2.0 FISHERIES OVERVIEW AND SUMMARY OF PAST INFORMATION

2.1 DESCRIPTION AND PURPOSE

The Klamath Hydroelectric Project (Project) consists of seven mainstem hydroelectric facilities on the Upper Klamath River and one tributary hydroelectric facility on Fall Creek. PacifiCorp owns and operates the Project under a single license issued in 1956 by the Federal Energy Regulatory Commission (FERC). The 50-year license contains requirements that define and regulate Project operations. The existing license expires on March 1, 2006.

2.2 OBJECTIVES

PacifiCorp is applying for a new license in a process called relicensing. This process considers the effect of the Project on many resource areas including fisheries. There are four main components to the fisheries study: fisheries investigation, instream flow, ramping and flow fluctuations, and fish passage. Theses studies will assist PacifiCorp and other stakeholders involved in the relicensing process (such as the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries, previously known as National Marine Fisheries Services, or NMFS]) and U.S. Fish and Wildlife Service [USFWS]) in making informed decisions.

The objectives addressed by this section are as follows:

- Summarize existing literature to describe the fishery downstream of Iron Gate Dam, upstream of Link River Dam, and the Klamath River tributaries in the Project area.
- Summarize existing lamprey literature and convene a workshop.

2.3 RELICENSING RELEVANCE AND USE IN DECISIONMAKING

PacifiCorp's application for Project relicensing is being prepared according to Section 18 of the Code of Federal Regulations (CFR), Part 4.50-4.51 Subpart F, Application for License for Major Project-Existing Dam*,* and Part 16.8, Consultation Requirements. PacifiCorp intends to consider Project capabilities as a cost-effective and reliable energy resource, and balance these capabilities with identified societal needs. The regulations require equal consideration of power generation, aquatic and terrestrial resources, recreational opportunities, cultural resources, aesthetics, and appropriate land management.

Section 18 CFR 4.51 (f)(3), Report on Fish, Wildlife, and Botanical Resources, requires a report discussing fish, wildlife, and botanical resources near the Project and the impact of the Project on those resources, and requires that the report be prepared in consultation with the relevant state and federal agencies. Information and analyses developed will assist PacifiCorp in responding to the fish resource requirements of the relicensing application.

Other pertinent regulations include, but are not necessarily limited to, the following.

2.3.1 Federal Power Act (FPA) Section 10(a)(1)

FERC must ensure that the Project to be licensed is best adapted to a comprehensive plan for developing the waterway for beneficial public purposes. In making this judgment, FERC considers comprehensive plans (including those that are resource-specific) prepared by federal and state entities and the recommendations of federal and state resource agencies, Indian tribes, and the public, affected by the proposed Project. PacifiCorp is developing a license application that is complementary to comprehensive plans along the Klamath River.

2.3.2 FPA, Section 18 Fish Passage Prescriptions

- NOAA Fisheries and the USFWS have a regulatory role in hydropower licensing and relicensing that involves providing technical evaluations on the impacts of hydroelectric power projects to fish and wildlife resources. Both agencies have authority under Section 18 of the FPA to mandate prescriptions for fish passage. This can include provisions for both upstream and downstream facilities.

2.3.3 FPA, Section 31(a)

After a license is issued, FERC monitors the licensee's compliance with the conditions of the license. Failure to comply with these conditions would subject the licensee to civil penalties or even rescission of the license.

2.4 METHODS AND GEOGRAPHIC SCOPE

2.4.1 Geographic Scope

The Project study area contains six river reaches and four reservoirs on the mainstem of the Klamath River, extending from river mile (RM) 282.3 at Upper Klamath Lake/Agency Lake in Oregon to the Klamath River downstream of Iron Gate dam at RM 190.1 in California. Figure 2.4-1 depicts these water bodies, several other prominent study area features, and the Oregon-California border at RM 209.3. Table 2.4-1 lists and briefly describes the six river reaches and four reservoirs, proceeding downstream from Upper Klamath Lake/Agency Lake, that are affected by project operations. Also included are important tributaries in the study area upstream and downstream of Iron Gate dam.

Figure

2.4-1 Project area

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11 x 17, color

Figure 2.4-1

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Figure 2.4-1

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Figure 2.4-1

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Table 2.4-1. River reaches and reservoirs.

Name	Description
Link River	The Link River is approximately 1.2 miles (1.9 km) long. It extends from the 16-foot-high (4.9 m) Link River dam on Upper Klamath Lake at RM 254.3 to the upper end of Lake Ewauna on the Klamath River at RM 253.1.
Klamath River – Keno Reach	The Keno reach of the Klamath River is approximately 4.7 miles (7.6 km) long. It extends from the 25-foot-high (7.6 m) Keno dam on Lake Ewauna (also known as Keno reservoir) at RM 233.0 to the upper end of J. C. Boyle reservoir at RM 228.3.
Klamath River – J.C. Boyle Bypass Reach	The J.C. Boyle bypass reach of the Klamath River is approximately 4.3 miles (6.9 km) long. It extends from the 68-foot-high (20.7 m) J.C. Boyle dam at RM 224.7 to the discharge from the 80-megawatt (MW) J.C. Boyle powerhouse at RM 220.4.
Klamath River – J.C. Boyle Peaking Reach	The J.C. Boyle peaking reach of the Klamath River is approximately 17.3 miles (27.8 km) long. It extends from the J.C. Boyle powerhouse discharge at RM 220.4 to the upper end of Copco No. 1 reservoir at RM 203.1. The Oregon-California state line is at RM 209.3. The upstream 11.1 miles (17.9 km) of this river reach are in Oregon and have been federally designated as a Wild and Scenic River.
Klamath River – Copco No. 2 Bypass Reach	The Copco No. 2 bypass reach of the Klamath River is approximately 1.4 miles (2.3 km) long. It extends from the 38-foot-high (11.6 m) Copco No. 2 dam at RM 198.3 to the 27-MW Copco No. 2 powerhouse at RM 196.9.
Klamath River – Downstream of Iron Gate Dam	Iron Gate dam, located at RM 190.1, is the downstream-most hydroelectric facility of the Klamath Hydroelectric Project and the downstream-most dam on the Klamath River. Two fish ladders are associated with Iron Gate fish hatchery operations. The entrance to one fish ladder is adjacent to the powerhouse and leads to the hatchery's trapping, holding, and spawning facilities at the dam's base. The second fish ladder is located just upstream of the Klamath's confluence with Bogus Creek, approximately 0.5 mile (0.8 km) downstream of the dam, operating with water released from the hatchery water supply.
Keno Reservoir	Keno reservoir is more appropriately described as a widened part of the head of the Klamath River. This segment includes what is also referred to as Lake Ewauna.
J.C. Boyle Reservoir	The wide and shallow J.C. Boyle reservoir (944 acres) (382 ha) is surrounded by a low-gradient sloping shoreline in the upper reservoir near the inflow. Below the Highway 66 bridge, the reservoir begins to deepen as the canyon narrows.
Copco Reservoir	Copco reservoir (1,000 acres) is deeper than Keno and J.C. Boyle reservoirs. It is located in a relatively steep canyon and contains several coves with more gradual slopes.
Iron Gate Reservoir	The 944-acre (382 ha) Iron Gate reservoir is similar to Copco reservoir in that it is in a deep and relatively steep canyon. However, there are fewer coves and low-slope shore areas than at Copco.
Fall Creek	Fall Creek is a tributary to Iron Gate reservoir and includes a 1.5-mile bypass reach associated with the Fall Creek hydropower development. It enters the reservoir at RM 196.3, approximately 0.6 mile (1.0 km) from of the Copco No. 2 powerhouse discharge.
Spencer Creek	Spencer Creek, located in Oregon and a tributary to J.C. Boyle reservoir, is an important spawning tributary for redband/rainbow trout* populations in the Keno reach. Project operations do not affect this creek.
Shovel Creek	Shovel Creek, located in California, is known to be an important spawning tributary for rainbow trout living in the J.C. Boyle peaking reach, especially the California portion. Project operations do not affect this creek.
Tributaries Below Iron Gate Reservoir	Major tributaries are the Shasta River, the Scott River, the Salmon River, and the Trinity River. Project operations do not affect these tributaries.

* This fish is referred to as redband trout in Oregon and rainbow trout in California. To accommodate stakeholders' comments, we have attempted to keep references to this fish relevant to the state in which it was found.

Upper Klamath Lake/Agency Lake and the Klamath River downstream of Iron Gate dam represent the upper and lower bounds of the study area. Their inclusion in the study area is important because of the interconnected nature of fisheries and the effects upstream and downstream factors can have on fisheries in the study area. Fisheries descriptions and assessments presented in the following text address the 64.2-mile-long (103.3 km) segment of the Klamath River and important tributaries (Spencer, Shovel, and Fall Creeks) between Link River dam at RM 254.3 and Iron Gate dam at RM 190.1. This segment consists of 28.9 miles (46.5 km) of river reaches and 35.3 miles of reservoirs. It contains six of the seven generating facilities and the re-regulation dam associated with PacifiCorp's Klamath Hydroelectric Project. The seventh generating facility is located on Fall Creek, a tributary entering Iron Gate reservoir at RM 196.3. Fisheries descriptions also include to a limited degree the 190-mile-long (305.8 km) reach of the Klamath River downstream of Iron Gate dam and its major tributaries (Shasta, Scott, Salmon, and Trinity Rivers). This portion of the study area is of particular interest because of the effects flow regimes (including ramping) associated with the operations of the Project (and the U.S. Bureau of Reclamation [USBR], Klamath operations), as well as water quality, and fish passage barriers associated with the Project, can have on downstream fisheries and aquatic habitat.

2.4.2 Methods

This section describes results of previous fisheries investigations in the Project area. It also describes some of the general attributes of the fish assemblages that are present. This literature review begins with a general overview of the study area and its fish assemblage, then describes the fishery resources in each study area river reach, reservoir, and major tributary.

The literature review consisted of the following main components:

- Fisheries literature review of the Project area and downstream of Iron Gate dam and upstream of Link River dam
- Fisheries literature review of tributaries of the Klamath River in the Project area
- Lamprey literature review

2.4.2.1 Fisheries Baseline Literature Review of the Project Area and Downstream of Iron Gate Dam and Upstream of Link River Dam

PacifiCorp performed a literature review of current fisheries, including salmonids and non-salmonids, above and below the Project area to the extent necessary to provide an understanding of the linkage to the fisheries in the Project area. References reviewed included Hardy and Addley (2001), USBR (1997), Klamath River Basin Fisheries Task Force (KRBFTF) (1991), and CH2M HILL (1985), and other references contained in the Klamath Hydroelectric Annotated Bibliography of Aquatics and Wildlife (Kier Associates, 2000). Information from these references was obtained to derive a taxonomic list of fishes, and to describe the current distributions, life histories, habitat use, and periodicity of key species and their life stages, including resident and anadromous salmonids, lamprey, suckers, sturgeon, and other species of management and cultural importance. Data from these references as available were compared to current fish species composition and relative abundance data for the Project area.

2.4.2.2 Fisheries Literature Review of Tributaries of the Klamath River in the Project Area

PacifiCorp performed a literature review of current fisheries in tributaries of the Klamath River in the Project area. Tributaries of particular note in the Project area included Spencer Creek and Shovel Creek, which are both key trout spawning and rearing areas. References reviewed included Beyer (1984), City of Klamath Falls (1986), Hemmingsen et al. (1992), and other references contained in the Klamath Hydroelectric Annotated Bibliography of Aquatics and Wildlife (Kier Associates, 2000). Data were obtained as available from the Oregon Department of Fish and Wildlife (ODFW) and California Department of Fish and Game (CDFG) databases (including such data as spawner and weir counts from Spencer Creek). PacifiCorp also conducted backpack electrofishing in Fall Creek in fall of 2001 and spring, summer, and fall of 2002, and at the mouth of Spencer Creek in summer and fall of 2002. Information from these sources were used to describe the current distributions, life histories, habitat use, and periodicity of key species and their life stages, particularly for trout and other species of management and cultural importance.

2.4.2.3 Lamprey Literature Review

Anadromous lamprey occur downstream of Iron Gate dam, and resident lamprey may occur in the Project area. PacifiCorp conducted a literature review on the general life history and habitat requirements of lamprey, including any information specific to the Klamath River. Key information sources on lamprey that were reviewed included a recent assessment titled <u>Oregon Lampreys: Natural History, Status, and Analysis of Management Issues</u> by Kathryn Kostow (2002) and results of recent lamprey investigations sponsored by the Yurok Tribe.

2.5 RELATIONSHIP TO REGULATORY REQUIREMENTS AND PLANS

This review is intended to provide baseline information that, together with environmental data and results of other past and ongoing studies, can be used to assess effects of Project operations on fish resources and to help formulate recommendations for PM&E measures consistent with agency and tribal management goals. The following contain references to objectives for fisheries in the study area:

- California Department of Fish and Game (CDFG) Upper Klamath Wild Trout Management Plan
- Oregon Department of Fish and Wildlife (ODFW) Klamath River Basin Fish Management Plan
- USFWS and NOAA Endangered Species Act requirements
- Klamath River Wild and Scenic River Plan
- Tribal natural resource goals and objectives and cultural values
- Klamath River Basin Task Force (KRBFTF) Long Range Plan

The results will be used to help determine whether and where current Project operations are allowing healthy fish populations to be maintained at levels consistent with management objectives, and, if not, what changes to Project operations or facilities might be needed to achieve these objectives.

2.6 TECHNICAL WORK GROUP COLLABORATION

PacifiCorp worked with stakeholders to establish a collaborative process for planning and conducting studies needed to support Project relicensing documentation. Beginning in early 2001 the stakeholders and PacifiCorp developed a Process Protocol to guide the collaborative effort. The structure is comprised of a Plenary group (all interested stakeholders) and a number of technical working groups. As part of this structure, an Aquatics Work Group (AWG) was established to address most of the fisheries studies, except those related to fish passage, which had its own Fish Passage Work Group. The AWG has met approximately monthly. Additional meetings (often via phone conference) of AWG participants have been held to address specific study topics. In late 2003 several of the monthly AWG meetings were combined with the Fish Passage Work Group meetings to address some of the study topics that cross over both work groups.

2.7 RESULTS AND DISCUSSION

2.7.1 Overview

Table 2.7-1 lists fish species reported to occur in the Klamath River and reservoirs upstream of Iron Gate dam (City of Klamath Falls, 1986; PacifiCorp, 2000). Table 2.7-1 also lists fish species that likely occur in the Klamath River drainage system downstream of Iron Gate dam. The list of downstream species was compiled from a list of fish species reported by Moyle (1976) to occur in the California portion of the lower Klamath River drainage system, which extends from the Oregon-California border (RM 209.3) to the mouth of the Klamath River (RM 0).

The scientific names of fish species discussed in the following text are listed in Table 2.7-1, together with these species' origin (native or introduced), status (protected or not, game or non-game), and several attribute classifications including water temperature preference and overall pollution tolerance. Species' attributes described by Zaroban et al. (1999) in their discussions of 132 freshwater fish species that occur in the Pacific Northwest cover most of the fish species listed in Table 2.7-1. In their classification of fish species' attributes, Zaroban et al. (1999) categorized water temperature preferences as cold, cool, or warm, indicating the thermal regime of a water body, depending on the species present. The overall pollution tolerance of a fish species is classified as sensitive (S), tolerant (T), or intermediate (I). Zaroban et al. (1999) reported that sensitive fish species "tend to either disappear or are greatly reduced in association with other human disturbances" and are "typically intolerant of siltation, turbidity, increased water temperature and lowered dissolved oxygen, and tend to be replaced by intermediate and tolerant species." Pollution tolerant species are defined as "fishes that tend to increase in abundance with human disturbances, particularly in relation to increased siltation, turbidity, and water temperature, and lowered concentrations of dissolved oxygen." Species with an "intermediate" pollution tolerance are "neither tolerant nor sensitive to increased siltation, turbidity, temperature, or lowered dissolved oxygen, but are typically replaced by tolerant species in those situations."

Table 2.7-1. Common and scientific names of fish species known to occur in the Klamath River and reservoirs upstream of Iron Gate dam and that likely occur in the Klamath River drainage system downstream of Iron Gate dam[1].

Common Name	Scientific Name	Origin[2]	Status[3]	Temperature Preference[4]	Pollution Tolerance[5]	Present Upstream of Iron Gate Dam[6]	Present Downstream of Iron Gate Dam[6]
Lampreys	**Petromyzontidae**						
Pit-Klamath Brook lamprey	*Lampetra lethophaga*	N	N	Cool	I	R	--
Klamath lamprey	*Lampetra similis*	N	N	Cool	I	R	--
Pacific lamprey	*Lampetra tridentata*	N	N, S	Cool	I	R	A
Sturgeons	**Acipenseridae**						
Green sturgeon	*Acipenser medirostris*	N	S	Cold	S	--	A
White sturgeon	*Acipenser transmontanus*	N	G	Cold	I	R (stocked by ODFW in UKL)	A
Herrings	**Clupeidae**						
American shad	*Alosa sapidissima*	I	G	Cool	I	--	A
Pacific herring	*Clupea pallasi*	N	G	--	--	--	O
Carps and Minnows	**Cyprinidae**						
Tui chub	*Gila bicolor*	N	N	Cool	T	R	R
Blue chub	*Gila coerulea*	N	N	Cool	T	R	R
Golden shiner	*Notemigonus crysoleucas*	I	N	Warm	T	R	R
Fathead minnow	*Pimephales promelas*	I	N	Warm	T	R	--
Klamath Speckled dace	*Rhinichthys osculus*	N	N	Cool	I	R	R
Suckers	**Catostomidae**						
Klamath Smallscale sucker	*Catostomus rimiculus*	N	N	Cool	I	R	R
Klamath Largescale sucker	*Catostomus snyderi*	N	S	Cool	I	R	R
Shortnose sucker	*Chasmistes brevirostris*	N	E, S	Cool	S	R	R
Lost River sucker	*Deltistes luxatus*	N	E, S	Cool	I	R	--
Bullhead Catfish	**Ictaluridae**						
Yellow bullhead	*Ameiurus natalis*	I	G	Warm	T	R	R
Brown bullhead	*Ameiurus nebulosus*	I	G	Warm	T	R	R
Channel catfish	*Ictalurus punctatus*	I	G	Warm	T	R	--

Table 2.7-1. Common and scientific names of fish species known to occur in the Klamath River and reservoirs upstream of Iron Gate dam and that likely occur in the Klamath River drainage system downstream of Iron Gate dam[1].

