.5 km below Weir Creek	11T	649708	5146680	P
Lochsa River	1	0.5 km above Fish Creek	11T	627859	5132511	P
Colt Killed Creek	1	20 m above bridge at mouth	11T	678054	5153007	A
Crooked Fork Creek	2	25 m below Road 595 bridge	11T	677494	5170792	A
Crooked Fork	2	25 m above mouth Shotgun Creek	11T	678910	5163298	A
Fish Creek	2	50 m above mouth	11T	627271	5132235	A
Pete King Creek	2	100 m below first bridge	11T	606419	5114444	A
Warm Springs Creek	2	~150 m above mouth	11T	662216	5148441	A
Weir Creek	2	0.7 km above mouth (above hot springs)	11T	650914	5147209	A
		Middle Fork Clearwater River				
M.F. Clearwater River	1	150 m below Three Devils Creek	11T	604538	5109756	P
M.F. Clearwater River	1	5 m below Five Mile boat launch	11T	564377	5133715	P
M.F. Clearwater River	2	0.01 m below Five Mile boat launch	11T	564375	5133711	P
Clear Creek	1	1.6 km above Big Cedar Creek (~30 m below bridge	11T	587743	5099708	A
Clear Creek	2	6.5 km below Big Cedar Creek	11T	582648	5104651	A
Eldorado Creek	2	50 m below Road 519 bridge	11T	599317	5125670	A
Lawyers Creek	3	100 m down from Hwy 59/95 bridge	11T	546495	5151530	A
Lolo Creek*	1	100 m above Tribal Weir (RKM 21)	11T	578759	5126725	A
Lolo Creek*	2	1.0 m below mouth of Utah Creek	11T	597380	5131206	A
Lolo Creek*	1	80 m above railroad bridge	11T	564077	5135532	A
Musselshell Creek	3	10 m down from culvert on Road 305	11T	596952	5135702	A
Musselshell Creek	3	Lolo Creek Road bridge	11T	595513	5133702	A
Musselshell Creek	3	50 m up from mouth	11T	596024	5129093	A
Orofino Creek	2	~200 m abv Cow Creek (50 m abv brdg	11T	581965	5149438	A
Orofino Creek	3	5.9 km from mouth	11T	562457	5147680	A
Orofino Creek	3	2.6 km above Pierce	11T	592669	5146360	A
		Potlatch River				
Potlatch River	1	1.61 km south of Juliaetta	11T	522577	5156977	A
Potlatch River	1	between Juliaetta & Kendrick by gravel pit	11T	524231	5159692	A
Potlatch River	1	1.1 km E of Kendrick, dwnstrm hwy brdg	11T	527276	5162538	A
Potlatch River	2	80 m down from Road 1963	11T	541498	5179847	A

Appendix B. Continued.

Clearwater River Drainage						**Status 2006**
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
Potlatch River	2	under Deary-Kendrick Hwy bridge	11T	527208	5162562	A
Potlatch River	2	Potlatch River Road bridge, E of Kendrick	11T	532995	5164719	A
Potlatch River	2	bridge at Boulder Creek Campground	11T	541479	5179867	A
Potlatch River	2	2.5 km up from East Fork	11T	544396	5183403	A
Potlatch River	2	60 m up from Moose Creek	11T	545366	5190672	A
Potlatch River	2	1.5 km up from Jackson Creek	11T	550176	5188258	A
Potlatch River	2	1.5 km down from Pine Creek	11T	530496	5163827	A
Potlatch River	2	0.4 km down from Juliaetta	11T	520153	5151455	A
Big Bear Creek	3	2.5 km dwn frm Moscow-Deary hwy brdg	11T	530542	5179359	A
E.F. Potlatch River	1	2.5 km up from mouth	11T	545152	5182924	A
E.F. Potlatch River	2	up from Road 4707	11T	531669	5187741	A
		Red River				
Red River	1	RKM 8	11T	623522	5072737	A
Red River	2	RKM 9	11T	624081	5072415	A
Red River	2	RKM 10	11T	624682	5072044	A
Red River	1	50 m below red river bridge, 1 mile below hot springs	11T	639138	5071034	A
Red River	3	100 m below bridge on Road 172	11T	636764	5068994	A
Red River	2	1 ½ mile below Red River Campground	11T	633155	5067995	A
Red River	1	RKM 0.6	11T	618767	5073249	P
Red River	2	RKM 0.6	11T	618743	5073377	P
Red River	2	RKM 0.7	11T	618759	5073216	P
Red River	1	RKM 0.99	11T	618756	5072948	P
Red River	1	RKM 3.43	11T	620462	5072076	P
Red River	2	RKM 3.43	11T	620446	5072073	P
Red River	1	RKM 5.0	11T	621663	5072366	P
Red River	2	RKM 5.0	11T	621784	5072139	P
Red River	2	RKM 6.0	11T	622398	5072613	P
Red River	1	RKM 6.4	11T	622676	5072813	P
Red River	1	RKM 7.0	11T	623294	5073057	P
Red River	2	RKM 6.0	11T	622331	5072837	P
Red River	2	RKM 7.0	11T	623205	5073264	P
Red Horse Creek	3	approx. 2 miles up from mouth	11T	626491	5074740	A
S.F. Red River	2	¼ mile above Red River ranger station	11T	628908	5062667	A
S.F. Red River	3	4.5 mi blw mouth, 1 mi above Trapper Crk	11T	628158	5059222	A
S.F. Red River	3	approx. ½ mile below Trapper Creek	11T	629156	5059414	A
S.F. Red River	3	approx. 1 ½ mile below Trapper Creek	11T	629470	5060184	A
S.F. Red River	3	approx. 1 mile below Trapper Creek	11T	629539	5060565	A
S.F. Red River	3	approx. 1 ¼ mile from mouth	11T	629321	5061440	A

Appendix B. Continued.