Common Name	Scientific Name	Origin[2]	Status[3]	Temperature Preference[4]	Pollution Tolerance[5]	Present Upstream of Iron Gate Dam[6]	Present Downstream of Iron Gate Dam[6]
Smelts	**Osmeridae**						
Surf smelt	*Hypomesus pretiosus*	N	G	Cold	S	--	O
Delta smelt	*Hypomesus transpacificus*	I	T,S	--	--	--	R
Longfin smelt	*Spirinchus thaleichtys*	N	G	Cool	I	--	O
Eulachon	*Thaleichthys pacificus*	N	G	Cool	I	--	A
Trout and Salmon	**Salmonidae**						
Cutthroat trout	*Oncorhynchus clarki*	N	G	Cold	S	--	R
Pink salmon	*Oncorhynchus gorbuscha*	N	G	Cold	S	--	A
Chum salmon	*Oncorhynchus keta*	N	G	Cold	S	--	A
Coho salmon	*Oncorhynchus kisutch*	N	G, T	Cold	S	--	A
Steelhead trout	*Oncorhynchus mykiss*	N	G	Cold	S	--	R, A
Redband/rainbow trout[7]	*Oncorhynchus mykiss gairdneri*	N	G, S	Cold	S	R	--
Sockeye salmon	*Oncorhynchus nerka*	N	G	Cold	S	--	O, A
Kokanee	*Oncorhynchus nerka kennerlyi*	I	G	Cold	S	--	R
Chinook salmon	*Oncorhynchus tshawytscha*	N	G	Cold	S	--	A
Brown trout	*Salmo trutta*	I	G	Cold	I	R	R
Brook trout	*Salvelinus fontinalis*	I	G	Cold	I	--	R
Arctic grayling	*Thymallus arcticus*	I	G	Cold	S	--	R
Silverside	**Atherinidae**						
Topsmelt	*Atherinops affinis*	N	G	--	--	--	O
Sticklebacks	**Gasterosteidae**						
Threespine stickleback	*Gasterosteus aculeatus*	N	N	Cool	T	--	R
Sculpin	**Cottidae**						
Sharpnose sculpin	*Clinocottus acuticeps*	N	N	--	--	--	O
Coast Range sculpin	*Cottus aleuticus*	N	N	Cool	I	--	R
Prickly sculpin	*Cottus asper*	N	N	Cool	I	--	R
Marbled sculpin	*Cottus klamathensis*	N	N	Cool	I	R	R

Table 2.7-1. Common and scientific names of fish species known to occur in the Klamath River and reservoirs upstream of Iron Gate dam and that likely occur in the Klamath River drainage system downstream of Iron Gate dam[1].

Common Name	Scientific Name	Origin[2]	Status[3]	Temperature Preference[4]	Pollution Tolerance[5]	Present Upstream of Iron Gate Dam[6]	Present Downstream of Iron Gate Dam[6]
Klamath Lake sculpin	*Cottus princeps*	N	N	Cold	I	R	--
Slender sculpin	*Cottus tenuis*	N	N, S	Cool	I	R	--
Pacific Staghorn sculpin	*Leptocottus armatus*	N	N	Cold	I	--	R
Sunfishes	**Centrarchidae**						
Sacramento perch	*Archoplites interruptus*	I	G	Warm	T	R	R
Green sunfish	*Lepomis cyanellus*	I	G	Warm	T	R	R
Pumpkinseed	*Lepomis gibbosus*	I	G	Cool	T	R	R
Bluegill	*Lepomis macrochirus*	I	G	Warm	T	R	R
Largemouth bass	*Micropterus salmoides*	I	G	Warm	T	R	R
White crappie	*Pomoxis annularis*	I	G	Warm	T	R	--
Black crappie	*Pomoxis nigromaculatus*	I	G	Warm	T	R	--
Perches	**Percidae**						
Yellow perch	*Perca flavescens*	I	G	Cool	I	R	R
Surfperches	**Embiotocidae**						
Shiner perch	*Cymatogaster aggregata*	N	N	Cold	S	--	O
Gobies	**Gobiidae**						
Arrow goby	*Clevelandia ios*	N	N	--	--	--	O
Righteye Flounders	**Pleuronectidae**						
Starry flounder	*Platichthys stellatus*	N	G	Cold	S	--	R

[1] Source: Species upstream of Iron Gate dam from City of Klamath Falls (1986) and PacifiCorp (2000). Species downstream of Iron Gate dam based on Moyle (1976).
[2] Origin: N = native; I = introduced.
[3] Status: N = non-game; G = game; E = federally listed as endangered; T = federally listed as threatened; S = federal and/or state sensitive species or species of concern.
[4] From Zaroban et al. (1999).
[5] Pollution Tolerance: T = tolerant; I = intermediate; S = sensitive. From Zaroban et al. (1999).
[6] R = resident; A = anadromous; O = occasional marine visitor; UKL = Upper Klamath Lake.
[7] This fish is referred to as redband trout in Oregon and rainbow trout in California. To accommodate stakeholders’ comments, we have attempted to keep references to this fish relevant to the state in which it was found.

Twenty-eight species of fish representing eight taxonomic families are known to occur in the Klamath River and reservoirs upstream of Iron Gate dam (Table 2.7-1). Half of these (14 species) are native to the Klamath drainage and occur primarily in river reaches, while the remaining 14 species have been introduced and occur primarily in Project area reservoirs (PacifiCorp, 2000). All 28 species are resident because Iron Gate Dam blocks further upstream migrations by anadromous species from the Lower Klamath River. Native species listed in Table 2.7-1 that occur upstream of Iron Gate Dam include all of the lampreys (three species), all of the suckers (four species), three species of sculpins, three species of carps and minnows, and one salmonid (redband/rainbow trout [This fish is referred to as redband trout in Oregon and rainbow trout in California. To accommodate stakeholders' comments, we have attempted to keep references to this fish relevant to the state in which it was found.]). Introduced species listed in Table 2.7-1 that occur upstream of Iron Gate dam include all of the sunfishes (seven species), all of the bullhead catfishes (three species), two species of carps and minnows, one percid (yellow perch), and one salmonid (brown trout).

Five of the 28 fish species present upstream of Iron Gate dam have special federal and/or state status and are native. They are: the shortnose sucker and Lost River sucker, which are listed as endangered under the federal Endangered Species Act (ESA) and by the States of Oregon and California; and redband/rainbow trout, Klamath largescale sucker, and slender sculpin, which are regarded as sensitive species or species of concern by federal and/or state agencies. Only one of the 14 native species (redband/rainbow trout) is classified as a game fish, while all but two of the 14 introduced species (golden shiner, fathead minnow) are classified as game fish (ODFW, 1997) (Table 2.7-1).

All 14 of the native fish species upstream of Iron Gate dam exhibit either a cool water (12 species) or cold water (two species) temperature preference. In addition, except for blue chub and tui chub, which are pollution tolerant, all native fish species exhibit either an intermediate (ten species) or sensitive (two species) pollution tolerance value. Redband/rainbow trout is the only native fish species that prefers cold water and also is sensitive to pollution. None of the native fish species prefers warm water (Table 2.7-1).

In contrast, the introduced fish species present upstream of Iron Gate dam generally prefer warmer water and are more tolerant of pollution than the native species. Of the 14 introduced species, 11 species exhibit a warm water preference, two species exhibit a cool water preference, and one species (brown trout) exhibits a cold water preference. Also, 12 of the introduced species (all of the sunfishes, bullhead catfishes, and the two carps and minnows) are pollution tolerant, with only two introduced fish species (brown trout and yellow perch) exhibiting an intermediate pollution tolerance value. None of the introduced fish species exhibits a sensitive pollution tolerance value (Table 2.7-1).

An estimated 44 fish species representing 16 taxonomic families occur in the Klamath River drainage system downstream of Iron Gate dam (Table 2.7-1). Twenty-six of these species are resident (spend their entire life in the Lower Klamath River system), nine species are anadromous (mature at sea and migrate to freshwater to spawn), eight species are occasional marine visitors, and one species (rainbow trout/steelhead) exhibits resident and anadromous life history forms. Resident species are represented primarily by the following families of fish: carps and minnows, suckers, bullhead catfishes, sculpins, sunfishes, and some of the salmonids (trout). Anadromous fish are represented by five species of salmonids (salmon and steelhead), two species of sturgeon, and one species each of lamprey, clupeid, and smelt. Occasional marine visitors include two species of smelt and one species each of clupeid, salmonid, silversides, sculpin, surfperch, and goby (Table 2.7-1).

Approximately two-thirds (30 species) of the 44 fish species present downstream of Iron Gate dam are native to the Klamath River drainage system. In addition, most of the 16 families of fish present downstream of the dam are dominated by, or consist entirely of, native species. Exceptions include the families of sunfishes, bullhead catfishes, carps and minnows, and freshwater perch. Salmonids occurring in the Klamath system downstream of Iron Gate dam consist of seven native species (Chinook, coho, pink, chum, and sockeye salmon, cutthroat trout, and rainbow trout/steelhead) and four introduced species (brown and brook trout, Arctic grayling, and kokanee [landlocked sockeye salmon]) (Table 2.7-1).

Four of the 44 species present downstream of Iron Gate dam have special federal ESA and State of California, status and are native (Table 2.7-1). They are (1) the shortnose sucker, which is listed as endangered, (2) the Pacific lamprey, which was recently petitioned for federal status under ESA, and (3) the delta smelt and (4) coho salmon, which are listed as threatened. Within the Klamath River drainage, the coho salmon evolutionarily significant unit (ESU) consists of naturally spawning populations. A fifth native species, green sturgeon, is undergoing a status review by NOAA Fisheries to determine whether federal listing as an endangered or threatened species is warranted. The remainder of the fish species occurring downstream of Iron Gate dam are approximately evenly divided between game species (primarily salmonids and sunfishes) and non-game species (primarily minnows and sculpins) (Table 2.7-1).

Patterns of temperature preference and pollution tolerance for native and introduced fish species downstream of Iron Gate dam are similar to those described for the Klamath River upstream of Iron Gate dam. All 30 of the native fish species downstream of Iron Gate dam exhibit either a cool or cold water temperature preference. In addition, except for tui chub, blue chub, and threespine stickleback, which are pollution tolerant, all of the native species exhibit either an intermediate or sensitive pollution tolerance value. In contrast, most of the introduced species generally prefer warmer water and are more pollution-tolerant than the native species. The exceptions to this are the introduced salmonids (brown and brook trout, Arctic grayling, and kokanee), which prefer cold water and exhibit intermediate or sensitive pollution tolerance values.

2.7.2 Mainstem Klamath River

The six study area river reaches identified in Section 2.1.2, as depicted in Figure 2.4-1 and listed in Table 2.4-1 are described in the following text.

2.7.2.1 Link River

Description of Area

The Link River is approximately 1.2 miles (1.9 km) long. It extends from the 16-foot-high (4.9 m) Link River dam on Upper Klamath Lake at RM 254.3 to the upper end of Lake Ewauna on the Klamath River at RM 253.1. The Link River channel is primarily bedrock, and at lower flows consists of smaller braided channels. The “Klamath Falls,” which are a long steep cascade rather than a waterfall, occur in the Link River and may constrain upstream fish passage at lower flows (ODFW, 1997).

Water quality in the Link River is affected by Upper Klamath Lake, which has been characterized as a large, relatively shallow, and highly eutrophic water body. Lake water quality probably is limiting to many fish species during late summer and early fall when water temperatures are warm and there are large blooms of the blue-green algae *Aphanizomenon flos-aquae*. This can result in large diurnal fluctuations in dissolved oxygen (DO) concentrations and pH levels, which can adversely affect aquatic life. Several fish kills in Upper Klamath Lake in recent years probably have been caused by poor water quality (PacifiCorp, 2000 and National Science Academy, 2003).

Link River dam is used to regulate water surface elevations in Upper Klamath Lake, supply water to the Project and the USBR Klamath Irrigation Project, and provide a required minimum instream flow to the Link River downstream to Lake Ewauna. Its regulation also is operated to meet necessary flows below Iron Gate dam. Link River dam contains a 105-foot-long (32 m) fish ladder to provide upstream passage for fish from the river to Upper Klamath Lake. However, ladder effectiveness has been judged to be quite poor, and a new ladder is being designed by the USBR (PacifiCorp, 2000).

The Link River dam diverts water from Upper Klamath Lake to PacifiCorp's East Side (3.2-megawatts [MW]) and West Side (0.6-MW) powerhouses, which are part of the Project. No fish screens are on the intake headworks leading to either powerhouse. However, Project operations are altered at certain times of the year to minimize entrainment of fish. Flows diverted through the East Side powerhouse are discharged to the Link River at approximately RM 253.8. Flows diverted through the West Side powerhouse are discharged to the Link River at approximately RM 253.1.

The Link River dam releases a minimum flow to the Link River to protect aquatic resources and to facilitate fish passage. The river reach between the dam and the East Side powerhouse tailrace has a year-round minimum instream flow requirement of 90 cubic feet per second (cfs) (2.5 cms), except during the summer when it is increased to 250 cfs (7.1 cms). East Side Down-ramping rates also have been established for the Link River to avoid potential fish stranding. These rates are: 20 cfs (0.6 cms) per 5 minutes at flow releases of zero to 300 cfs (8.5 cms); 50 cfs (1.4 cms) per 30 minutes at flow releases of 300 to 500 cfs (8.5 to 14.2 cms); and 100 cfs (2.8 cms) per 30 minutes at flow releases of 500 to 1,500 cfs (14.2 to 42.5 cms) (PacifiCorp, 2002).

Fish Resources

Previous fisheries investigations in the Link River include entrainment studies conducted in the East Side and West Side powerhouse canals downstream of Link River dam during 1997, 1998, and 1999. The overall objective of the study was to monitor entrainment of all life stages of fish, with emphasis on the shortnose and Lost River suckers. The USFWS listed these two species of suckers as endangered on July 18, 1988 [53 Federal Register (FR) 27130], issued a draft plan for their recovery on January 19, 1993 (58 FR 5017), and designated proposed critical habitat for both species on December 1, 1994 (58 FR 5017). Study emphasis also was placed on fish longer than about 3 inches (75 mm) in fork length (FL) because the USFWS identified this length as a target size for possible future screening of the powerhouse canals (Cell Tech and PacifiCorp, 2000). Results of larval monitoring and juvenile/adult monitoring in both powerhouse canals provide an index of fish species and their relative abundance in the Link River, as well as estimates of fish species and numbers entrained through the powerhouses.

At least 15 taxa of fish were collected in both the East Side and West Side powerhouse canals during the 2.5-year entrainment study. Based on an entrainment index that was calculated from the number of fish collected, percent of canal flow sampled, and sampling efficiency, an estimated 792,808 fish would have passed through the East Side powerhouse from July 14, 1997, to October 20, 1999. An estimated 528,906 fish would have passed through the West Side powerhouse from April 21, 1997, to October 20, 1999 (Cell Tech and PacifiCorp, 2000).

Blue chub and fathead minnow were the most abundant fish species collected in the East Side canal, accounting for 37 percent and 18 percent, respectively, of the estimated total (Cell Tech and PacifiCorp, 2000). Both of these species exhibit a tolerance of increased siltation, turbidity, and water temperature, and reduced DO (Zaroban et al. 1999). The third most abundant fish taxa collected in the East Side canal (accounting for 15 percent of the total) was “all suckers combined,” which included shortnose sucker, Lost River sucker, and Klamath largescale sucker. Other relatively abundant fish species in the East Side canal and their percent of the estimated total were tui chub (12 percent), Klamath Lake sculpin (7 percent), yellow perch (5 percent), and marbled sculpin (3 percent). Other fish taxa, in declining order of abundance, that each comprised less than 1 percent of the estimated total included “all lamprey,” slender sculpin, redband/rainbow trout, “all sunfish,” speckled dace, and brown bullhead.

Fish species composition and relative abundance in the West Side canal were somewhat similar to the East Side canal. Blue chub and fathead minnow were the numerically dominant species in the West Side canal, accounting for 39 percent and 32 percent, respectively, of the estimated total. Other relatively abundant fish species in the West Side canal and their percent of the estimated total were tui chub (10 percent), yellow perch (7 percent), Klamath Lake sculpin (6 percent), and “all suckers combined” (5 percent). Other fish taxa, in declining order of abundance, that each comprised less than 1 percent of the estimated total in the West Side canal included marbled sculpin, “all lamprey,” slender sculpin, “all sunfish,” speckled dace, redband/rainbow trout, and brown bullhead.

Five native fish species with special management status were collected in the Link River entrainment studies. They include shortnose sucker and Lost River sucker, which are federally listed endangered species, redband/rainbow trout and slender sculpin, which are State of Oregon sensitive species, and Klamath largescale sucker, which is a federal species of concern. Redband/rainbow trout also is recognized as a species of concern by federal resource management agencies. ODFW (1997) reported that redband/rainbow trout in the Klamath River are a unique stock indigenous to the river and its tributaries and refers to them as the “Klamath River redband stock.” ODFW’s fisheries management policies for the Link River are to manage redband/rainbow trout for natural production and to not stock hatchery trout (ODFW, 1997).

Of the three species of suckers collected during the entrainment study, shortnose sucker was usually the most abundant, Lost River sucker the second most abundant, and Klamath largescale sucker the least abundant. In the East Side canal, suckers accounted for approximately 15 percent of the total catch, but peaked in August and September when they made up approximately 50 percent of the monthly catches. This late summer/early fall peak may indicate that fish were moving downstream to avoid poor water quality conditions in Upper Klamath Lake. Suckers collected were dominated by smaller-sized individuals, with 71 percent less than 3.0 inches (75 mm) FL; 28 percent 3.0 to 5.9 inches (75 to 150 mm) FL; and 1 percent greater than 5.9 inches (150 mm) FL (Cell Tech and PacifiCorp, 2000).

Redband/rainbow trout were very uncommon in entrainment study collections, accounting for less than 0.1 percent of the estimated total for both the East Side and West Side canals. Most redband/rainbow trout collected during the study were greater than 3.0 inches (75 mm) FL, but less than 7.9 inches (200 mm) FL. The timing of redband/rainbow trout collected in entrainment samples appeared to be related to water temperatures. In the warmest study year (1997), 61 percent of redband/rainbow trout were collected in December. In the coolest study year (1999), redband/rainbow trout were collected during all months sampled except August (the warmest month). Peak months of redband/rainbow trout collection were November and December in 1997; January and March through July in 1998; and March, April, June, September, and October in 1998. Redband/rainbow trout present in entrainment samples may represent individuals emigrating downstream through Upper Klamath Lake and/or perhaps individuals rearing in the lake near Link River dam that were inadvertently entrained into the powerhouse diversions.

Results of fish passage studies conducted by the ODFW and PacifiCorp in 1989 at the Link River dam fish ladder provide information on the timing of upstream movements by redband/rainbow trout. At that time, 124 trout were counted at the Link River dam fish ladder. More than 80 percent passed in April and May (Buchanan et al. 1989). Average FL was 12.9 inches (327 mm).

Few redband/rainbow trout pass from Link River into Upper Klamath Lake (Buchanan et al. 1991). One trout tagged at Link River dam subsequently spawned in the Williamson River. In addition, a spent redband/rainbow trout that had been tagged while spawning in the Williamson River later was found on the trash racks at Link River dam. The ODFW (1997) suggested that perhaps some redband/rainbow trout that spawn in the lower Williamson River drop down through Upper Klamath Lake into the Link and Klamath Rivers.

2.7.2.2 Klamath River - Keno Reach

Description of Area

The Keno reach of the Klamath River is approximately 4.7 miles (7.6 km) long. It extends from the 25-foot-high (7.6 m) Keno dam on Lake Ewauna (also known as Keno reservoir) at RM 233.0 to the upper end of J. C. Boyle reservoir at RM 228.3. The Keno reach of the Klamath passes through a canyon and has an average gradient of 50 feet (15.2 m) per mile, or about 1 percent. The river channel is generally broad with habitat consisting of rapids, riffles, and pocket water among rubble and boulders (ODFW, 1997). Spencer Creek, a key tributary to the Klamath River, enters just downstream of the Keno reach at RM 227.6.

Water quality in the Keno reach is influenced by water quality in Lake Ewauna, which is influenced by water quality in Upper Klamath Lake. Summer water quality in Lake Ewauna is generally poor because of heavy algae growth, high water temperatures and pH, low DO, and elevated nutrients from the addition of domestic effluent in the Klamath Falls area. This combination of warm water, abundant nutrients and organic materials from upstream sources, and adequate dissolved oxygen resulting from the river's turbulence create a productive aquatic environment (ODFW, 1997). Summer water temperatures in the Keno reach, however, are marginal (too warm) for trout and could be limiting the trout population. The Keno reach is closed to trout fishing in the summer because its high water temperatures cause excessive mortality in a catch-and-release fishery (ODFW, 1997).

Keno dam is operated as a re-regulating project, which serves a number of purposes. These include the control of water levels to maintain steady reservoir elevations in the 20-mile-long (32.2 km) Lake Ewauna, flows to and from USBR's Klamath Irrigation Project, inflows to J.C. Boyle reservoir, and minimum stream flow requirements below Iron Gate dam. PacifiCorp (2002) has an agreement with the ODFW to release a minimum instream flow of 200-250 cfs (7.1 cms) at Keno dam, and a self-imposed down-ramping rate below Keno dam of 500 cfs or 9 inches (14.2 cms) per hour. Keno dam also contains a 350-foot-long (106.7 m) fish ladder to provide upstream passage for fish from the river to Lake Ewauna. There are no power-generating facilities at Keno dam.

<u>Fish Resources</u>. Fisheries information available for the Keno reach focuses on redband/rainbow trout. ODFW's (1997) primary management objective for this reach (and downstream to the Oregon-California border) is wild trout management, with emphasis on sustaining populations of wild redband/rainbow trout. Available information on other fish species occurring in the Keno reach is limited. However, it is likely that many of the native riverine fish species listed in Table 2.7-1 as occurring upstream of Iron Gate dam also are present in the Keno reach. These probably include redband/rainbow trout; Klamath smallscale, Klamath largescale, shortnose, and Lost River suckers; tui and blue chubs; lampreys (perhaps Klamath and Pit-Klamath brook); sculpins (perhaps marbled, only), and Klamath speckled dace. Many of the introduced fish species listed in Table 2.7-1 generally are not associated with the riverine habitat characteristics described above for the Keno reach.

Redband/rainbow trout, tui chub, and Klamath smallscale sucker may be among the most abundant fish species in the Keno reach. Physical habitat components like those in the Keno reach typically are associated with trout populations, which is reflected in ODFW's wild redband/rainbow trout management policy for this reach of the Klamath River. Tui chub has been among the most abundant species captured upstream (Lake Ewauna) and downstream (J.C. Boyle reservoir) of the Keno reach and also may be abundant in quieter waters of this free-flowing reach (PacifiCorp, 2000). In addition, Klamath smallscale sucker, which occurs in both riverine and reservoir environments (Moyle, 1976), has been the most abundant catostomid captured just downstream in J.C. Boyle reservoir (Toman, 1983) and in free-flowing reaches below J.C. Boyle dam (City of Klamath Falls, 1986). The possible presence of the lake-dwelling, endangered shortnose and Lost River suckers in the Keno reach may reflect the downstream emigration of juveniles and adults from upstream basin habitat, a behavior suggested for these two species when present in the Klamath River below J.C. Boyle dam (Henriksen et al. 2002).

The Klamath River has been classified for wild redband/rainbow trout management since 1978. Beginning in 1954, the river from Keno dam approximately 18 miles (29.0 km) downstream to the Frain Ranch was stocked with hatchery rainbow trout, but this practice was discontinued in 1978 with implementation of ODFW's wild trout management policy. The ODFW believes that stocked rainbow trout died before reaching maturity because of their high susceptibility to *Ceratomyxa shasta* (*C. shasta)*, a protozoan pathogen to which the native Klamath River stock of redband/rainbow trout is generally immune (ODFW, 1997).

In earlier investigations on the Klamath River reported by Toman (1983), creel census data for the Keno dam to Frain Ranch reach showed that although angler catch rates of rainbow/redband/rainbow trout varied annually, overall averages were similar during and following the discontinuance of stocking rainbow trout. During the period from 1953 to 1982, angler catch rates averaged 0.48 fish per hour during the last 4 years that stocking occurred versus 0.51 fish per hour after stocking was discontinued (Toman, 1983). Creel data during the period from 1979 to 1984 showed consistently lower catch rates, averaging 0.23 trout per hour, in the Keno reach compared to the downstream J.C. Boyle bypass and peaking reaches (0.62 fish per hour and 0.78 fish per hour, respectively) (Table 2.7-2). Most redband/rainbow trout caught by anglers in the Keno dam to Frain Ranch reach were 8 to 16 inches long (200 to 400 mm), with some fish exceeding 20 inches (500 mm). A greater portion of the fish caught in the Keno reach were larger fish than those caught in the bypass and peaking reaches (Figure 2.7-1). Trout caught in the peaking reach were larger than those caught in the bypass reach.

Although the Keno reach contains an excellent trout fishery, and is suitable for migration and rearing, it contains no significant amount of spawning gravel (Fortune et al. 1966). Most spawning habitat for redband/rainbow trout occurring in the Klamath River between Keno dam and the Oregon-California border is in Spencer Creek (ODFW, 1997). This creek is the only substantial tributary to the Klamath River in Oregon, and enters the upper end of J.C. Boyle reservoir (see Section 2.7.2.5 for further discussion of fish resources in Spencer Creek). Redband/rainbow trout continue to spawn in Spencer Creek, and consist primarily of fish that have reared and are otherwise resident in the Keno reach (ODFW, 1997). Monitoring of the fish ladder at Keno dam also has documented small numbers of trout moving upstream past the dam. In the 12-month period from October 1988 through September 1989, 76 trout were captured in the upstream trap at the Keno dam ladder (Buchanan et al. 1989). Of these, 66 were captured in October and November 1988. Only four trout were counted passing the dam in April and May 1989, suggesting that few, if any, trout from the Keno reach move upstream to spawn. The average fork length (FL) of the 76 trout observed at Keno dam was 9.1 inches (230 mm).

Table 2.7-2. Total trout per hour Oregon Department of Fish and Wildlife creel survey data.

Year	Keno Reach	J. C. Boyle Bypass	J. C. Boyle Peaking Reach
1979	0.33	0.41	0.74
1980	0.27	0.67	0.71
1981	0.09	0.47	1.31
1982	0.13	0.87	0.56
1983	0.08	0.62	0.56
1984	0.49	0.69	0.77
Mean	**0.23**	**0.62**	**0.78**

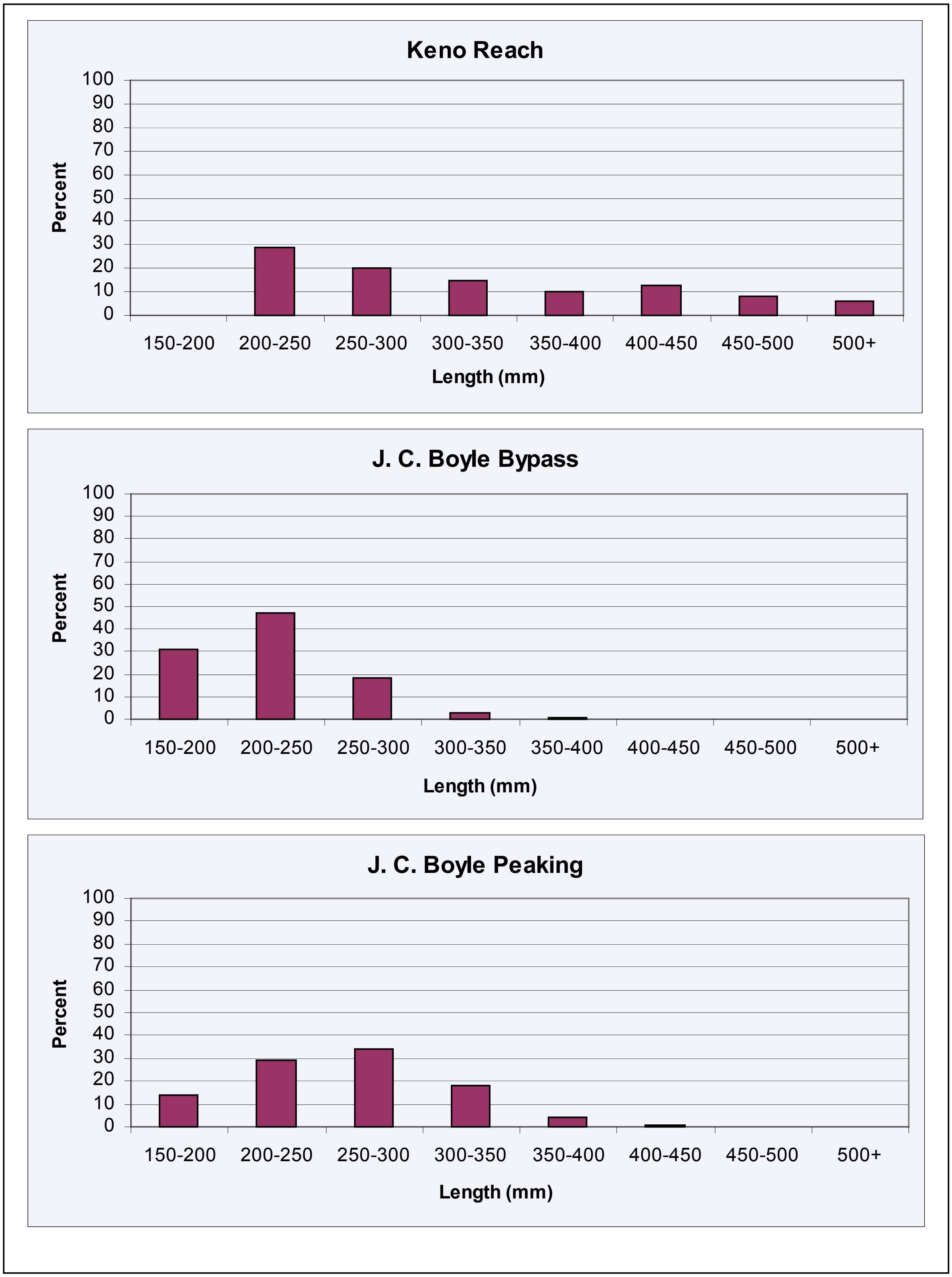


Figure 2.7-1. Trout length histograms from ODFW creel survey data: 1979–1982.

2.7.2.3 Klamath River - J.C. Boyle Bypass Reach

Description of Area

The J.C. Boyle bypass reach of the Klamath River is approximately 4.3 miles (6.9 km) long. It extends from the 68-foot-high (20.7 m) J.C. Boyle dam at RM 224.7 to the discharge from the 80-MW J.C. Boyle powerhouse at RM 220.4. A minimum instream flow requirement of 100 cfs (2.8 cms) is discharged from J.C. Boyle reservoir to the bypass reach. This minimum flow is comprised of approximately 80 cfs (2.3 cms)that is directed through the 569-foot-long (173.4 m) fish ladder at the dam, plus 20 cfs (0.6 cms) that is directed through the juvenile fish bypass system (vertical traveling screens with 0.25-inch (6.4 mm) mesh) at the powerhouse canal intake (PacifiCorp, 2000, 2002).

This reach of the Klamath River has a relatively steep gradient of approximately 100 feet (30.5 m) per mile, or about 2 percent. The river channel is narrow (approximately 100 feet (30.5 m) wide) and consists primarily of rapids, runs, and pools among large boulders with some large cobble interspersed (City of Klamath Falls, 1986; ODFW, 1997). Gravel is scarce in the bypass reach, with its recruitment limited naturally and by the presence of J.C. Boyle dam and only a few tributaries (City of Klamath Falls, 1986). During non-spill periods, riffles and runs with a few pools are the predominant habitat in the bypass reach. When spill from the dam is substantial, habitat in the bypass reach consists of a series of rapids and fast runs (City of Klamath Falls, 1986).

Water discharged from J.C. Boyle dam to the upper end of the bypass reach during summer is typically quite warm (exceeds 70°F (21.2°C), highly productive, and often degraded—the same as noted for upstream water quality on the Klamath during summer (ODFW, 1997). Springs in the bypass reach begin entering the river about 0.5 mile downstream of J. C. Boyle dam and contribute an estimated 220-250 cfs (6-2-7.1 cms) of cool (about 48°F (8.9°C)), clear groundwater to the river flow (City of Klamath Falls, 1986). Because of the springs' contributions, flows at the end of the bypass reach during summer when the dam is not spilling are relatively constant at about 350 cfs (9.9 cms) and water temperature is about 55°F (12.8°C) (ODFW, 1997). The ODFW (1997) observed that dual opposing effects of the springs during summer are to cool and make water temperatures more suitable for trout, and to dilute the productivity of water discharged from J.C. Boyle reservoir.

The J.C. Boyle powerhouse, located 4 miles (6.4 km) downstream of the dam, typically is operated as a power-peaking facility. Depending on the water year (wet, average, dry) and availability of flows, peaking operations usually extend from late spring through late fall. During the peaking cycle, the reservoir is drawn down during the day and refilled at night. Reservoir water level fluctuates up to about 3.5 feet (1.1 m) annually, but averages 2 feet (0.6 m) during a 24-hour period.

Fish Resources

The J.C. Boyle bypass reach is in the ODFW Wild Trout Management Area and thus most available fisheries information is on redband/rainbow trout. Angler catch rates and size distribution of trout captured in the bypass reach are shown in Table 2.7-2 and Figure 2.7-1. During the years 1979 through 1984, annual angler catch rates in the bypass reach varied from 0.41 to 0.87 redband/rainbow trout per hour and averaged 0.62 fish per hour. This catch rate is almost three times greater than the catch rate for the Keno reach during these same years and is slightly less than the angler average catch rate of 0.77 redband/rainbow trout per hour in the Klamath between the J.C. Boyle powerhouse and the Oregon-California border. Trout caught in the bypass reach tend to be smaller than those caught in the upstream Keno reach and the downstream peaking reach. Unlike the Keno reach, the fishing season from J.C. Boyle dam to the Oregon-California border is open year-round with catch-and-release requirements in the summer months.