Clearwater River Drainage						Status 2006
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
		South Fork Clearwater River				
S.F. Clearwater River	1	Mile marker 38	11T	609616	5075170	P
S.F. Clearwater River	1	Crooked River bridge	11T	614488	5075498	P
S.F. Clearwater River	1	300 m above Cougar Creek	11T	588746	5074676	P
S.F. Clearwater River	1	30 m above Johns Creek	11T	586353	5074897	P
S.F. Clearwater River	1	.80 km below Castle Creek Campground	11T	579557	5075693	P
American River	2	BLM day picnic site East of Elk City	11T	623183	5077492	A
American River	2	0.75 km up Trailhead 443	11T	619636	5084038	A
American River	2	0.37 km up Trailhead 443	11T	619739	5083802	A
American River	2	100 m south of campground	11T	620293	5083544	A
American River	2	2 km USFS boundary Road 443	11T	620430	5083042	A
American River	2	1 km below bridge Road 443	11T	620716	5081910	A
American River	2	50 m down bridge Road 1189	11T	623199	5077815	A
American River	2	1 km down bridge Road 1189	11T	623180	5077487	A
American River	1	1 km down Buffalo Gulch	11T	619021	5074739	A
American River	2	2 km up from mouth	11T	618879	5074152	A
American River	1	0.5 km up from mouth	11T	618557	5073994	A
Crooked River	1	1.6 km up from mouth	11T	614468	5074033	A
Johns Creek	1	10 m above mouth	11T	617079	4962360	A
Johns Creek	2	50 m below gauge	11T	586354	5074805	A
Leggett Creek	3	2.1 km above mouth (~50 m above brdg)	11T	605464	5076619	A
Little Elk	3	0.1 km down closed Road 686.1	11T	617516	5083280	A
Meadow Creek	2	1.6 km below McComas Meadows	11T	583845	5081626	A
Meadow Creek	2	approx. 10 m from mouth	11T	583345	5075392	A
Meadow Creek	3	where Road 244 crosses the creek	11T	587186	5085100	A
Meadow Creek	3	McComas Meadow at bridge	11T	583754	5082220	A
Mill Creek	3	0.4 km up	11T	582808	5074990	A
Newsome Creek**	2	up the trail, Newsome townsite	11T	606300	5085090	A
Newsome Creek**	1	below fish weir	11T	607691	5075885	A
Newsome Creek**	1	above cattle guard	11T	607386	5080955	A
Newsome Creek**	2	1.5 km up from mouth	11T	607242	5077169	A
Newsome Creek**	2	2.25 km up Newsome Creek Road from highway turnoff	11T	607249	5077183	A
Ten Mile	3	35 m up from mouth	11T	602329	5073159	A
Ten Mile Creek	3	100 m below Sourdough Road bridge	11T	604364	5068147	A
W.F. American River	3	1.0 km down Table Meadow	11T	616194	5087682	A

Appendix B. Continued.

Clearwater River Drainage — **Status 2006**

River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
		Selway River				
Selway River	1	150 m below Slide Creek	11T	619797	5104309	P
Selway River	1	0.3 km below Race Creek	11T	632592	5100228	P
Selway River	1	3.8 km below Gedney Creek	11T	627024	5102736	P
Selway River	1	150 m above Gedney Creek	11T	630609	5101407	P
Selway River	1	Johnson Bar (across from Goddard Crk)	11T	611608	5106137	P
Selway River	2	0.9 km above Road 443 bridge	11T	632225	5100248	P
Selway River	2	1.0 km above mouth of Meadow Creek	11T	632865	5100150	P
Selway River	2	0.81 km down from mouth Bear Creek	11T	666953	5098663	P
Selway River	2	under bridge at Selway Lodge	11T	667125	5096593	P
Selway River	3	0.81 km up from Shearer airstrip	11T	667346	5093997	A
Selway River	3	2.4 km up from Shearer airport	11T	667419	5093120	A
Bear Creek	2	50 m from Selway Trail brdg at Bear Crk	11T	667486	5098216	A
Deep Creek	3	1 km up from mouth	11T	677957	5064119	A
Ditch Creek	3	50 m from mouth	11T	666978	5096240	A
Elk Creek	3	80 m up from mouth	11T	667441	5095767	A
Gedney Creek	1	at the mouth	11T	630475	5101567	A
Indian Creek	3	65 m up from mouth	11T	673847	5073046	A
Little Clearwater River	3	140 m up from mouth	11T	unknown	unknown	A
Meadow Creek	2	0.5 km above mouth	11T	632039	5099700	A
Whitecap Creek	3	1.5 km up mouth	11T	675963	5081361	A
		Snake River				
Snake River	2	2 km below Salmon River	11T	514153	5080658	P
Snake River	1	1.0 km above Heller Bar	11T	503089	5102437	A
Snake River	1	1.5 km below Heller Bar	11T	503408	5104959	A
Snake River	1	80 m blw Billy Creek boat ramp (ID side)	11T	504030	5107655	A
Snake River	1	200 m above Captain John Creek	11T	505139	5110606	A
Snake River	1	2 km below Buffalo Eddy	11T	503867	5115320	A
Snake River	1	1.5 km below Couse Creek	11T	503432	5119877	A
Snake River	1	6.6 km above Asotin	11T	500031	5127765	A
Snake River	1	Hells Gate Park S end, swimming beach	11T	495394	5133994	A
Snake River	2	Hells Gate North end	11T	495394	5133994	A
Snake River	2	E side Confluence Island, 75 m abv WA	11T	497400	5141506	A
Snake River	2	2 km below Salmon River	11T	516733	5074792	A
Snake River	2	approx. 9 km below Salmon River	11T	510190	5086407	A
Snake River	2	0.5 km below Captain John Creek	11T	505767	5111393	A
Snake River	2	0.5 km below Billy Creek	11T	504926	5108754	A

Appendix B. Continued.

Salmon River Drainage						Status 2006
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
		East Fork Salmon River				
E.F. Salmon River	2	150 m above FS station, blw hot springs	11T	700423	4872006	A
E.F. Salmon River	3	Germania Trailhead	11T	703419	4880317	A
E.F. Salmon River	2	200 m below Sheep Creek	11T	703724	4883396	A
E.F. Salmon River	2	2.6 km below Jimmy Lake Road	11T	712995	4891019	A
E.F. Salmon River	2	2 km blw Herd Crk, 50 m abv Road Crk	11T	716643	4895996	A
E.F. Salmon River	2	0.7 km above the mouth	11T	714094	4904167	A
E.F. Salmon River	2	just below Herd Creek Road bridge	11T	715963	4892631	A
West Pass Creek	3	0.75 km above the mouth	11T	701760	4872814	A
Herd Creek	3	1.3 km above the mouth	11T	718750	4891566	A
Herd Creek	3	2.5 km above mouth	11T	717562	4890679	A
Germania Creek	3	0.4 km above the mouth	11T	703332	4879064	A
Deer Creek	3	Germania trailhead (mouth of Deer Crk)	11T	703438	4880321	A
Boulder Creek	3	1.3 km above the mouth	11T	704393	4887890	A
		Lemhi River				
Lemhi River	2	at sportsman access past Tendoy	12T	292758	4971347	A
Lemhi River	3	2.6 km above Hayden Creek	12T	293021	4968963	A
Lemhi River	2	1.0 km below Muddy Creek	12T	291853	4979461	A
Lemhi River	2	10.2 km below Muddy Creek	12T	290561	4988648	A
Lemhi River	2	0.66 km above mouth, behind Saveway	12T	273518	5006290	A
Lemhi River	2	at Sacajawea Center, 3.9 km abv mouth	12T	275151	5005373	A
Lemhi River	2	60 m above McFarland BLM access	12T	297159	4963957	A
Hayden Creek	3	55 m above Hayden Pond foot bridge	12T	289501	4968218	A
Hayden Creek	3	50 m below Bear Valley Creek	12T	285782	4961053	A
Texas Creek	3	at bridge on Hwy Idaho Falls	12T	315632	4944489	A
		Little Salmon River				
Little Salmon River	2	Meadow Creek Resort	11T	556520	4983694	A
Little Salmon River	2	150 m above hwy jct W Smoky Bldr Rd	11T	555198	4996678	A
Little Salmon River	2	Highway 55/95 rest area	11T	550956	5020963	A
Little Salmon River	2	Hwy 55/95 bridge 0.3 km above Hzrd Crk	11T	554963	5003075	A
Big Creek	3	10 km upstream of New Meadows	11T	560580	4968984	A
Big Creek	3	13 km above New Meadows	11T	561512	4967496	A
Boulder Creek	3	2.4 km down from Ant Basin Road	11T	544843	4996346	A
Boulder Creek	3	4.8 km down from Ant Basin Road	11T	546051	4997701	A
Boulder Creek	3	0.4 km downstream from Lower Boulder Creek Road	11T	549041	5001059	A
Goose Creek	3	1 km below Last Chance campground	11T	563887	4981322	A
Hard Creek	3	50 m up from mouth	11T	556337	5003274	A
Hazard Creek	3	20 m up from Hard Creek	11T	556347	5003348	A

Appendix B. Continued.