Other fish species present in the J.C. Boyle bypass reach are likely similar to those species described for the Keno reach. They probably are represented by many of the native species listed in Table 2.7-1, which include the species known to occur just downstream in the Wild and Scenic reach of the Klamath River. In addition to these native species, several non-native warm water species, believed to originate from J.C. Boyle reservoir, have been observed in the upper portion of the bypass reach above the inflow of cool spring water. These species include several sunfishes and bullheads (Toman, 1983).

Results of electrofishing and hook-and-line sampling in upper (above springs) and lower sections of the J.C. Boyle bypass reach during November 1989 and February 1990 showed that the redband/rainbow trout population was dominated by age 0+ to age 2+ fish (City of Klamath Falls, 1990). Age 3+ fish were difficult to find and only one age 4+ was collected. Slightly smaller sizes of fish at ages 1 and 2 were observed in the 0.5-mile upper section of the bypass reach compared to those in the lower section. This difference was attributed to the limiting low winter and high summer water temperatures in the upper section compared to the more favorable growth temperatures in the lower section below the spring inflow (City of Klamath Falls, 1990).

Spawning by redband/rainbow trout from the J.C. Boyle bypass reach occurs in Spencer Creek, which flows into J.C. Boyle reservoir, and in the mid-section of the bypass reach (City of Klamath Falls, 1986). Previous studies reported that some trout have been observed spawning in the bypass reach, but that suitable spawning gravel is scarce and limited to patches behind large boulders (City of Klamath Falls, 1986; ODFW, 1997). Peak spawning by redband/rainbow trout in this area of the Klamath River basin extends from about mid-March to mid-April, but can vary somewhat depending on water temperature (Beyer, 1984; Hanel and Gerlach, 1964). Most redband/rainbow trout that spawn in Spencer Creek return downstream as spent adults from about mid-May through June (Toman, 1983).

About mid-August, young-of-the-year (YOY) redband/rainbow trout, which originated from spawners in Spencer Creek, begin to move downstream through the screen bypass system at J.C. Boyle dam to the section of bypass reach upstream of the springs (City of Klamath Falls, 1990). Many YOY redband/rainbow trout have been observed by PacifiCorp biologists while snorkeling the J.C. Boyle bypass reach (PacifiCorp, 2000). In 1984, it was estimated that approximately 200,000 downstream migrating age 0 redband/rainbow trout passed J.C. Boyle dam from about mid-August through October and that this number is within the range predicted for age 0 outmigrants from Spencer Creek (City of Klamath Falls, 1986).

2.7.2.4 Klamath River – J.C. Boyle Peaking Reach

Description of Area

The J.C. Boyle peaking reach of the Klamath River is approximately 17.3 miles (27.8 km) long. It extends from the J.C. Boyle powerhouse discharge at RM 220.4 to the upper end of Copco No. 1 reservoir at RM 203.1. The Oregon-California border is at RM 209.3. The upstream 11.1 miles (17.9 km) of this river reach are in Oregon and have been federally designated as a Wild and Scenic River. The downstream 6.2 miles (10.0 km) are in California. Key tributaries to this river reach are Rock Creek at RM 213.9 and Shovel Creek at RM 206.5. Only Shovel Creek is large enough to support trout spawning.

The City of Klamath Falls (1986) described water and substrate habitat types in the Oregon and California portions of this river reach. The peaking reach of the Klamath River is in a deep undeveloped canyon and has a relatively steep overall gradient of approximately 35 feet per mile (17.2 m per km), or about 0.7 percent (ODFW, 1997). This reach has a minimum instream flow that consists of the 100 cfs (2.8 cms) requirement released at J.C. Boyle dam to the bypass reach, plus the additional natural discharge of about 250 cfs (7.1 cms) from the springs located with the bypass reach (PacifiCorp, 2002). In the Oregon portion, habitat includes cascades, deep and shallow rapids, runs, riffles, and occasionally deep pools, with the proportions of each varying according to river gradient and width at a particular river location. Substrate in the Oregon portion is mostly boulders and large cobbles with a few small pockets of gravel behind boulders. Riparian bank cover in the Oregon portion is generally good, but reflects some cattle grazing effects. Many large boulders provide good instream cover for fish.

The California segment of the peaking reach is wider and less steep than the Oregon segment, contains fewer cascades but more riffles and runs, and infrequently exhibits pools and quiet water. The substrate is primarily bedrock, boulders, and cobbles, with a few gravel pockets occurring below boulders downstream of Shovel Creek. The California portion exhibits good bank cover (riparian) and good instream cover (boulders, rooted aquatic plants, undercut banks) for fish (City of Klamath Falls, 1986).

The flows in the peaking reach can range from more than 10,000 cfs (283.2 cms) during spring runoff of wet years to approximately 350 cfs (9.9 cms) during summer and fall when the J.C. Boyle reservoir is refilling during peaking cycles. During a 24-hour period, these flows can vary between approximately 350 cfs (9.9 cms) and 3,450 cfs (97.7 cms) as a result of peaking operations at the J.C. Boyle facility, but typically the facility is operated such that peaking-cycle flows vary between 350 cfs (9.9 cms) and 1,500 cfs (42.5 cms) (only one of the two turbines operating) or between 1,500 cfs (42.5 cms) and about 3,000 cfs (85.0 cms) (one turbine base loaded, second turbine peaking) depending on inflows to J.C. Boyle reservoir. The licensed up-ramping and down-ramping rate below the J.C. Boyle powerhouse discharge is 9 inches (228.6 mm) per hour, but typically is operated at about 7 inches (177.8 mm) per hour.

These daily river flow fluctuations can affect aquatic resources in the peaking reach by modifying physical habitat and water quality, but they also have allowed for commercial and recreational rafting opportunities during summer from the J.C. Boyle powerhouse to Copco No. 1 reservoir (PacifiCorp, 2000). Daily flow fluctuations during the warmer months of the year regularly expose shoreline areas of the river channel, thereby limiting the production of aquatic insects and other benthic invertebrates to riverbed locations that remain wet during the low-flow period of the daily flow cycle. Still, the river produces what has been described as an "immense quantity" of aquatic invertebrates (National Park Service, 1994). Crayfish are also abundant in this reach. Peaking operations also affect water quality during summer and fall (ODFW, 1997). During power generation, water entering the peaking reach consists primarily of the highly productive, but warm water from J.C. Boyle reservoir. When power generation ceases, water entering the peaking reach consists primarily of the cooler, but less productive spring-influenced water from the bypass reach.

Fish Resources

Fish species composition and relative abundance in the J.C. Boyle peaking reach were referred to in previous discussions of upstream river reaches and are described briefly here. Native fish species known or suspected to occur in the peaking reach include redband/rainbow trout; Klamath smallscale, Klamath largescale, shortnose, and Lost River suckers; tui and blue chubs; lampreys (perhaps Pacific, Klamath, and Pit-Klamath brook); sculpins (perhaps marbled, only), and Klamath speckled dace (City of Klamath Falls, 1986). Brown trout, an introduced species, occasionally has been reported by anglers in the Klamath River between the Oregon-California border and Copco No. 1 reservoir (City of Klamath Falls, 1986). Henricksen et al. (2002) reported that use of the J.C. Boyle peaking reach by the endangered Lost River and shortnose suckers likely is limited to the downstream emigration of juveniles and adults from upstream basin habitat. Potential sucker spawning was documented in the first riffle upstream of Copco reservoir (Beak, City of Klamath Falls, 1986). Both of these species have a strong preference for lakes.

Information on fish species composition and relative abundance also is available from electro-fishing (boat and shoreline) studies conducted in three sections of the J.C. Boyle peaking reach in 1984 (City of Klamath Falls, 1986). These data show that Klamath smallscale sucker was always the most abundant species and redband/rainbow trout was among the three most abundant species collected throughout the reach. The most abundant species captured in the upper 6 miles of the peaking reach were Klamath smallscale sucker (46 percent of the total), rainbow/redband/rainbow trout (24 percent), tui chub (14 percent), and blue chub (9 percent). Marbled sculpin, Klamath speckled dace, and lamprey also were collected and individually comprised from 2 to 3 percent of the total catch. Continuing downstream approximately 5 miles to near the Oregon-California border, the most abundant species collected were Klamath smallscale sucker (40 percent of the total), Klamath speckled dace (31 percent), rainbow/redband/rainbow trout (13 percent), marbled sculpin (9 percent), tui chub (7 percent), and fathead minnow (1 percent, non-native species). From approximately the Oregon-California border to Copco No. 1 reservoir, the most abundant species collected were Klamath smallscale sucker (41 percent), yellow perch (28 percent, non-native species), rainbow/redband/rainbow trout (20 percent), and tui chub (5 percent). Klamath speckled dace, lamprey, marbled sculpin, and golden shiner (non-native species) each comprised 1 to 2 percent of the total catch in this most downstream section (City of Klamath Falls, 1986). The proximity of Copco No. 1 reservoir to the downstream-most section may account for some of the variation in species composition there compared to the upstream sections.

The Oregon portion of the peaking reach of the Klamath River is managed as a wild trout fishery by the ODFW (1997) and this portion comprises the Wild and Scenic River section managed by the U.S. Bureau of Land Management (BLM). The primary fisheries management objective is to sustain populations of wild redband/rainbow trout. The CDFG manages the California portion of the peaking reach similarly. This reach was designated a wild trout area (WTA) in 1974 and has since been managed under California's Wild Trout Program (WTP), which was established in 1971. The objective of the WTP is to maintain natural and attractive trout fisheries, with major emphasis on the perpetuation of wild strains of trout. No hatchery rainbow trout have been stocked in the Oregon portion of the Klamath River since 1978 or in the California portion of the Klamath River since 1974 (City of Klamath Falls, 1986). Adult steelhead were stocked in the Oregon portion of the Klamath from 1970 to 1974, but stocking was discontinued because of the lack of angler interest (CDFG, 1991) and concerns about adverse interactions with resident redband/rainbow trout (ODFW, 1997).

The Oregon portion of the peaking reach is regulated as a catch-and-release trout fishery from June through September and is open to a limited catch the rest of the year. Poor water quality in this river reach during summer and fall may contribute to the reduced palatability of redband/rainbow trout that has been reported to occur during this time of year (ODFW, 1997). The California portion of the peaking reach is open to a limited catch of redband/rainbow trout from April to November, except within 250 feet (76.2 m) upstream and downstream from the mouth of Shovel Creek where fishing is closed from November through June. Currently, Shovel Creek proper is closed to fishing year-round to protect important wild trout spawning areas (Henriksen et al. 2002).

The redband/rainbow trout population in this river reach has been described as highly productive and self sustaining (National Park Service, 1994). Population estimates for adult redband/rainbow trout (longer than 197 mm or 7.8 inches) in August 1984 were 890 fish per mile (95 percent confidence interval of 763 to 1,069 fish per mile) in the upper 6 miles (9.7 km) of this reach, and 1,911 fish per mile (95 percent confidence interval of 475 to 7,936 fish per mile) in the next 5 miles (8 km) downstream to near the Oregon-California border (City of Klamath Falls, 1986). These population estimates are comparable to those in the lower Deschutes River in central Oregon, another wild trout stream noted as one of the most productive in the state (National Park Service, 1994).

The redband/rainbow trout population in the peaking reach of the Klamath River supports a high quality recreational fishery. Annual angler catch rates in the Oregon portion of the peaking reach varied from 0.56 to 1.31 redband/rainbow trout per hour during the years 1979 through 1984 and averaged 0.77 redband/rainbow trout per hour (see Section 3.0, Table 3.5-25). These catch rates are comparable to or exceed those of other high quality trout stream in Oregon including the Deschutes and Metolius Rivers (City of Klamath Falls, 1986). Annual angler catch rates in the California portion of the peaking reach were slightly lower, varying from 0.44 to 0.88 trout per hour during 1974 to 1977, 1981, and 1982, and averaging 0.59 redband/rainbow trout per hour. The CDFG (2000) reported that the Upper Klamath River WTA had the highest overall catch rate among the wild trout rivers it monitors in California.

There is no or little spawning habitat for trout in either the Oregon or California portions of the peaking reach (City of Klamath Falls, 1986; Henriksen et al. 2002). Gravel and its accumulation in this reach are limited because J.C. Boyle dam blocks gravel recruitment, there are few tributary streams available to contribute gravel, and the steep gradient of the reach limits gravel accumulation. The lack of redband/rainbow trout spawning habitat has been identified as a potential limiting factor in this reach, but the extent to which spawning may occur in this reach is unknown (PacifiCorp, 2000).

During the fall of 1988, 453 rainbow trout more than 7.9 inches (200 mm) FL from the Klamath River downstream of the J.C. Boyle powerhouse were tagged (City of Klamath Falls, 1989). The ODFW monitored fish passage at the J.C. Boyle fish ladder in late 1988 and throughout 1989. None of the tagged fish was observed in the fish ladder. Of those fish sampled in the ladder (433 fish), most (64 percent) were less than 7.9 inches (200 mm) long. The results suggest that most of the fish moving upstream over the ladder were from the J.C. Boyle bypass reach and that few, if any, originated from the area downstream of the J.C. Boyle powerhouse.

2.7.2.5 Klamath River – Copco No. 2 Bypass Reach

Description of Area

The Copco No. 2 bypass reach of the Klamath River is approximately 1.4 miles (2.3 km) long. It extends from the 38-foot-high (11.6 m) Copco No. 2 dam at RM 198.3 to the 27-MW Copco No. 2 powerhouse at RM 196.9. The powerhouse discharges directly into Iron Gate reservoir. The Copco No. 2 bypass reach is in a deep, narrow canyon with a steep gradient similar to that of upstream Klamath River reaches. The channel consists of bedrock, boulders, large rocks, and occasional pool habitat. The riparian zone is well developed, but has been clearly influenced by the altered flow regime. PacifiCorp discharges a non-regulatory minimum flow of approximately 5 to 10 cfs (0.1 to 0.3 cms) from Copco No. 2 dam to the bypass reach. There is no ramping rate requirement for the bypass reach (PacifiCorp, 2000, 2002).

Copco No. 2 dam is located only 0.3 mile (0.5 km) downstream of Copco No. 1 dam, being separated by the small 40-acre (16.2 ha) Copco No. 2 reservoir. There is no riverine habitat immediately downstream of Copco No. 1 dam because Copco No. 1 powerhouse discharges directly into Copco No. 2 reservoir. Neither dam has upstream or downstream fish passage facilities. Water quality in Copco reservoir during summer generally is degraded as a result of warm surface water temperatures and blooms of blue-green algae (*Aphanizomenon flos-aquae*). Water quality in the Copco No. 2 bypass reach during summer is probably similar to that in the reservoir (PacifiCorp, 2000, 2002).

Fish Resources

Before 2001, no fisheries studies had been conducted in the Copco No. 2 bypass reach. The low base flow (approximately 10 cfs (0.3 cms)) and proximity to Copco No. 1 and No.2 reservoirs and upper Iron Gate reservoir undoubtedly influence the fish community in this reach. Native species such as redband/rainbow trout, sculpin, speckled dace, chubs, and suckers probably occur in this short reach. Sunfishes, perch, shiners, and minnows originating from the nearby reservoirs also may be found at certain times of the year.

2.7.2.6 Klamath River – Downstream of Iron Gate Dam

Description of Area

Iron Gate dam, located at RM 190.1, is the downstream-most hydroelectric facility of the Klamath Hydroelectric Project and the downstream-most dam on the Klamath River. Iron Gate dam was completed in 1962, is 173 feet (52.7 m) high, and has a 730-foot-long (225 m) ungated spillway to transport high flows past the structure. It impounds Iron Gate reservoir with a surface area of approximately 944 acres (382.0 ha). An 18-MW powerhouse with a hydraulic capacity of 1,750 cfs (49.6 cms) is located at the dam's base. The entrance to the powerhouse penstock is covered with 4-inch (101.6 mm) bar spacing to prevent trash entrainment. Downstream fish passage potentially could occur through the powerhouse penstock and turbine or via the spillway when flow exceeds 1,750 cfs (49.6 cms), although fish survival rates are unknown. There are no upstream fish passage facilities past Iron Gate dam (PacifiCorp, 2000, 2002).

To mitigate for Iron Gate dam's blockage of upstream migrations by anadromous species and the loss of salmon and steelhead spawning and nursery areas between Iron Gate dam and Copco dam, PacifiCorp constructed the Iron Gate fish hatchery in 1966 as stipulated in the last Klamath Hydroelectric Project FERC license (CH2M HILL, 1985; PacifiCorp, 2002). PacifiCorp funds a large percentage of the annual costs of the hatchery, which is operated by the CDFG. Fall Chinook salmon, coho salmon, and steelhead are reared at the hatchery. Currently, the hatchery meets FERC-mandated quotas for fall Chinook salmon and coho salmon, but not for steelhead because of poor returns and limited opportunities for egg collection. Fish disease at the hatchery has been sporadic (PacifiCorp 2000, 2002). CH2M HILL (1985) reported that juvenile hatchery-reared steelhead have been periodically lost to *Ceratomyxa shasta*, a protozoan parasite, which is found in the Klamath River basin. In addition, coho salmon eggs in the hatchery have been lost to softshell disease (small openings in the egg membrane following artificial spawning) and white spot disease (egg injury during or after artificial spawning).

Two fish ladders are associated with Iron Gate fish hatchery operations. The entrance to one ladder is adjacent to the powerhouse and leads to the hatchery's trapping, holding, and spawning facilities at the dam's base. The second ladder is located at the main hatchery facility, is upstream of the Klamath River's confluence with Bogus Creek, approximately 0.5 mile (0.8 km) downstream of the dam. Fish can be sorted at the second ladder and either returned to the river or trucked to the hatchery. PacifiCorp (2000) reported that these facilities could be used in the future to collect, sort, and transport anadromous fish to areas upstream of Iron Gate dam if fisheries agencies decided to implement these management actions.