Salmon River Drainage						Status 2006
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
Mud Creek	3	Junction Mud Creek / 051 Road	11T	548851	4988589	A
Rapid River	2	1.6 km upstream from Rapid R. hatchery	11T	546548	5020475	A
Rapid River	2	80 m above West Fork	11T	545655	5016778	A
Rapid River	2	1.3 km below West Fork	11T	545858	5018369	A
		Middle Fork Salmon River				
M.F. Salmon River	2	0.9 km below Loon Creek (at RKM 45)	11T	673397	4964577	P
M.F. Salmon River	2	upper Grouse Camp	11T	676350	4970746	P
M.F. Salmon River	2	30 m above mouth of Camas Creek	11T	679901	4970746	P
M.F. Salmon River	2	sandy beach above bend by Aparejo Point Rapids	11T	679333	4976189	P
M.F. Salmon River	2	Mormon Ranch (RKM 30.0)	11T	679030	4979532	P
M.F. Salmon River	2	1.4 km above Foundation Creek	11T	669615	4961119	P
M.F. Salmon River	2	0.4 km above White Creek	11T	670721	4962198	P
M.F. Salmon River	2	0.2 km above Camas Creek	11T	679811	4973423	P
M.F. Salmon River	2	below Jackass Rapids	11T	679809	4973413	P
M.F. Salmon River	2	above mouth of Woolard Creek	11T	679232	4991746	P
M.F. Salmon River	2	0.7 km above Papoose Creek	11T	678675	5005414	P
M.F. Salmon River	2	0.5 km above confluence of Salmon R.	11T	688197	5018364	P
M.F. Salmon River	2	0.3 km below Stoddard Creek	11T	682697	5011557	P
M.F. Salmon River	2	0.67 km below Nolan Creek	11T	684139	5013611	P
M.F. Salmon River	2	100 m above boat launch	11T	635711	4932157	A
M.F. Salmon River	2	beach at Gardels Hole Campsite	11T	634741	4936690	A
M.F. Salmon River	2	2 m above Spike Creek	11T	636896	4941183	A
M.F. Salmon River	2	1.5 km below Rapid River	11T	646543	4949985	A
M.F. Salmon River	2	0.3 km above Pistol Creek	11T	646542	4953858	A
M.F. Salmon River	2	0.2 km below Indian Creek	11T	651163	4959203	A
M.F. Salmon River	2	0.3 km below Indian Creek	11T	651123	4959188	A
M.F. Salmon River	2	300 m below Marble Creek	11T	656655	4956317	A
M.F. Salmon River	2	1.0 km above Range Creek	11T	661037	4954296	A
M.F. Salmon River	2	0.5 km from mouth of Mahoney Creek	11T	664510	4957376	A
M.F. Salmon River	2	0.4 km below Foundation Creek	11T	668216	4960417	A
M.F. Salmon River	2	1.3 km above Foundation Creek	11T	669600	4961137	A
M.F. Salmon River	2	0.7 km above Placer Creek	11T	687318	5019689	A
Bear Skin Creek	3	1 km above mouth	11T	620064	4917849	A
Bear Valley Creek	1	0.6 km below Pole Creek	11T	629619	4916477	A
Bear Valley Creek	1	20 m above Elk Creek	11T	629680	4918534	A
Bear Valley Creek	1	50 m above Sack Creek	11T	626872	4912758	A
Bear Valley Creek	1	bridge on Cub Crk, ~14.0 km abv mouth	11T	621432	4908657	A
Bear Valley Creek	1	2.6 km below Cub Crk Rd (at campsite)	11T	624856	4910456	A
Bear Valley Creek	1	50 m below Cache Creek	11T	626085	4911380	A

Appendix B. Continued.

Salmon River Drainage						**Status 2006**
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
Big Creek	3	at the mouth of Smith Creek	11T	639420	5001124	A
Big Creek	3	0.75 km above Edwardsville	11T	631427	4995790	A
Big Creek	3	300 m below Bighorn bridge	11T	677765	4995593	A
Cache Creek	3	300 m above mouth (~100 m abv brdg)	11T	626121	4911095	A
Camas Creek	3	0.1 km above mouth	11T	unknown	unknown	A
Cape Horn Creek	3	1 km above highway bridge	11T	645399	4916366	A
Cape Horn Creek	3	1 km above highway bridge	11T	645515	4916644	A
Elk Creek	1	5 km below North Fork	11T	625261	4919735	A
Elk Creek	1	100 m above mouth	11T	629565	4918623	A
Marsh Creek	1	1.5 km below Lola Creek Campground	11T	644859	4918648	A
Marsh Creek	1	1 km above Camp Creek	11T	646817	4916313	A
N.F. Elk Creek	2	200 m above mouth	11T	621666	4919177	A
Pistol Creek	3	0.5 km from mouth	11T	646278	4953701	A
		North Fork Salmon River				
N.F. Salmon River	2	2.6 km above Hughes Creek	12T	268326	5041841	A
N.F. Salmon River	2	0.66 km above the mouth	12T	265875	5033309	A
N.F. Salmon River	2	N.F. Ranger Station (2.5 km above Hughes Creek	12T	267962	5041441	A
		Pahsimeroi River				
Pahsimeroi River	3	upper section at culvert	12T	288064	4905114	A
Pahsimeroi River	3	under bridge just above mouth	11T	733945	4952766	A
Big Creek	3	confluence of south and north forks	12T	292836	4923891	A
		Salmon River				
Salmon River	1	3 km above Mackay Bar	11T	619092	5029349	P
Salmon River	1	100 m below Corn Creek	11T	681285	5026289	P
Salmon River	1	0.66 km above Middle Fork	11T	689893	5019233	P
Salmon River	1	0.37 km above Owl Creek	11T	700280	5021542	P
Salmon River	1	3.3 km above Panther Creek	11T	706998	5023035	P
Salmon River	1	350 m above Shoup	11T	713515	5028610	P
Salmon River	1	at Indian Creek at Indianola	11T	721631	5030877	P
Salmon River	1	0.66 km below North Fork	11T	734127	5032386	P
Salmon River	1	0.8 km below mouth of N.F. Salmon R.	11T	734205	5032286	P
Salmon River	1	15 m above Lucile BLM boat ramp	11T	554259	5040595	P
Salmon River	1	Shorts Bar	11T	554608	5028886	P
Salmon River	1	4 km above Lake Creek	11T	563642	5028810	P
Salmon River	1	150 m below Fall Creek	11T	579469	5031197	P
Salmon River	1	0.75 km above Big Mallard Creek	11T	635542	5044186	P
Salmon River	1	1.2 km above Whitewater Ranch	11T	633499	5043638	P
Salmon River	2	80 m abv Hwy bridge (Scenic Byway 79)	11T	679755	4861166	A

Appendix B. Continued.

Salmon River Drainage						**Status 2006**
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
Salmon River	2	2.6 km above Stanley Highway	11T	680706	4859142	A
Salmon River	2	2.6 km abv Sawtooth Hatchery (turnout)	11T	670541	4887686	A
Salmon River	2	1.3 km above Williams Creek	11T	670920	4884079	A
Salmon River	2	below Hell Roaring Creek	11T	673488	4877631	A
Salmon River	2	1 km abv Blaine-Custer Co Hwy bridge	11T	674236	4873837	A
Salmon River	2	50 m above Pole Creek Road bridge	11T	677594	4863157	A
Salmon River	1	1.3 km above Red Fish Lake Creek	11T	669013	4892047	A
Salmon River	1	3.9 km below Lower Stanley, bluff on SE side of river	11T	668610	4900846	A
Salmon River	1	10.5 km below Lower Stanley	11T	676410	4903283	A
Salmon River	1	O'Brian Campground	11T	683866	4902903	A
Salmon River	2	at Coleman Campground	11T	687165	4902392	A
Salmon River	1	150 m below mouth of E.F. Salmon R.	11T	713432	4905189	A
Salmon River	1	at mouth of Horse Creek	11T	718654	4917317	A
Salmon River	2	2 km blw Challis Crk at sportsman access	11T	724181	4936420	A
Salmon River	2	at Cottonwood Recreational Area	11T	731502	4950078	A
Salmon River	2	1 km below Cow Creek	11T	737217	4956509	A
Salmon River	1	Kilpatrick access point	11T	263907	4968209	A
Salmon River	3	Deadwater picnic area	11T	730946	5030004	A
Salmon River	1	at Bobcat Gulch sportsman access	12T	267746	5027662	A
Salmon River	1	Morgans Bar	12T	271953	5015073	A
Salmon River	1	at Fourth of July sportsman access	12T	269319	5026929	A
Salmon River	2	200 m below Camp Creek at BLM access	12T	267728	4984243	A
Salmon River	2	at 8 mile BLM access	12T	271312	4994995	A
Salmon River	1	100 m above Hammer Creek boat launch	11T	552626	5067782	A
Salmon River	1	100 m abv S Twin brdg, W side of river	11T	555112	5056497	A
Salmon River	1	250 m above Elkhorn Creek	11T	571214	5027989	A
Salmon River	1	Vinegar Creek boat ramp, end of road	11T	586607	5034433	A
Bargamin Creek	2	at USFS campground	11T	653038	5064903	A
Basin Creek	3	1 km above mouth	11T	673534	4903728	A
Challis Creek	3	Mill Creek Road, 30 m above bridge	11T	716430	4937560	A
Crooked Creek	3	Dixie Ranger Station	11T	616171	5041752	A
Eagle Creek	3	3.4 km up from mouth	11T	520785	5095896	A
Eagle Creek	3	0.16 km up from mouth	11T	523024	5093900	A
French Creek	3	3 km from mouth	11T	575679	5027387	A
French Creek	3	0.25 km up from mouth	11T	576226	5029792	A
Little Whitebird Creek	3	10 m up from Road 642 culvert	11T	570692	5066065	A
Mallard Creek	3	at Whitewater Ranch Road	11T	632023	5048428	A
Mallard Creek	3	3.2 km hike, 200 m up from mouth	11T	634999	5044037	A
Panther Creek	2	2.0 km above mouth	11T	704714	5019901	A

Appendix B. Continued.