Iron Gate dam is operated as a regulating facility to dampen the effects of fluctuating river levels caused by load factoring operations at the Copco No. 1 and Copco No. 2 facilities. At the direction of the USBR, PacifiCorp has regulated outflow from Iron Gate dam since 1997 to meet minimum/target Klamath River instream flows below the dam. These flows have been specified since 1997 in biological opinions (BOs) prepared by NOAA Fisheries to protect species present downstream of Iron Gate dam that are listed under the federal ESA. Development of minimum/ target flows was prompted by the NOAA Fisheries ESA listing of the southern Oregon/northern California coast coho salmon ESU as a threatened species on May 6, 1997 [62 FR 24588] (PacifiCorp, 2000, 2002).

Minimum/target flows downstream of Iron Gate dam are stipulated in the USBR's Klamath Project Operations Plan and reflect ESA consultation between the USBR and NOAA Fisheries. These flows generally exceed the minimum instream flows required by the FERC license and can change annually depending on water year type.

Klamath River flow is measured at U.S. Geological Survey (USGS) gauging station No. 11516530, approximately 0.6 mile (1.0 km) downstream of Iron Gate dam. Measured river flow includes outflow from Iron Gate dam, Iron Gate fish hatchery return water, and inflow from Bogus Creek, which enters the Klamath River between the dam and gauging station.

The Iron Gate facility downramps occasionally in response to changes in the specified minimum/ target flows, plant shutdowns, and following spill events in the spring. Two sets of ramping rates have been developed for Iron Gate dam. The first is contained in the current FERC license and is 250 cfs (7.1 cms) per hour or 3 inches (76.2 mm) per hour, whichever is less. NOAA Fisheries recently specified a more conservative second set of ramping rates in its 2001 BO issued for USBR Klamath Project Operations based on a concern that certain downramping rates at Iron Gate dam may result in fish stranding at points downstream. The NOAA Fisheries BO specifies the following Iron Gate dam ramping rates (PacifiCorp, 2002):

- No more than 50 cfs (1.4 cms) per 2-hour period not exceeding 150 cfs (4.2 cms) per 24-hour period when flow through the Iron Gate powerhouse is at or less than the powerhouse hydraulic capacity of 1,750 cfs (49.6 cms)
- No more than 125 cfs (3.5 cms) per 4-hour period not exceeding 300 cfs (8.5 cms) per 24-hour period when flow past Iron Gate dam (powerhouse plus spillway) exceeds 1,750 cfs (49.6 cms).

In response to the NOAA Fisheries concern regarding stranding, PacifiCorp (2002) reported that only one stranding incident has been documented downstream of Iron Gate dam. Stranded juvenile salmonids were found near the BLM Tree of Heaven campsite in 1998 following a rapid reduction of inflow to, and outflow from, the Iron Gate facility. Stranding occurred in an artificial spawning channel that had been created by the CDFG in the late 1970s. Because the channel has not been maintained and no longer functions as originally engineered, the potential for stranding at this site was considered to be high (PacifiCorp, 2002).

A geomorphic study recently was conducted that provided a detailed description of conditions from Iron Gate dam to the mouth of the Klamath River, a distance of approximately 190 miles (305.8 km) (Ayres Associates, 1999). Study results showed that from the dam to the confluence with the Shasta River (RM 176.6), a 13.5-mile-long (21.7 km) reach where most anadromous fish spawning occurs in the mainstem Klamath River, river bed substrate contains a wide range of sizes, is relatively loosely packed, and is easily excavated by spawning fish (Ayres Associates, 1999).

Ayres Associates (1999) also concluded that water quality in the Klamath River likely limits all runs of anadromous fish at some point in their life cycle, especially during summer and early fall. Hardy and Addley (2001) reported that in the Mid-Klamath subbasin, which the Klamath River Basin Fisheries Task Force (KRBFTF, 1991) defined as extending from Iron Gate dam downriver approximately 150 miles (241.4 km) to Weitchpec, the mainstem Klamath River can be affected by water quality from upstream releases at Iron Gate dam during low-flow periods. Water-quality-related effects have included elevated water temperatures during late summer. Hardy and Addley (2001) also reported that water releases at Iron Gate dam as a result of Klamath Projects operation, together with water allocation practices in the Shasta and Scott River basins, generally have resulted in increased winter flows and reduced summer flows in the mainstem Klamath River in the Mid-Klamath subbasin compared to historical conditions.

Fish Resources

Species composition and several attributes of the fish assemblage in the Klamath River drainage downstream of Iron Gate dam are listed in Table 2.7-1 and described in Section 2.7.2.1. The following discussion focuses on the status of anadromous populations in this reach of river and those salmonid species that return to Iron Gate fish hatchery. Anadromous populations using the four major tributaries to the Klamath River downstream of Iron Gate dam (the Shasta, Scott, Salmon, and Trinity rivers) are described briefly. General periodicities of use by anadromous species in the Klamath River basin also are briefly described. Much of the following discussion is based on summaries by the National Research Council (2003), Hardy and Addley (2001), CH2M HILL (1985), and KRBFTF (1991) of previous fisheries studies describing historical and current anadromous fish use in the Klamath River basin.

Anadromous species historical use of the Klamath River basin extended from the mouth of the Klamath River upstream past Upper Klamath Lake/Agency Lake to the Sprague and Williamson Rivers. Historical use of the Upper Klamath River basin by anadromous species also included other Klamath River tributaries, such as Spencer Creek, that are upstream of Iron Gate dam and presently inaccessible to anadromous species (Hardy and Addley, 2001; Fortune et al. 1966).

The primary anadromous species historically using the Upper Klamath River basin above Upper Klamath Lake was Chinook salmon (Fortune et al. 1966). It was well documented that a fall Chinook salmon run entered the Upper Klamath River starting in September and October. These salmon contributed to a fishery near Keno and at Klamath Falls. Historical accounts cited in Fortune et al. (1966) indicated that there also may have been a spring run of Chinook salmon to Upper Klamath Lake but that they were gone “before the time when white man came to the area.” Although no information was available on exact spawning areas for Chinook salmon, it was known that they entered the Williamson River and its major tributary, the Sprague River. These Chinook salmon stocks were believed to have been genetically adapted to the narrow limits of migration, spawning and incubation requirements afforded by the unique conditions in the Upper Klamath basin and Upper Klamath Lake (Fortune et al. 1966).

Fortune et al. (1966) provides the most comprehensive review of historical presence of steelhead trout upstream of the present location of Iron Gate dam. Based on this evaluation, it was clear that steelhead were present in the Upper Klamath River up to, and including, Spencer Creek. However, there was no conclusive evidence that steelhead trout ever existed above Upper Klamath Lake. Referring to the question of steelhead runs above the lake, Fortune et al. (1966) concluded, “Though it is possible that steelhead trout did migrate to the upper basin, no conclusive evidence of such runs can be derived from the reports examined.” There was abundant documentation of large rainbow trout observed in the area, but at the time there was no clear means to differentiate sea run steelhead trout from the large adfluvial redband rainbow trout that resided in Upper Klamath Lake and Lake Ewauna and spawned in the tributaries to Upper Klamath Lake. Given the rapid growth of the redband/rainbow trout in local waters, anadromous steelhead trout may not have been able to compete with these larger resident trout (KRBFTF, 1992). Citing observations in Snyder (1931) for steelhead trout in the upper Klamath River, and based on meristic evidence from museum specimens of steelhead from Spencer Creek, Benke (1992) concluded that steelhead trout of the Upper Klamath River were “coastal rainbow trout and quite distinct from the native lucustrine trout of Upper Klamath Lake.” He notes the unique natural eutrophic condition of Upper Klamath Lake and its high pH as factors favoring the selection of the local interior redband genotype.

Klamathon dam, which was located downstream of present-day Iron Gate Dam, blocked most upstream passage of fish between 1889 and 1902 (KRBFTF, 1992). After this dam was destroyed in 1902 salmon runs were again documented in the upper river at Klamath Falls. The last runs of Chinook salmon destined to the upper basin were curtailed after 1910 when the Bureau of Fisheries installed a fish collection rack at Klamathon (Fortune et. al. 1966). Completion of Copco No. 1 dam in 1918 created a permanent blockage to the upper basin.

Historical and current distributions of anadromous species in the Lower Klamath River system include the mainstem Klamath River; major tributaries such as the Shasta, Scott, Salmon, and Trinity Rivers; and many smaller tributaries in the lower basin. Anadromous salmonids historically and currently using the Lower Klamath River basin downstream of Iron Gate dam include spring/summer-, fall-, and winter-run steelhead; spring- and summer/fall-run Chinook salmon; and coho salmon. Hardy and Addley (2001) also reported that chum and pink salmon historically occurred and still are captured infrequently in the Lower Klamath River. Hardy and Addley (2001) stated that the lack of historical quantitative catch data for areas beyond the mainstem Klamath River and its tributaries in the lower basin make it difficult to determine the historical distribution of other important fish resources, such as white and green sturgeon, Pacific lamprey, coastal cutthroat trout, and eulachon (candlefish).

NOAA Fisheries distribution maps for anadromous salmonids show five ESUs are present in the Klamath River basin downstream of Iron Gate dam. These ESUs and their federal listing status consist of the following:

- Southern Oregon and Northern California Coastal Chinook salmon ESU. This ESU is present downstream of the Trinity River-Klamath River confluence. NOAA Fisheries determined that federal listing was not warranted for this ESU on September 16, 1999 (64 FR 50394).

- Upper Klamath-Trinity rivers Chinook salmon ESU. This ESU is present upstream of the Trinity River-Klamath River confluence. NOAA Fisheries determined that federal listing was not warranted for this ESU on March 9, 1998 (63 FR 11482).

- Southern Oregon/Northern California coasts coho salmon ESU. NOAA Fisheries listed this ESU as threatened on May 6, 1997 (62 FR 24588) and designated critical habitat downstream of Iron Gate dam on May 5, 1999 (64 FR 24049).

- Klamath Mountains Province steelhead ESU. NOAA Fisheries determined that federal listing was not warranted for this ESU on April 4, 2001 (66 FR 17845).

- Pacific Coast chum salmon ESU. NOAA Fisheries determined that federal listing was not warranted for this ESU on March 10, 1998 (63 FR 111774).

Hardy and Addley (2001) summarized population trend data for steelhead trout, fall-run Chinook salmon, and coho salmon in the Klamath River basin and in the mid-Klamath subbasin (from Iron Gate dam downriver to Weitchpec). Spring-run Chinook salmon also are present in this subbasin of the Klamath River, but they generally do not occur far upstream past the confluence with the Salmon River (PacifiCorp, 2001). Hardy and Addley (2001) reported that miles of suitable habitat available to these three species in the Mid-Klamath subbasin total approximately 168 miles (270.4 km) for fall and spring Chinook salmon, 250 miles (402.3 km) for steelhead, and 190 miles (305.8 km) for coho salmon. CH2M HILL (1985) reported that the most important fall Chinook spawning areas in the mid-Klamath subbasin are in the mainstem Klamath River between Iron Gate dam and the mouth of the Shasta River, a 13.5-mile-long (21.7 km) river reach, and in Bogus Creek downstream of Iron Gate dam. About 50 percent of the fall Chinook salmon spawning in the mainstem Klamath River occurs in this 13.5-mile (21.7 km) reach (Hardy and Addley, 2001).

Steelhead. Steelhead runs in the Klamath basin before the 1900s probably exceeded several million fish (Hardy and Addley, 2001). Subsequent steelhead runs in the Klamath and Trinity River systems declined steadily to an estimated 400,000 fish in 1960; 250,000 fish in 1967; 241,000 fish in 1972; and 135,000 fish in 1977. Hardy and Addley (2001) reported that in the 1980s, the hatchery-influenced summer/fall-run of steelhead throughout the Klamath and Trinity rivers consisted of approximately 10,000 fish, while the winter-run steelhead component was estimated at approximately 20,000 fish. During the period 1980 through 1997, numbers of adult steelhead in the Klamath River Basin were estimated to be declining at a rate of approximately 10 percent per year (NMFS Fisheries, 1998). Numbers of adult summer steelhead in the Klamath Basin in the 1990s have been estimated to vary between only about 1,000 and 1,500 fish (National Research Council, 2003). Numbers of adult steelhead in the Trinity River Basin are reported to be relatively stable, varying between approximately 1,300 and 2,800 fish per year, although about 50 to 90 percent of these fish are hatchery fish NMFS, 1998).

As previously noted, NOAA Fisheries (previously NMFS) recently determined that listing for the Klamath Mountains Province steelhead ESU, whose distribution includes the Klamath River basin downstream of Iron Gate dam, is not warranted. However, NOAA Fisheries expressed concern that populations of this steelhead ESU are not self-sustaining (Hardy and Addley, 2001). In their status review of this steelhead ESU, NMFS (1994) stated U.S. Forest Service (USFS) biologists described Klamath River winter-run steelhead stocks as low and possibly declining, and the summer-run stocks as depressed, with possibly a reduced range. Forest Service biologists described Trinity River winter-run steelhead stocks as stable to depressed with heavy hatchery influence in the mainstem and North Fork, and the summer-run stocks as either low but stable or unknown, except for a drastic reduction in the South Fork Trinity River (NMFS, 1994).

In the 1980s the hatchery-influenced summer/fall-run of steelhead throughout the Klamath and Trinity Rivers consisted of approximately 10,000 fish, while the winter-run steelhead component was estimated at approximately 20,000 fish (Hardy and Addley, 2001). Adult steelhead returns to the Iron Gate fish hatchery, which consist of fall/winter-run fish (KRBFTF, 1991), have varied widely since counts began in the mid-1960s, ranging from 12 fish in 1996 to 4,411 fish in 1978 (CDFG file data).

Iron Gate hatchery produces and releases about 200,000 winter steelhead smolts to the Klamath River each year (National Research Council, 2003). Steelhead smolts are released in late March and most reach the estuary in late April along with wild steelhead smolts (National Research Council, 2003). Adult steelhead returns to Iron Gate hatchery, which consist of fall/winter-run fish (KRBFTF 1991), have varied widely since counts began in the mid-1960s. Annual hatchery returns averaged 1,935 fish through 1990, 166 fish from 1991 through 1995, and declined to only 11 fish in 1996 (Hardy and Addley, 2001). Recent counts (1997 through 2001) have increased slightly and averaged 265 fish per year. A total of 532 steelhead returned to Iron Gate hatchery in 2000, the largest number since 1989, when a total of 759 fish returned. Numbers of steelhead and other juvenile outmigrants in the mainstem Klamath River are monitored for a portion of the spring and summer at the Big Bar trapping site, approximately 6 miles upstream of the Trinity River, using rotary screw traps (Scheiff et al. 2001). This trapping location provides information on juveniles outmigrating from nearly all of the Klamath River basin upstream of the Trinity River confluence, including juveniles reared at and released from Iron Gate hatchery. From 1997 through 2000, monitoring at the Big Bar site occurred from late March or early April through mid-July or mid-August (Scheiff et al. 2001). Monitoring was discontinued after this time due to low trap catches and large algae loads.

Abundance indices for steelhead outmigrants during the trapping periods at the Big Bar site were 18,618 fish in 1997; 66,125 fish in 1998; 34,078 fish in 1999; and 14,456 fish in 2000 (Scheiff et al. 2001). The abundance index for steelhead outmigrants consisted of an average of 99.8 percent naturally produced fish and 0.2 percent hatchery produced fish over the four-year period. Steelhead outmigrants consisted of an average of 13 percent Age 0 fish; 47 percent Age 1 fish; 37 percent Age 2 fish; and 3 percent Age 3 fish. Scheiff et al. (2001) cautioned that these abundance indices are not intended to represent population estimates because they are contingent on the assumptions that catch rates are directly proportional to the percentage of river flow sampled and that individuals from a given species are equally susceptible to capture. However, these indices can be used to compare relative abundance during trapping seasons among various years (Scheiff et al. 2001).

<u>Chinook Salmon</u>. Hardy and Addley (2001) reported that in the Klamath River basin, fall Chinook numbers have declined drastically over much of the last century and that spring Chinook, which were considered to be more abundant than summer/fall-run fish prior to 1900, today consist of only remnant numbers. The total estimated catch and escapement of Chinook salmon in the Klamath River between 1915 and 1928 averaged between 300,000 and 400,000 fish annually. By 1972, an estimated 148,500 Chinook salmon entered the Klamath River. Between 1978 and 1995, the average annual escapement of wild and hatchery-produced fall Chinook had declined to 58,820 adults, with an annual low of 18,133 adults (Hardy and Addley, 2001). Over the last 25 years, numbers of adult fall-run Chinook in the Klamath River basin have varied between approximately 27,000 and 218,000 fish, with natural spawners representing about 20,000 to 40,000 of these totals (Andersson, 2003). In 2002, the Chinook salmon total in-river fall run in the Klamath River basin was estimated to be 162,297 fish, with natural spawners comprising approximately 42 percent (68,165 fish) of this total. The Klamath basin Chinook salmon spring run, which uses the Salmon and Trinity River Subbasins, has varied between approximately 200 and 1,500 adults per year over the last 25 years, and in 2002 was estimated to consist of just over 1,000 fish (Andersson, 2003).

Iron Gate hatchery produces and releases approximately 5 to 8 million Chinook salmon smolts (all fall-run fish) to the Klamath River each year (National Research Council, 2003). Smolts are typically released in late May or early June, and most reach the estuary 1 to 2 months later. A second release of Chinook yearlings occurs in November. Numbers of fall Chinook adults returning to Iron Gate hatchery have ranged from 365 fish in 1966 during the first year of hatchery operation to 13,725 fish in 1977 (CH2M HILL, 1985). Returns for 2001 and 2002 are the highest on record for Iron Gate hatchery with a combined total for those 2 years of 111,042 Chinook.

KRBFTF (1991) reported that fall Chinook salmon arrive at Iron Gate hatchery from approximately mid-September through mid-November, peaking in abundance about mid-October.

Numbers of Chinook salmon outmigrants were monitored at the Big Bar trapping site on the Klamath River from 1997 through 2000 during the same times as described previously for steelhead outmigrants. Nearly all Chinook outmigrants captured were Age 0 fish. Peak catches of Age 0 Chinook salmon occurred in late June or early July from 1997 through 2000 (Scheiff et al. 2001). Abundance indices for Age 0 Chinook salmon during the trapping periods at the Big Bar site were 546,736 fish in 1997; 1,914,406 fish in 1998; 798,674 fish in 1999; and 511,798 fish in 2000. Iron Gate Hatchery fish comprised 83 percent, 53 percent, 58 percent, and 44 percent of the Age 0 Chinook captured in the Big Bar trap from 1997 through 2000, respectively (Scheiff et al. 2001).

Coho salmon. Coho salmon populations in the Klamath River Basin today are substantially smaller and at much greater risk than historically (Hardy and Addley, 2001). As previously noted, NOAA Fisheries listed the Southern Oregon/Northern California Coasts coho salmon ESU, whose distribution includes the Klamath River basin downstream of Iron Gate dam, as a threatened species in 1997 and designated critical habitat for this ESU downstream of Iron Gate dam in 1999. Hardy and Addley (2001) reported that annual coho salmon spawning escapement, including hatchery stocks, to the Klamath River system in 1983 was estimated to vary between 15,400 and 20,000 adults. These estimates represent more than a 90 percent decline in coho salmon abundance since the 1940s and at least a 70 percent decline in abundance since the 1960s (CH2M HILL 1985; Hardy and Addley, 2001).

Iron Gate hatchery currently releases an average of about 71,000 coho smolts to the Klamath River each year (National Research Council, 2003). Coho smolts are released between about mid-March and early May and reach the estuary at the same time as wild smolts, peaking in late May and early June. Annual returns of coho salmon to Iron Gate hatchery have been highly variable, ranging from two fish in 1966 during the first year of hatchery operation to 4,097 fish in 1997.

Natural production of coho salmon in the Klamath River basin is minor compared to historical levels (Brown et al. 1994). Surveys in 2001 indicated that 17 of 25 streams in the Klamath River basin known to historically support coho salmon currently support small numbers of juvenile coho; in addition, wild coho stocks in the Trinity River subbasin have declined by about 96 percent from historical levels (National Research Council, 2003). In the early 1990s, estimated coho salmon spawning escapement for the entire Klamath-Trinity river system was only 1,860 native and naturalized fish. Some tributary streams in the Middle and Upper Klamath River basin still support coho populations that may be native, while native coho runs are greatly diminished in lower Klamath tributaries (Brown et al. 1994). Of the larger tributaries, the Scott River probably holds the largest number of native coho while the Salmon River probably has few, if any, native coho. Reasons for the decline of native coho salmon populations in California include loss of stream habitat, interactions with hatchery fish, overexploitation, and climatic factors (Brown et al. 1994).

Numbers of coho salmon outmigrants were monitored at the Big Bar trapping site on the Klamath River from 1997 through 2000 during the same times as described previously for steelhead and Chinook salmon outmigrants. Abundance indices for coho salmon outmigrants at the Big Bar site during trapping periods each year were very low compared to Chinook and steelhead outmigrants, varying between 2,108 fish in 1998 and 6,918 fish in 1999 (Scheiff et al. 2001). The abundance index for coho salmon outmigrants consisted of an average of 73 percent naturally produced Age 0 coho; 17 percent naturally produced Age 1 coho; and 11 percent hatchery produced Age 1 coho. Age 0 coho were captured from the start of trapping into early July and Age 1 coho typically were captured from early May to mid-June (Scheiff et al. 2001).

Two other important anadromous species, Pacific lamprey and green sturgeon, also use or could potentially use the mid-Klamath subbasin for spawning and rearing. Pacific lamprey is a federal species of concern currently under review for ESA listing. NOAA Fisheries is reviewing the status of Pacific lamprey to determine whether federal listing is warranted. The National Research Council (2003) reported that Pacific lamprey were once very abundant in California coastal rivers but today their numbers are low and declining. Both Pacific lamprey and green sturgeon have been observed as far upstream as Iron Gate dam (KRBFTF, 1991; Hardy and Addley, 2001). Hardy and Addley (2001) reported that no quantitative data are available for the mid-Klamath subbasin on the status of Pacific lamprey, although their distribution is believed to be generally similar to that of steelhead.

The federally endangered shortnose sucker also is reported to occur in the Klamath River downstream of Iron Gate dam (see Table 2.7-2). The presence of this lake-dwelling species may reflect the downstream emigration of juveniles and adults from upstream basin habitat, a behavior suggested for this species when present elsewhere in the Klamath River downstream of Klamath Project dams (Henriksen et al. 2002).

2.7.3 Major Tributaries

Major tributaries entering the Klamath River downstream of Iron Gate dam are the Shasta River at RM 176.6 north of Yreka, the Scott River at RM 143.0 near Hamburg, the Salmon River at RM 66.0 near Somes Bar, and the Trinity River at approximately RM 40 near Weitchpec. All of these tributaries enter the Klamath River in what the KRBFTF (1991) defined as the mid-Klamath subbasin. Anadromous fish production in each of these four tributary subbasins generally is reduced compared to estimated historical levels (CH2M HILL, 1985; KRBFTF, 1991; Hardy and Addley, 2001). Anadromous fish use of each tributary subbasin is described briefly in the following text. Additional information regarding anadromous salmonid production from each of these major tributaries is presented in Section 7.0 (Fish Passage Planning and Evaluation - EDT Model).

The National Research Council (2003) reviewed factors in the Klamath basin that likely are most limiting to anadromous fish species. Emphasis was placed on coho salmon, spring-run Chinook salmon, and summer steelhead because of the magnitude of risk these populations currently face. However, all anadromous species would benefit from the following improved conditions, particularly in major drainages including the Shasta, Scott, Salmon, and Trinity rivers and their tributaries because of their importance to salmonid spawning and rearing. It was concluded that for most tributaries, restoring low summer temperatures is probably the most critical factor (and action) that would benefit all salmonids, especially those salmonids at greatest risk. Other important factors (actions) that are linked to the need to lower summer water temperatures and that also would benefit anadromous production, include removing fish passage barriers, improving physical habitat for spawning and rearing, and increasing minimum stream flows

(National Research Council, 2003). These actions would be expected to benefit anadromous life stages in the mainstem Klamath River as well.

2.7.3.1 Shasta River Subbasin

Anadromous species historically and currently using the Shasta River subbasin include fall-run Chinook salmon, coho salmon, fall-run steelhead, and Pacific lamprey (Hardy and Addley, 2001). There are an estimated 35 miles of fall Chinook habitat, 38 miles of coho habitat, and 55 miles of fall steelhead habitat in the Shasta River subbasin (Hardy and Addley, 2001). Habitat values for fall Chinook salmon and coho salmon are similar to values reported in 1955, but less than pre-development estimates (Hardy and Addley, 2001). The habitat value for steelhead is less than in 1955 and pre-development estimates (Hardy and Addley, 2001). The National Research Council (2003) reported that current habitat values are substantially less than historical values. Fish use of remaining habitat in the Shasta subbasin is contingent on flow and water quality, both of which may be inadequate in dry years (National Research Council 2003).

Fall Chinook spawning runs in the Shasta River have declined from more than an estimated 80,000 fish in the 1930s to approximately 500 to 700 adults annually from 1990 to 1992. From 1993 to 1999, annual fall Chinook spawning escapement to the Shasta River averaged 4,649 fish and varied between about 1,400 and 13,000 adults. Increased numbers of fall Chinook spawners between 1993 and 1999 may reflect cooperative efforts by farmers and ranchers in the Shasta Valley beginning in the early 1990s to produce a “pulse flow” in the Shasta River. This is discussed in more detail at the end of this section.

Fall steelhead and coho salmon populations in the Shasta River also have declined from historical levels, although current population data are less clear for these two species than for Chinook salmon (Hardy and Addley, 2001). Adult steelhead and coho salmon are trapped and counted at the Shasta Racks on the Shasta River about 0.5 mile upstream from the river’s mouth. Because trapping only extends to early December, peak steelhead and coho spawning runs are missed and counts do not represent population estimates. However, review of fish counts from the early 1930s through the late 1990s indicates declines in run sizes for both species. Highest historic counts at the Shasta Racks are approximately 900 adult coho salmon in 1978 and 5,657 adult steelhead in 1940 (Klamath Resource Information System, 2003). Very few coho salmon adults (no more than 15 annually) or steelhead adults have been trapped at the Shasta Racks from 1990 to 1996 (Shasta River Weir Historic Coho Counts, 2003).

Numbers of Chinook salmon, coho salmon, and steelhead outmigrants in the Shasta River were monitored by the California Department of Fish and Game (CCDFG) using a rotary screw trap from late February through early July 2002 (Chesney and Yokel, 2003). Trapping was halted after this time because of declining river flows. Totals of 526,256 Chinook outmigrants, 8,294 steelhead outmigrants, and 747 coho salmon outmigrants were captured from late February through early July (Chesney and Yokel, 2003). There were an estimated 3,135,902 Chinook salmon outmigrants during a 14-week period that peaked in mid-March, and an estimated 6,657 steelhead outmigrants during a 7-week period that peaked in mid-April (smolts) and early June (parr). Too few coho salmon were captured to estimate the total number of coho outmigrants, although peak catches occurred in late April and late May. Many of the steelhead and coho salmon outmigrants were Age 0 fish that moved from the Shasta River to the Klamath River as Shasta River flows began to decline (Chesney and Yokel, 2003).

Overall, anadromous fish production in the Shasta River subbasin is believed to be limited by reduced river flows because of agricultural diversions, high summer water temperatures, stream diversions, and degraded spawning gravels resulting from various land use practices (Hardy and Addley, 2001). The principal causes of decline of salmonid production in the Shasta Subbasin are probably a substantial reduction of flows by water withdrawal and associated poor water quality (National Research Council, 2003). Reduced river flows from May through October on average and dry water years may restrict access by fall Chinook salmon to the lower 10 to 15 miles of the Shasta River, as compared to fall Chinook access to 38 miles of river during wet years (CH2M HILL, 1985). Low river flows also can reduce the suitability of rearing habitat for juvenile coho salmon and steelhead. There are no known current quantitative data on the distribution or abundance of Pacific lamprey in the Shasta River subbasin (Hardy and Addley, 2001).

A major bottleneck for salmonid production in the Shasta Subbasin is high water temperatures, especially from late June through early September (National Research Council 2003). Cooperative beneficial efforts by farmers and ranchers in the Shasta Valley were begun in the early 1990s by closing all irrigation diversions on a chosen day so that river flows increase and flush young Chinook salmon out of the Shasta River before late summer when water quality problems develop (Klamath Resource Information System, 2003 -December 9, 2003).

2.7.3.2 Scott River Subbasin

Anadromous species historically and currently using the Scott River subbasin include fall Chinook salmon, coho salmon, fall steelhead, and Pacific lamprey, the same as in the Shasta subbasin. Hardy and Addley (2001) reported estimates of 59 miles of fall Chinook habitat, 88 miles of coho habitat, and 142 miles of fall steelhead habitat in the Scott River subbasin. CH2M HILL (1985) indicated that habitat values for fall Chinook salmon and possibly fall steelhead in the Scott River subbasin are similar to historical values, but that the habitat value for coho salmon is about 30 percent less than historically. CH2M HILL (1985) reported that Pacific lamprey probably have access to as much or more habitat as fall steelhead in the Scott River subbasin.

Trend data for numbers of adult fall Chinook salmon in the Scott River subbasin indicate a general decline since the 1960s, while trends for coho salmon and fall steelhead in the Scott River subbasin are likely similar to the overall trends for the rest of the Klamath Basin (Hardy and Addley, 2001). The CDFG estimated that in the early 1960s there were approximately 8,000 adult fall Chinook, 800 adult coho salmon, and 5,000 adult steelhead in the Scott River subbasin (Shasta-Scott Coho Salmon Recovery Team, 2003). For the period 1995 through 1999, the estimated number of naturally spawning fall Chinook salmon in the Scott River subbasin averaged 8,381 fish annually and varied from 3,327 to 14,477 fish (Klamath River Basin Fall Chinook Salmon Spawner Escapement Data, 2003). The Scott subbasin is reported to be the largest contributor of natural fall Chinook spawners of any Klamath River basin tributary (except the Trinity River) or the mainstem Klamath (Scott River Watershed CRMP Committee, 1995).

The Scott River subbasin remains one of the most important tributary watersheds for coho salmon in the Klamath River basin (National Research Council, 2003). However, recent coho salmon spawning data in this subbasin indicate a decline from 1960s levels. Totals of 173 live coho salmon adults and 212 spawning redds were observed in the Scott subbasin during spawning surveys in December 2001 and January 2002; spawning occurred primarily in December (Maurer, 2002). Only 19 coho salmon were observed during spawning surveys in the Scott subbasin in December 2002 and January 2003, although field viewing conditions were poorer than the previous year (Shasta-Scott Coho Salmon Recovery Team, 2003). Quantitative data on adult steelhead populations in the Scott River subbasin appear to be lacking (Scott River Watershed CRMP Committee, 1995; Hardy and Addley, 2001). Factors limiting anadromous fish production in the Scott River subbasin are generally similar to those described for the Shasta River subbasin.

Numbers of Chinook salmon, coho salmon, and steelhead outmigrants in the Scott River were monitored using a rotary screw trap from late February through mid-July 2002 (Chesney and Yokel, 2003). Totals of 11,793 Chinook outmigrants, 11,918 steelhead outmigrants, and 1,939 coho salmon outmigrants were captured from late February through mid-July (Chesney and Yokel, 2003). There were an estimated 319,286 Chinook salmon outmigrants during an 8-week period and an estimated 6,657 steelhead smolt outmigrants during a 5-week period. Peak catches of both species occurred in approximately late March/early April and again in late June/early July. Too few coho salmon were captured to estimate the total number of coho outmigrants, although peak catches occurred in mid- to late June 2002 (Chesney and Yokel, 2003).

2.7.3.3 Salmon River Subbasin

The Salmon River subbasin historically supported and currently supports spring-run and fall-run Chinook salmon, coho salmon, spring (summer)-run and fall-run steelhead, Pacific lamprey, and green sturgeon. CH2M HILL (1985) reported that in this subbasin there are approximately 81 miles of Chinook salmon habitat compared to 90 miles historically, 85 miles of coho salmon habitat compared to 105 miles historically; and 109 miles of steelhead habitat compared to an estimated 105 miles historically. The National Research Council (2003), citing a previous estimate by the CDFG, reported there are approximately 140 miles of fall-run Chinook salmon spawning and rearing habitat in the Salmon subbasin. Pacific lamprey are believed to have access to at least as much habitat as steelhead in the Salmon River subbasin, and green sturgeon are believed to use the lower 6 miles of the Salmon River (CH2M HILL, 1985).

CH2M HILL (1985) stated that fall Chinook salmon and steelhead are the most prominent anadromous species in the Salmon River subbasin. However, Andersson (2003) reported that the sizes of both the fall and spring runs of Chinook salmon in the Salmon River Subbasin have been declining over the last 5 years. Fall Chinook natural spawner escapement to the Salmon River during the period 1989 through 1994 varied from 1,480 to 4,667 fish per year and averaged 3,051 fish (Scott River Watershed CRMP Committee, 1995). An estimated 762 fall Chinook spawners were present in the Salmon River in 1999 (CDFG fish counts). In 2002, the Klamath River basin spring Chinook salmon run was estimated to be just over 1,000 fish (Andersson, 2003). West (1991) estimated that the 180 adult spring Chinook salmon that returned to the Salmon River Subbasin in 1991 would produce approximately 27,900 fry that would emerge in 1992. KRBFTF (1991) and the National Research Council (2003) stated that the Salmon River subbasin may support the last wild, naturally spawning spring Chinook salmon population in the Klamath River basin.

The greatest number of spring (summer)-run steelhead adults in the Salmon River during the period 1979–1996 occurred in 1988 when an estimated 128 fish were present (Israel, 2003). Only

27 summer-run steelhead were estimated to be present in the Salmon River in 1996. Israel (2003) stated that summer steelhead runs are the most imperiled runs of this species in the Klamath River basin. Regarding coho salmon, Brown et al. (1994) stated there are few if any native populations of this species remaining in the Salmon River subbasin.

Hardy and Addley (2001) stated that there are no significant constraints on anadromous fish production in the Salmon River subbasin. The Salmon River remains one of the most pristine watersheds in the lower Klamath River basin, has a natural unregulated hydrograph, no significant diversions, and limited agricultural activity. Hardy and Addley (2001) reported that fall Chinook salmon populations in the Salmon River subbasin have experienced declines over time, but these declines are associated with factors external to the Salmon River. However, in a recent review, the National Research Council (2003) reported it is likely that land use activities in the Salmon River watershed have had the largest adverse effects on salmon and steelhead production in the Salmon River subbasin.