Salmon River Drainage						**Status 2006**
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
Panther Creek	2	1.3 km above Cobalt	11T	716512	4995742	A
Panther Creek	2	2.6 km below Naipas Creek	11T	715823	5004112	A
Pole Creek	3	2.6 km above mouth	11T	680205	4864099	A
Slate Creek	3	1.6 km down from Little Slate	11T	572245	5052947	A
Slate Creek	3	3.2 km down from North Fork	11T	566228	5052889	A
Slate Creek	3	0.8 km up frm USFS bndry by Hurley Crk	11T	562822	5053631	A
Smiley Creek	3	2 km above Smiley Creek Lodge	11T	676523	4860785	A
S.F. Whitebird Creek	3	40 m down from Road 642	11T	572775	5068205	A
Valley Creek	2	0.66 km abv closed brdg on Valley Crk Rd	11T	654246	4909201	A
Valley Creek	2	19.7 km abv mouth at sportsman access	11T	657488	4906280	A
Valley Creek	2	5.3 km above Stanley	11T	659878	4900356	A
Whitebird Creek	2	1.6 km down from North Fork	11T	559209	5071050	A
		South Fork Salmon River				
S.F. Salmon River	1	~50 m abv Cougar Crk trail road bridge		601454	4972280	A
S.F. Salmon River	1	4.5 km below Secesh River (road end)		605326	4988947	A
S.F. Salmon River	2	Fitsum Creek (across from mouth)		600791	4983518	A
S.F. Salmon River	1	2 km above Krassell		600316	4978918	A
S.F. Salmon River	1	Buck Horn Cmpgrnd (single site on river)		599625	4976686	A
S.F. Salmon River	2	S.F. guard station (just below bridge 337)		611626	5003222	A
S.F. Salmon River	1	9.5 km below Warm Lake Creek		603537	4953598	A
S.F. Salmon River	1	4.0 km above mouth of Warm Lake Crk		603690	4943324	A
S.F. Salmon River	1	Stolle Meadows Campground		604553	4939087	A
Blackmare Creek	3	10 m up from mouth		602483	4963881	A
Buckhorn Creek	3	first bridge above mouth		599631	4974597	A
Cabin Creek	3	S.F. Salmon Road		604361	4946569	A
Dollar Creek	3	30 m above mouth		603394	4952691	A
E.F. of S.F. Salmon R.	2	3 km above road bridge		620281	4979670	A
E.F. of S.F. Salmon R.	2	just above mouth of Profile Crk (~1.0 m)		623980	4979263	A
E.F. of S.F. Salmon R.	2	10 km above mouth		609210	4977976	A
Johnson Creek	2	48.3 km above mouth		619384	4976786	A
Johnson Creek	2	0.8 km above Icehole Campground		618215	4970516	A
Lake Creek	2	~1.5 km above mouth		585897	5012787	A
Secesh River	2	Chinook Campground		593529	5007293	A
Summit Creek	2	2 km above mouth		585856	5010574	A
Trail Creek	3	6 km up from mouth		601952	4943274	A
Warm Lake Creek	3	0.2 km down S.F. Salmon River Road		604350	4946429	A
Warren Creek	3	2 km below Warren / Burgdorf Road		601817	5015476	A

Appendix B. Continued.

Salmon River Drainage						**Status 2006**
River/Creek	Sampling Hierarchy	Location	GPS (NAD 27) Zone	GPS (NAD 27) Easting	GPS (NAD 27) Northing	Present/ Absent
		Yankee Fork Salmon River				
Yankee Fork	2	200 m above Custer Cemetery		684812	4918116	A
Yankee Fork	2	0.66 km above Jordan Creek		682090	4916508	A
Yankee Fork	2	2.6 km above mouth		682093	4907286	A
W.F. Yankee Fork	2	1.1 km above mouth		680674	49913483	A

Salmon River	1's	46
	2's	85
	3's	56
		187
Clearwater	1's	41
	2's	53
	3's	30
		124
Snake	1's	9
	2's	7
	3's	0
		16

Appendix C. Habitat utilization determination and associated sampling protocols from Claire (2003).

METHODS

IDFG determined the 41 1-kilometer Red River sections on USGS 1:24,000 quadrangle maps from mouth to headwaters. In 2000-2002 one-hundred meter subsample stream reaches were randomly selected from 41 1-kilometer sections and the stream habitat was classified as pool, riffle, glide, etc., using a modified version of stream classification methodology utilized in Platts et al. (1983) and Overton et al. (1997). Stream habitat measurements taken in sampled habitat units included: wetted width, channel width, habitat unit length, maximum depth, average flow velocity, substrate (cover) size percent composition, stream temperature, and riparian canopy cover percent (shade). In 2001 and 2002 random sampling was restricted to Red River downstream of rkm 7.5 to in order to adjust to known Pacific lamprey distribution.