2.7.3.4 Trinity River Subbasin

The overall Trinity River subbasin is comprised of the Lower, Middle, Upper, and South Fork Trinity River subbasins. Anadromous fish are present in each of these subbasins, except the Upper Trinity where the completion of Lewiston dam in 1962 blocked access by Chinook and coho salmon, steelhead, and Pacific lamprey to more than 109 miles of spawning habitat (CH2M HILL, 1985; National Research Council, 2003). The Trinity River hatchery, located at the base of Lewiston dam, began operation in 1963 to compensate for salmon and steelhead spawning and rearing habitat losses upstream of Lewiston dam and farther upstream above Trinity dam. The Trinity River hatchery produces spring-run and fall-run Chinook salmon, coho salmon, and steelhead (CH2M HILL, 1985).

The Trinity River hatchery releases approximately 1 million juvenile spring Chinook salmon and roughly 1 to 3 million juvenile fall Chinook salmon each year. Releases usually occur in late May to early June, with fish reaching the estuary 1 to 2 months later (National Research Council, 2003). The Trinity River run of up to several thousand adult spring Chinook salmon each year apparently consists primarily of returning Trinity River hatchery fish (National Research Council 2003). In addition, approximately one-third of the adult fall Chinook run in the Trinity River is reported to consist of returning Trinity River hatchery fish (National Research Council, 2003). Total fall Chinook spawner escapement to the Trinity River subbasin in 1996, 1997, and 1998 totaled approximately 54,000, 24,000, and 41,000 fish, respectively (Quihillalt, 1999).

The Trinity River hatchery also produces coho salmon and winter steelhead. The hatchery has released an average of about 525,000 coho salmon smolts per year in recent years (National Research Council, 2003). Coho smolts are released between about mid-March and early May and reach the estuary at the same time as wild smolts, peaking in late May and early June. The Trinity River hatchery produces about 800,000 winter steelhead smolts each year. Steelhead smolts are released in late March and most reach the estuary in late April along with wild steelhead smolts (National Research Council, 2003). Information presented by the National Research Council (2003) suggests runs of returning coho adults to the Trinity River are likely dominated by hatchery-produced fish, while hatchery produced steelhead have comprised from 20 to 34 percent of steelhead runs in the Trinity River.

Numbers of steelhead and other juvenile outmigrants in the Trinity River subbasin are monitored in the mainstem Trinity River near Willow Creek, approximately 23 miles above the mouth of the Trinity, using rotary screw traps. From 1997 through 2000, monitoring at the Willow Creek site occurred during both spring and fall because of spring and fall releases of fish at Trinity River hatchery (Scheiff et al. 2001). Fish trapping began in mid-March in 1997 and 1999, mid-April in 1998, and mid-May in 1999. Trapping ended in early December in 1997, mid-March in 1998, and late September in 1999 and 2000. Monitoring was discontinued after this time either because funds were exhausted or fall storms made sampling difficult. As described previously for outmigrant trapping at the Big Bar site on the Klamath River, Scheiff et al. (2001) cautioned that outmigrant abundance indices they calculated are not intended to represent population estimates because they are contingent on the assumptions that catch rates are directly proportional to the percentage of river flow sampled and that individuals from a given species are equally susceptible to capture. However, abundance indices can be used to compare relative abundance during trapping seasons among various years (Scheiff et al. 2001).

Abundance indices for steelhead outmigrants during the trapping periods at the Willow Creek site were 47,697 fish in 1997; 56,233 fish in 1998; 158,684 fish in 1999; and 27,213 fish in 2000 (Scheiff et al. 2001). The abundance index for steelhead outmigrants consisted of an average of 69 percent naturally produced fish and 31 percent hatchery produced fish over the four-year period. Steelhead outmigrants captured at the Willow Creek site consisted of an average of 28 percent age 0 fish, 36 percent age 1 fish, 34 percent age 2 fish, and 2 percent age 3 fish (Scheiff et al. 2001).

Abundance indices for Chinook salmon outmigrants at the Willow Creek site were 570,407 fish in 1997; 1,237,953 fish in 1998; 544,172 fish in 1999; and 456,169 fish in 2000. Chinook outmigrants captured were nearly all age 0 fish, with Trinity River hatchery fish accounting for 68 percent, 69 percent, 41 percent, and 45 percent of the Chinook outmigrant catch from 1997 through 2000, respectively (Scheiff et al. 2001). Reduced hatchery proportions in the catch during 1999 and 2000 may reflect reduced sampling effort during fall months compared to 1997 and 1998. Peak catches of both natural and hatchery produced Chinook outmigrants occurred in July and again in October (Scheiff et al. 2001).

Abundance indices for coho salmon outmigrants at the Willow Creek site from 1997 through 2000 were low and very low compared to indices for steelhead and Chinook outmigrants, respectively. Coho abundance indices varied from 8,576 outmigrants in 2000 to 108,995 outmigrants in 1999 (Scheiff et al. 2001). The abundance index for coho outmigrants over the 4-year period consisted of an average of 86 percent hatchery produced age 1 coho, 7 percent naturally produced age 1 coho, and 7 percent hatchery produced age 0 coho (Scheiff et al. 2001).

Anadromous salmonids historically and currently spawning and rearing in the Lower, Middle, and South Fork Trinity River subbasins include spring-run and fall-run Chinook salmon, coho salmon, and steelhead (fall- and winter-run fish in the Lower subbasin and spring-, fall-, and winter-run fish in the Middle and South Fork subbasins) (CH2M HILL, 1985; Hardy and Addley 2001). The South Fork Trinity River is the largest tributary in the Trinity River subbasin and was historically a significant producer of Chinook salmon, coho salmon, and steelhead in this subbasin (National Research Council, 2003). Pacific lamprey and green sturgeon continue to use each of these three subbasins, except for the South Fork Trinity, where sturgeon use is believed to have discontinued following the severe flood in 1964 (CH2M HILL, 1985). Quantitative data on the status and abundance of Pacific lamprey and green sturgeon in the Trinity River subbasin are generally lacking (Hardy and Addley, 2001).

Compared to historical levels, overall population trends in the Trinity River subbasin for anadromous salmonids are either reduced or are believed to be generally declining, similar to overall trends observed in the Klamath River basin (Hardy and Addley, 2001). KRBFTF (1991) reported that current runs of spring Chinook salmon in the Trinity River subbasin are supported in large part by the Trinity River hatchery, which was founded using ancestral spring Chinook salmon stocks. In addition, wild coho stocks have declined approximately 96 percent from historical levels in the Trinity River and hatchery-produced fish likely now dominate coho spawner escapement (National Research Council, 2003). The National Research Council (2003) stated that annual data on numbers of salmon and steelhead returning to the Trinity River and its tributaries are fragmentary and incomplete, but added there is general agreement that populations of the most sensitive salmonids, including coho, spring-run Chinook, and summer steelhead, have declined to a few hundred individuals of wild origin.

Numerous factors have been identified as limiting anadromous fish production in the Trinity River subbasin (CH2M HILL, 1985; Hardy and Addley, 2001). They include high summer water temperatures that limit mainstem rearing habitat; decreased flows because of water diversions that reduce rearing habitat; migration barriers at agricultural diversions; sedimentation of spawning gravels from various causes; and in some instances, riparian encroachment into the stream channel that results in losses of rearing habitat. In the South Fork Trinity River subbasin, specifically, naturally high background- and human-caused sediment delivery, loss of riparian cover and deep pools, and elevated water temperatures have impacted salmonid habitat (National Research Council, 2003). In some areas of the Trinity River subbasin, miles of stream habitat currently available to anadromous species are believed to be comparable to historical levels because of recent habitat improvement projects (Hardy and Addley, 2001).

2.7.3.5 Mid-Klamath River Subbasin

Anadromous species use the Klamath River basin and subbasins throughout the year. Periods of use are briefly described below for spring-run and fall-run Chinook salmon, coho salmon, steelhead trout, green sturgeon, and Pacific lamprey. Table 2.7-3 depicts life stage periodicities for several of these anadromous species in the more upstream reaches of the Mid-Klamath subbasin.

Table 2.7-3. Estimated fish periodicity on the Klamath River.
Numbers in this table represent periods of use: 2 = 2-week period; 4 = 4-week period; circled number indicates peak use.

Species/Lifestage	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Spring Chinook Type I												
Adult migration	4	4							4	4	4	4
Adult spawning			④	②								
Incubation			4	4	④	④	④	④	④	4	2	
Fry emergence						4	4	④	④	④	4	
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration							2	4	4	4	④	4
Spring Chinook Type II												
Adult migration		2	4	2								
Adult spawning			4	4								
Incubation			4	4	4	4	4	4	4			
Fry emergence								4	4	2		
Rearing	4	4						4	4	4	4	4
Juv. outmigration			4	4	2							
Fall Chinook Type II (fall juvenile migrant)												
Adult migration		4	④	④								
Adult spawning				④	2							
Incubation				4	4	4	4	4	4			
Fry emergence								4	④	④		
Rearing	4	4						4	4	4	4	4
Juv. outmigration			4	4	4							
Fall Chinook Type I (ocean type)												
Adult migration		4	④	④								
Adult spawning				④	2							
Incubation				4	4	4	4	4	4			
Fry emergence							4	④	④	④		
Rearing							4	④	④	④	④	②
Juv. outmigration	④	2								4	④	④
Coho												
Adult migration				4	④	④	4					
Adult spawning					4	④	4					
Incubation					4	4	4	4	4			
Fry emergence								④	④	2		
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration	4							4	④	④	4	4

Table 2.7-3. Estimated fish periodicity on the Klamath River.
Numbers in this table represent periods of use: 2 = 2-week period; 4 = 4-week period; circled number indicates peak use.

Species/Lifestage	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Steelhead Fall/Winter[1]												
Adult migration			4	4	4							
Adult spawning						4	4	4	4	4		
Incubation						4	4	4	4	4		
Fry emergence									4	4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. outmigration	2								4	4	4	4
Redband/Rainbow Trout[2]												
Adult migration				4	4			2	4	4	2	
Adult spawning								2	4	4	2	
Incubation									4	4	4	4
Fry emergence	2									4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. Emigration[3]	4	4	4	4						4	4	4
Lamprey[4]												
Adult migration	2[5]	2[5]	2[5]			4	4	4	4	4	4	4
Adult spawning	2								2	4	4	4
Incubation	4								2	4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
Juv. Emigration[6]	4	4	4	4	4	4	4	4	4	4	4	4
Suckers[7]												
Adult migration								2	4	4	2	
Adult spawning									4	4	4	
Incubation									4	4	4	2
larval emergence										4	4	4
Rearing	4	4	4	4	4	4	4	4	4	4	4	4

Notes:

1 The mainstem Klamath River tributaries have the highest incidence of a half-pounder life history within the Klamath – Trinity system. Approximately 90 to 100 percent of steelhead juveniles from Iron Gate fish hatchery and nearby tributaries return to freshwater 4 to 5 months later as half-pounders (Shaw et al. 1998).

2 Limited trout spawning has been observed in the mainstem Klamath River within the Project area (J.C. Boyle bypass reach). Spawning does occur in Shovel and Spencer creeks (Beyer, 1984; ODFW, 1992).

3 The resident trout juvenile emigration indicates when fish are leaving their natal streams and entering the mainstem Klamath River.

4 The information in this table is for the anadromous Pacific lamprey (*Lamptera tridentata*) which occurs below Iron Gate dam. Above the dam, five potential lamprey species reside in the upper Klamath basin (Kostow, 2002). The nonparasitic Pit-Klamath brook lamprey and the parasitic Klamath River lamprey are considered sister species of the Pacific lamprey. The Pit-Klamath Brook lamprey is found in the upper Klamath basin above Klamath Falls and the Klamath River lamprey distribution is from upper Klamath basin down to Copco dam. The Miller Lake lamprey was thought to be endemic to Miller Lake (upper Klamath basin) and was extirpated (poisoned) from Miller Lake by ODFW in 1958 and declared extinct in 1973. However, this species was rediscovered in the 1990s and the expanded distribution

Table 2.7-3. Estimated fish periodicity on the Klamath River.
Numbers in this table represent periods of use: 2 = 2-week period; 4 = 4-week period; circled number indicates peak use.

Species/Lifestage	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun

includes Miller Lake basin, upper Klamath marsh, and the Klamath River above the marsh. The other two recognized species in the upper Klamath basin include the nonparasitic lamprey (*Lamptera folletti*) and the parasitic species currently called *Lamptera tridentata. L. folletti* was described in 1976 as having a distribution in Lost River and the Klamath basin around the lower Klamath marsh near Klamath Falls. However, it is not known whether *L. folletti* is present, or ever was present. The other species is called *L. tridentata*, but is likely a separate species since it is land-locked and a true *tridentata* will not persist if it is blocked from saltwater migrations. For the purposes of this table, the life history of the Pacific lamprey is a surrogate for the other lamprey species since very little is known about their life history.

[5] The river lamprey (*L. ayresi*) has not been found in the Klamath basin, but its range is reported to be the Sacramento River to SE Alaska. The extension of adult lamprey migration will cover this species if it is present.

[6] This includes both ammocoetes and eyed-lamprey migration.

[7] The Klamath basin contains four recognized species of catostomids: Klamath smallscale sucker, Klamath largescale sucker, the shortnose sucker, and the Lost River sucker. Both the shortnose and the Lost River sucker are federally listed endangered species and this table represents their life history strategies (USFWS, 1993).

Adult spring Chinook salmon enter the Klamath River from February through July, peaking from March to mid-June (CH2M HILL, 1985; Hardy and Addley, 2001). Migrating adults hold in deeper pools of natal tributaries for 2 to 4 months, primarily during the summer, where they reach sexual maturity (National Research Council, 2003). Spawning can occur from September through mid-November, but peaks in October (National Research Council, 2003). In the Salmon River, spawning occurs from mid-September through late October (West, 1991). Eggs incubate for 40 to 60 days before hatching, fry remain in the gravels another 2 to 4 weeks, then emerge from December through May. In the Salmon River, first emergence is not observed until March and extends until early June (West, 1991). Most young rear in fresh water runs and pools in headwaters where adults hold before beginning outmigrations toward sea approximately 1 year later from March through July (CH2M HILL, 1985; Hardy and Addley, 2001; and National Research Council, 2003). Spring Chinook often hold, spawn, and rear in upstream reaches of tributaries that are inaccessible to fall Chinook later in the year because of low flows and high temperatures in downstream tributary reaches (National Research Council, 2003).

Adult fall Chinook salmon enter the Klamath River from mid-July to February, depending on the specific run of fish (CH2M HILL, 1985; Hardy and Addley, 2001). The run peaks from early September through late October, and consists primarily of 3-year-old fish but with 2- and 4-year-old fish also present (National Research Council, 2003). Migrating adults hold in pools of the mainstem Klamath and in the lower reaches of larger tributaries prior to spawning (CH2M HILL, 1985; Hardy and Addley, 2001). Spawning can occur between early September and late December, but often peaks in October and November. In 2001, adult fall Chinook salmon were first recorded entering the Shasta River on September 11, peaked on October 1, with 95 percent of the run entering the river by October 27. From 1993 through 1996, fall Chinook spawning in the mainstem Klamath River in the vicinity of the Scott River and Seiad Creek extended from about mid-October to mid-November and peaked in late October (National Research Council, 2003).

Eggs of fall Chinook salmon incubate for 50 to 60 days, with young emerging from the gravels from early November to late February and perhaps later. In the mainstem Klamath, young emerge from early February through early April, while in the Shasta River, young fall Chinook have been captured as early as mid-January (National Research Council, 2003). Outmigrations of juvenile fall Chinook salmon, which are able to tolerate slightly warmer waters than coho salmon, occur year-round. Type I juveniles outmigrate in the spring and early summer months shortly after emergence, while Type II juveniles outmigrate in the fall and early winter after spending 3 to 9 months in large tributaries or the mainstem Klamath (KRBFTF, 1991; Hardy and Addley, 2001). Type III fall Chinook juveniles, which are reported to only rarely occur in the Klamath basin, spend an entire year in fresh water before outmigrating the following spring (KRBFTF, 1991). Sullivan (1989, in Wallace, 2000) found that most adult Chinook salmon returning to the Klamath-Trinity basin were Type I fish but that some tributary populations showed differences in the proportion of Type II and Type III fish. Sullivan (1989, in West, 1991) found that Type II and III fish were most common to the Salmon and Scott rivers.

Outmigrant traps on the Shasta and Scott rivers typically capture fall Chinook fry, parr, and smolts from early February through July (National Research Council, 2003). Peak catches occur in March or early April in the Shasta River and from mid-April to mid-May in the Scott River. Numbers of fall Chinook juveniles in the mainstem Klamath are considerably reduced by August and September (National Research Council, 2003). Studies of YOY Chinook salmon in the Klamath River estuary during 1997, 1998, and 1999 indicated that peak emigration occurs in June and July (Wallace, 2000). However, a higher proportion of YOY Chinook emigrating during late summer are of natural origin and appear to rear in the estuary for a slightly longer period of time than YOY Chinook emigrating during early summer. Estuary residence time, as determined by mark and recapture efforts, for YOY Chinook averaged between about 6 and 13 days during early summer and between about 10 and 18 days during late summer (Wallace, 2000).