The substrates within habitat units (riffles, pools, etc.) were visually classified using Platts et al. (1983) size classification. Substrate classification transects perpendicular to the thalweg of the stream channel at three points (25%, unit center, and 75% of the distance from the downstream to upstream boundary) in a habitat unit were used to augment and calibrate visual estimation in 2000. Water velocity measurements were taken with a mechanical flow meter 1.0 cm above substrate (Hammond 1979a) and at 60% of depth above the substrate in a habitat unit; at 25% from left bank, stream center, and 25% from right bank. Habitat unit flow velocity measurements were also taken at 20% and 80% of depth (at the three locations) above the substrate if the depths were greater than two meters. Maximum depth was recorded in individual units. Individual water velocity and site depth measurements were taken over substrates where Pacific lamprey ammocoetes were captured on emergence. Individual site emergence flow velocity measurements for each unit were averaged. Substrates yielding Pacific lamprey ammocoetes were documented. Canopy cover (shade) values were obtained using a standard concave forestry densiometer with only 17 of the total 25 squares corner points uncovered. Readings at three locations left bank, right bank, and stream center were taken in a habitat unit at one-half the distance from downstream boundary to upstream boundary. The densiometer was held 30 cm above the water surface and 30 cm from the wetted edge while obtaining left bank, and right bank readings. Upstream and downstream (2 total) readings were taken at stream center 30 cm above the water surface. The total of counted densiometer squares for an individual location was multiplied by 1.5, (normal densiometer readings utilize 25 uncovered points, 17 x 1.5 = ~25 (25.5)) yielding a reading of one-quarter of the total stream shade. The four measurements were summed to obtain canopy cover in a unit.

The habitat types in the 100 m reaches were electroshocked systematically with an Engineering Technical Services ABP-2 electroshocker from the downstream habitat type, working upstream without repeating sampling in like habitat types. Stream habitat units were electroshocked from bank to bank working upstream from the lowermost point of the riffle, pool, glide, etc., being sampled to the upstream end to ensure complete coverage of the unit. Effective electrofisher settings were optimized, recorded, and repeated throughout units electrofished to standardize effort. Electroshocking elapsed times were recorded and electroshocking effort per unit of area was expressed as m^2 electroshocked/minute. Pacific lamprey abundance in a unit was expressed as ammocoetes/100 m^2.

Pacific lamprey ammocoete minimum population estimates in Red River were completed following Pajos and Weise (1994) and Morkert (1993) methodology, however, a one-pass effort was utilized to minimize impact to lamprey. The electroshocking catch per unit of area fished (lamprey/100 m^2) for individual habitat types was expanded for total habitat type area in a 100 m section. The Pacific lamprey densities were averaged for individual habitat types in a 100 m section and multiplied by the estimated stream habitat type area per kilometer of stream section. Minimum population estimates were determined for individual kilometers utilizing Pacific lamprey average density information obtained in corresponding kilometer reaches.

Non-random presence-absence electroshocking surveys were conducted on potential Pacific lamprey ammocoete habitat sites in the mainstem South Fork Clearwater River (SFCR), tributaries, Red River, and the South Fork of Red River. Selection of sites was determined utilizing initial sampling information indicating Pacific lamprey ammocoete preferred habitat. Five sites were sampled in upper Red River upstream of rkm 24.0, six in the South Fork of Red River (rkm 1.5 to rkm 8.0), and 23 in the main SFCR (mouth to Red River) and tributaries. Capture locations were recorded and mapped in order to assess distribution of Pacific lamprey ammocoetes in the SFCR basin and Red River subbasin.

Three downstream migrant traps currently operated by IDFG in the SFCR drainage were used to monitor Pacific lamprey ammocoete and macrothalmia downstream movements and assist in determining SFCR drainage Pacific lamprey distribution. Traps were operated 24 hours and checked twice daily (a.m., and p.m.). The Crooked River scoop trap (rkm 1.0) was operated in 2000 and 2001. In 2002 a 1.50 m diameter rotary screen trap replaced the scoop trap on Crooked River. A 1.50 m diameter rotary screen trap on American River (rkm 3.0) and another 1.50 m diameter rotary screen trap on Red River (rkm 5.0) were operated in 2000, 2001, and 2002. Red River rotary screen trap historical records (1992-1999) were examined to augment Pacific lamprey 2000-2002 downstream migration information. Outmigrant estimates past traps were made using (Beamish and Levings 1991) trap-area fished methods.

Captured Pacific lamprey were anesthetized, enumerated, measured for total length, weighed, and released near the capture location following recovery in fresh water. Pacific lamprey (>100 mm TL) captured while electroshocking were marked with injections of florescent orange elastomeric solution (0.5 cm in length) under the skin. Mark orientation and location was differentiated to distinguish between field seasons with marks in 2000 on the left side, posterior to the gill openings, and in 2001 on the right side, posterior to the gill openings. No Pacific lamprey ammocoetes were marked in 2002 due to the limited potential for recapture and the stress of marking to the individual ammocoetes.

Eight kilometers of Red River and its tributaries with suitable substrates (Red Horse Creek, South Fork of Red River) were visually surveyed for spawning adult Pacific lamprey from April 19 to July 7 in 2000 (Appendix A1). Seven kilometers of Red River and its tributaries were surveyed from April 30 to July 1 in 2001. In 2002, 0.3 km of Red River were surveyed once on June 7. In 2000 redd surveys were primarily upstream of Red River rkm 13.0. In 2001 redd surveys were expanded to include habitat in the Red River rkm 7.5 section and the lower reaches of Red Horse Creek. Redd surveys were reduced to one section in 2002 due to the suspected limited number of adult spawners in the subbasin.

Red River stream temperature information was obtained from the (IDFG) Red River trap (rkm 5.0) and plotted to determine maximum annual stream temperature in the subbasin. Stream temperature and substrate temperature were both measured at ten Red River sites on August 9, 2001. The substrate temperatures were obtained at 10.0 cm beneath the substrate surface in fine gravel-fine silt deposits.

ANALYSIS

Pacific lamprey ammocoete habitat preferences were analyzed with Analysis of Variance (ANOVA). For analysis, Pacific lamprey density (ammocoetes/m^2) values for individual habitat types were utilized. The natural log average Pacific lamprey ammocoete density values for individual lateral scour pools, riffles, rapids, etc., were analyzed to determine if mean Pacific lamprey densities were different. The Pacific lamprey density values in lateral scour pool and straight scour pool habitats were analyzed as "lateral scour pool" (a single habitat type) average densities due to similarity in the structure of the two habitats. The riffle and riffles with pockets (pocket water) densities were combined and analyzed as "riffles" due to similarity in the structure of the two habitats. ANOVA requires an average value (of two or greater samples), therefore the single alcove habitat unit Pacific lamprey density was not included in ANOVA of the ammocoete density and habitat type relationship.

The Pacific lamprey ammocoete density relationship to stream habitat unit parameters (water velocity, maximum depth, canopy cover (shade), and substrate type) were assessed through linear regression and modeled with best fit step-wise multiple regression. To simplify analysis, Pacific lamprey ammocoetes/m2 natural log values rather than ammocoetes/100 m^2 were utilized. Linear and multiple regression F-tests ($\alpha = 0.05$) were utilized to determine the strength of the relationship between ammocoete density and stream parameters. The Pacific lamprey ammocoete densities obtained in alcove habitat and one lateral scour pool were excluded from linear and multiple regression of the velocity, substrate, maximum depth, and canopy cover parameters.

Initial sampling in Red River indicated Pacific lamprey ammocoete density differences were minimal when comparing substrate size classes (fine sand, sand, coarse sand etc.). Therefore substrate classes (fine sand, coarse sand etc.) were combined into three classifications: "coarse" (large boulder, small boulder, cobble), "medium" (course gravel, medium gravel, fine gravel), and "fine" (course sand, fine sand, silt/organic) and analyzed in relationship to Pacific ammocoete densities in the corresponding units.

Severe difficulty was encountered visually identifying individual ammocoete emergence sites when multiple ammocoetes emerged simultaneously. As a result there were numerous occasions when accurate measurement and calculation of site of emergence stream velocities, depths, and canopy cover was not possible. The habitat unit average velocities, maximum depths, and canopy cover measurements (rather than individual site of emergence) for corresponding units were incorporated in order to analyze the Pacific lamprey ammocoete density in response to the parameters.

Appendix D. Pacific lamprey adult translocation protocols as discussed in Howard et al. (2005).

METHODS

Outplanting

Collection

Adult lampreys (n = 133) were collected by the United States Geological Survey (USGS) for experiments in August, 2003 from Bonneville Dam. USGS provided the CTUIR Lamprey Research and Restoration Project with the lampreys on January 27, 2004. Lampreys were transported to the Minthorn Springs acclimation facility located on Minthorn Springs Creek at the mouth of the Umatilla River at river kilometer 103. The lampreys were held at the Minthorn Springs facility to allow adults to reach maturation with ambient river water temperatures.

Maintenance

All lampreys transported to the Minthorn Springs facility were treated with oxytetracycline at a dose of 10 mg kg-1 for bacterial infections prior to being placed in tanks. Fish were maintained in ~ 1,000 liter, 1.2 x 1.2 x 1.2 meter bonar tanks, using Minthorn Spring river water. Water was supplied to the tanks with a 1/2 horsepower submersible pump. Water is pumped into a head distribution tank that is located 2.1 meter above grade, through 2 cm hose and fittings, and is gravity fed to each holding tank. Effluent lines are also gravity fed, and are placed in holdings tanks, so if for any reason the pump fails, the holding tanks will not lose water. Lampreys were maintained in outdoor tanks and were therefore subjected to a natural photoperiod. Water flowed directly from the river channel into the tanks, and therefore water temperature was near ambient.

Timing of Release

Efficient management of brood stock depends upon an accurate prediction of sexual maturity and ripeness. Lamprey sexual maturity (ripeness) is often accompanied by external changes in body shape, and pigmentation. In general females tend to swell and become gorged with eggs making it possible to determine ripeness by detecting a softening of the belly wall. In addition, both males and females change from a blue to brown color when ripe. Males exhibit a similar softening of the belly wall, and easily expel sperm when the abdomen is pressed. Lampreys were checked weekly for ripeness beginning in early April when water temperatures reached 10º C. When at least 25 percent of males began spermiating, lampreys are considered ready to be released into spawning areas of the channel.