Adult coho salmon typically enter the Klamath River from mid-September through mid-January as 3-year-old fish and begin their upstream spawning migrations in response to fall/winter rains and increased river flows (CH2M HILL, 1985; Hardy and Addley, 2001). Peak migration typically occurs between late October and mid-November (National Research Council, 2003). Spawning occurs primarily in Klamath River tributaries from November through January, especially in forested watersheds, but some mainstem spawning also occurs (CH2M HILL, 1985; Hardy and Addley, 2001; National Research Council, 2003). Eggs incubate for approximately 7 weeks before hatching, fry remain in the gravels another 2 to 3 weeks, then emerge primarily in April and May. Juvenile coho salmon usually rear in fresh water for approximately 1 year before outmigrating toward sea between February and mid-June when parr transform into smolts (CH2M HILL, 1985, Hardy and Addley, 2001). Some coho fry have been captured in outmigrant traps at the mouths of the Shasta and Scott rivers from May to early July shortly after emergence; however, most probably remain in tributaries near where they were spawned (National Research Council, 2003). Data summarized by the National Research Council (2003) indicate that coho juveniles are uncommon in the mainstem Klamath River during early summer and virtually absent by late summer in their first year of life, apparently because of elevated water temperatures and limited suitable thermal refugia for this species.

Three runs of steelhead spawn and rear in the Klamath River basin, with the primary difference among runs being the timing of their spawning migration (CH2M HILL, 1985; Hardy and Addley, 2001). Adult spring/summer-run steelhead usually enter the Klamath River from mid-April to late May. They migrate upstream to natal tributaries and larger creeks where they hold until spawning. Fall-run steelhead enter the Klamath River primarily during October and

November, hold for several months, then migrate to smaller spawning tributaries. Winter-run steelhead usually move into the Klamath River during December and January and migrate directly to spawning areas (CH2M HILL, 1985; Hardy and Addley, 2001). KRBFTF (1991) suggested that winter-run steelhead may have the widest distribution of any salmonid in the Klamath basin because their time of return during winter rains and high flows allows them access to many smaller tributaries.

The National Research Council (2003) described two basic steelhead life history strategies for the Klamath River basin that encompass the seasonal runs described in the preceding text. These consist of winter steelhead (ocean maturing fish) that include both fall-run and winter-run individuals, and summer steelhead (stream maturing fish) that include spring-run and summer-run individuals. Winter steelhead are reported to enter the Klamath River from late August to February, and to spawn primarily in tributaries and, to a lesser extent, in the mainstem Klamath (National Research Council, 2003). Spawning peaks in February and March but can occur during the period January through April. Summer steelhead enter the Klamath River from May to July and migrate upstream to deep pools of cooler larger tributaries where they hold until becoming sexually mature. Summer steelhead spawn primarily in December, usually in waters upstream of where winter steelhead spawn (National Research Council, 2003).

Steelhead that survive after spawning migrate downstream from approximately mid-March through late May (CH2M HILL, 1985; Hardy and Addley, 2001). Up to approximately 30 percent of mature steelhead survive to return and spawn a second time after another year at sea, while up to approximately 20 percent of mature steelhead survive to return and spawn a third time (National Research Council, 2003). Sexually immature steelhead known as half-pounders enter the Klamath River with the spring/summer- and fall/winter-run adults, then return to sea the following winter or spring.

Steelhead eggs generally incubate from 4 to 7 weeks, depending on water temperature, and fry emerge during the period March through June. Juveniles rear in fresh water from one to 3 years, but usually 2 years, then outmigrate toward sea between March and late July. Large numbers of steelhead parr have been observed moving out of the Shasta and Scott rivers to the Klamath River in early July (National Research Council, 2003). A variety of habitat types, depending on fish size, in tributaries as well as the mainstem Klamath River, provide important rearing habitat for juvenile steelhead and half-pounders (CH2M HILL, 1985; Hardy and Addley, 2001). The National Research Council (2003) stated that a key to the success of steelhead in fresh water is their thermal tolerance, which exceeds that of most other salmonids. This may account, in part, for the wider distribution of juvenile steelhead than juvenile coho salmon in the Klamath River basin during warm summer months.

Adult green sturgeon enter the Klamath River from late February through late July. Spawning can occur from March through July but usually peaks during the period mid-April to mid-June (National Research Council, 2003). Spawning occurs in the lower mainstem Klamath and Trinity rivers in deep pools with strong bottom currents (National Research Council, 2003). Outmigration of spent adults typically peaks in August and September. Juvenile sturgeon outmigrate primarily during late summer and early fall usually at 2 years of age or less (CH2M HILL, 1985; Hardy and Addley, 2001). They remain in the Klamath River estuary for 6 to 8 years before entering the ocean and beginning extensive migrations (KRBFTF, 1991). Green sturgeon return to the Klamath basin to spawn after spending 3 to 13 years at sea (National Research Council, 2003.

Pacific lamprey are reported to enter the Klamath River and tributaries where they hold until reaching sexual maturity from October through April. Adults are believed to spawn primarily in the mainstem and larger tributaries from April to July and then die (Hardy and Addley, 2001; National Research Council, 2003). Eggs incubate for 2 to 3 weeks before hatching, and the juvenile ammocoetes remain in the gravels for up to 5 or 6 years (CH2M HILL, 1985). Outmigration of juveniles has been reported to occur in March during high flows, but also during late summer months (Hardy and Addley, 2001; National Research Council, 2003). Individuals spend from 6 to 18 months growing in the ocean before entering the Klamath River to spawn (KRBFTF, 1991).

2.7.3.6 Other Small Tributaries

Unnamed Tributary #1

This very small intermittent tributary, located below the Boyle powerhouse, drains the area identified as the Chicken Hills (USGS topographic map) and enters the Klamath River at RM 216.3. Appearance of the stream channel, although dry when surveyed during fall 2003, suggests that it may carry a heavy debris/sediment load during high runoff events. The streambed substrate consisted of a mix of cobble, gravel, and boulders. The gradient of the stream increases rapidly just upstream of its mouth and appears too steep for trout passage. If spawning occurs in this tributary it would be confined to just its mouth at the confluence with the Klamath River.

Unnamed Tributary #2

This unnamed tributary is a small spring-fed stream that flows through the lower Frain Ranch area, entering the left bank of the Klamath River at RM 14.4 just upstream of the Caldera Rapid. The source of its perennial flow is a spring located approximately 100 yards from the mouth. It flows through an established riparian area before entering the Klamath River. Although the spring water source provides a flow of less than 0.5 cfs, this tributary also appears to captures some surface run-off during storm events. Gravel is the dominate substrate, and rooted macrophytes are present. The gravels appear suitable for trout spawning in the lower reach of the stream, although the amount of potential spawning habitat is only approximately 1 square yard. An off road vehicle trail crosses the tributary at the site where the gravel was identified.

Rock Creek

This intermittent tributary enters the Klamath River at RM 213.7 just downstream of the Caldera Rapid. It typically does not flow during the summer and fall, but channel features such as pools, rifles, and undercut banks, as well as braiding and meandering of the stream channel suggests that considerable flows occur during runoff events. Rock Creek appears to carry a large amount of bed load for such a small stream as demonstrated by the amount of cobble, boulders, and gravel found within and adjacent to the channel. The lower portion of the stream that was surveyed is low gradient and has a moderately well developed riparian zone. Fish passage into the creek may be limited by a gradient barrier just upstream from the mouth. However, given the geomorphic characteristics and the potential flow that the creek may carry, Rock Creek may support some limited trout spawning in the lower reaches. Data from the radio-telemetry study conducted by PacifiCorp in 2003 observed some trout remaining near its mouth during the spawning period.

Tom Creek

Tom Creek is a small tributary that flows through a low gradient free-range grazing area before becoming incised and entering the Klamath River as a cascade/falls at the California/Oregon state line at RM 210.7. Fish passage into this tributary is prevented by a cascade at the mouth. The cool water temperature and perennial flow of the creek indicates that it is fed by a spring source. This creek may have some value in adding cool water, although a very limited amount, to the peaking reach during the warmer portions of the year.

2.7.4 Klamath River Reservoirs

2.7.4.1 Keno Reservoir

Keno reservoir is more appropriately described as a widened part of the head of the Klamath River. This segment includes what is also referred to as Lake Ewauna. Summer water quality is generally poor, with heavy algae growth, high temperatures and pH, and low dissolved oxygen. Many of the water quality problems are related to the quality of water received from Upper Klamath Lake; however, they are exacerbated by wastewater effluent from the City of Klamath Falls, USBR irrigation return water, and accumulated wood waste at the reservoir bottom deposited from prior lumber mill operations. Additional studies conducted by the ODFW (1996) and Hummel (1993) concluded that summer water quality was poor for fish throughout the reach.

Relatively little information is known about the fish resources in this reservoir, although the ODFW (1996) and Hummel (1993) studies both showed tui chub, blue chub, and fathead minnow dominating the catch. A few Lost River and shortnose suckers were captured, as well as some bass, pumpkinseed, Sacramento perch, and speckled dace. See Section 1.2.3 for a more detailed discussion regarding fish resources in the reservoir.

2.7.4.2 J.C. Boyle Reservoir

The wide and shallow J.C. Boyle reservoir (944 surface acres [382.0 ha]) is surrounded by a low-gradient sloping shoreline in the upper reservoir near the inflow. Below the Highway 66 bridge, the reservoir begins to deepen as the canyon narrows. The upper end of the reservoir contains a large amount of aquatic vegetation during the summer and there are several large shoreline wetland areas. Usually, the J.C. Boyle facility is operated as a load-factoring facility, which can cause the reservoir to fluctuate about 2 feet (0.6 m) per day. Depending on water year type and available flow, this operation regime usually begins in late spring and continues through the late fall. Similar to upstream conditions, the generally poor water quality is further impaired by algae blooms.

The fish resources in the reservoir are best characterized by data collected by Oregon State University for PacifiCorp to assess the abundance and distribution of endangered suckers in Project reservoirs. Native species were found to comprise approximately 55 percent of adult fish caught in the reservoir; 1.5 percent of these fish were suckers. It is the only reservoir where all sucker life stages were captured in the years of sampling. It is likely that this reservoir is seeded with juvenile suckers from Upper Klamath Lake. Tui chubs were the most dominant adult native species caught, and redband/rainbow trout were the fifth most abundant. The most dominant non-native species caught were bullheads, which ranked fourth in overall species abundance. See Section 2.7.4.2 for a more detailed discussion regarding fish resources in the reservoir.

2.7.4.3 Copco Reservoir

Copco reservoir is deeper than Keno and J.C. Boyle reservoirs. It is located in a relatively steep canyon and contains several coves with more gradual slopes. The 1,000-acre (404.7 ha) reservoir has large areas of thick aquatic vegetation in shallow areas, and nearshore riparian habitat generally is lacking because of the cliff-like nature of shorelines. Only small, isolated pockets of wetland vegetation exist. Water quality in the reservoir during the summer is generally poor because large blooms of algae occur annually and surface water temperatures are warm. Copco No. 1 powerhouse discharges directly in to Copco No. 2 reservoir; therefore, there is essentially no river habitat downstream from Copco No. 1 dam.

Copco reservoir contains a diverse fishery, including both warm water and cold water species, although warm water fish are the most abundant. According to a recent study, more than 60 percent of the fish in the reservoir are non-native species, with bullheads and perch being the most abundant. Suckers were the most abundant native species. Few trout are caught in the reservoir. It should be noted that the Oregon State University study was designed to target suckers. Copco reservoir, however, appears to have a sizable population of suckers. The study found that 13 percent of the adult fish sampled in the reservoir were the endangered sucker species (mostly shortnose suckers); however, few juveniles were found. See Section 1.2.3 for a more detailed discussion regarding fish resources in the reservoir.

2.7.4.4 Iron Gate Reservoir

The 944-acre (382.0 ha) Iron Gate reservoir is similar to Copco reservoir (No. 1) in that it is in a deep and relatively steep canyon. However, there are fewer coves and low-slope shore areas than at Copco reservoir. As with the other reservoirs, Iron Gate reservoir has water quality problems in the summer, and large patches of thick aquatic vegetation occur in the shallow areas of the reservoir. The fishery in Iron Gate reservoir is similar to that of the larger Copco reservoir. There are few trout and large numbers of non-native fish, mostly perch and crappie, along with bullheads. Non-native fish comprised approximately 77 percent of adult fish captured in the reservoir. Iron Gate reservoir provides a popular fishery for perch and is also the site of bass tournaments in the summer. See Section 1.2.3 for a more detailed discussion regarding fish resources in the reservoir.

2.7.5 Upper Klamath River Tributaries

2.7.5.1 Fall Creek

Fall Creek is a tributary to Iron Gate reservoir. It enters at RM 196.3, approximately 0.6 mile (1.0 km) downstream of the Copco No. 2 powerhouse discharge. The 2.2-MW Fall Creek hydroelectric facility is operated by PacifiCorp in a run-of-river mode. It is primarily spring-fed at a relatively consistent flow and has no reservoir storage. Base flows above the diversion dam typically exceed 40 cfs (1.1 cms). The diversion dam is about 0.4 mile (0.6 km) south of the Oregon-California border and the powerhouse tailrace is roughly 2 miles (3.2 km) upstream of the mouth of Fall Creek. A minimum instream flow of 0.5 cfs (0.01 cms) is released to the 1.2-mile-long (1.9 km) bypass reach at the diversion dam. A continuous minimum instream flow of 15 cfs (0.4 cms) is maintained downstream of the powerhouse tailrace. There is no ramping rate associated with the Fall Creek project, which is operated as a run-of-river (ROR) facility. The City of Yreka diverts approximately 20 cfs (0.6 cms) for its water supply just downstream of the powerhouse. Just downstream of this an additional flow of up to about 10 cfs (0.3 cms) is diverted to the Fall Creek fish-rearing facility, then returned a short distance downstream (PacifiCorp, 2000, 2002).

Fish known to occur in the Fall Creek bypass reach include primarily rainbow trout. It is likely that many of the native, riverine species of fish discussed previously use portions of Fall Creek. This predominantly spring-fed tributary may provide refuge for redband/rainbow trout from Iron Gate reservoir during the summer when water quality conditions decline in the reservoir.

2.7.5.2 Spencer Creek

Spencer Creek, located in Oregon and a tributary to J.C. Boyle reservoir, is an important spawning tributary for redband/rainbow trout. The ODFW (1997) stated that historically, redband/ rainbow trout rearing in the Klamath River in Oregon spawned in Spencer Creek. The estimated spawning-season (through May) passage through the ladder ranged from 800 to 3,399 adult trout in the first four years after the dam was built (1959 – 1962) (Table 2.7-4). The seasonal pattern of fish movement through the ladder was similar in all years. Most of the movement occurred in the spring, peaking in April, and again in the fall, mostly September and October. Monitoring of the fish ladder ceased and no further studies were conducted until 26 years later, starting in 1988 and continuing through 1991. The actual numbers of trout passing through the ladder each of these four years were 507, 588, 412, and 70, respectively, indicating a drop from the 1960 - 1962 period (Table 2.7-5). A more detailed discussion of trout use at the J.C. Boyle fish ladder is found in Section 7.0, Fish Passage.

Table 2.7-4. Upstream migrating redband/rainbow trout captured in Spencer Creek weir, 1991.

Date	Number of Fish Trapped	Hours of Trapping
February 22 – 28	9	161
March 1 – 31	396	691
April 1 – 30	1,222	711
May 1 – 31	186	744
June 1 – 21	0	480
Total	**1,813**	**2,787**

Table 2.7-5. Monthly estimates of upstream passage of rainbow trout at J.C. Boyle dam.

Month	Year							
	1959[1]	**1960[1]**	**1961[1]**	**1962[1]**	**1988[2]**	**1989[2]**	**1990[2]**	**1991[2]**
January	--	--	--	--	--	--	--	--
February	--	--	99	--	--	--	--	--
March	--	580	1,075	308	20	5	51	--
April	--	165	1,459	742	92	135	207	35
May	289[3]	55[4]	766	430	20	64	12	5
June	532	--	21	165	11	15	16	7
July	48	--	--	63	5	5	5	--
August	333	--	--	--	18	46	27	6
September	1,980	--	14	--	67	147	59	2
October	2,252	--	448	517	227	166	33	15
November	95	--	--	7	47	8	2	--
December	--	--	--	--	--	--	--	--
Total	**5,529**	**800**	**3,882**	**2,232**	**507**	**588**	**412**	**70**

1 Estimates—the number of fish presented for the data collected in 1959, 1961, and 1962 are based on weekly projections; sampling effort is not available from these studies (Hanel and Gerlach, 1964); 1960 estimates—Toman (1983); 1988 through 1991 estimates (actual counts)—ODFW, 1992.

2 Number of fish counted.

3 Estimates were made for the second half of the month only.

4 Estimates were made for the first half of the month only.

Large numbers of trout spawn in Spencer Creek today, but most originate from the Keno reach and, perhaps to a lesser extent, the J.C. Boyle bypass reach. In 1990, the ODFW conducted an upstream and downstream trapping study in Spencer Creek, which enters the upper end of J.C. Boyle reservoir. As part of the study, 300 adult trout that passed upstream through the J.C. Boyle fish ladder were tagged (ODFW, 1990). Most of these fish were tagged in March and April 1990. The Spencer Creek trap collected 926 adult rainbow trout from March 4 through May 8, 1990. Of these fish, only eight were from the group that had been tagged at the J.C. Boyle fish ladder. On the basis of these results, the study concluded that nearly all of the adult trout migrating to Spencer Creek originated from the Keno reach upstream of J.C. Boyle reservoir. The destination of the majority of the trout that passed over the dam is unknown. No suitable spawning habitat other than in Spencer Creek is known to exist upstream of J.C. Boyle dam to Keno dam.

In 1991, the ODFW operated an upstream trap at a weir constructed across Spencer Creek. A total of 1,813 adult redband/rainbow trout was captured (Table 2.7-5) (Buchanan et al. 1991). Of these, most (67 percent) were observed in April 1991. Also in 1991, the ODFW operated a downstream migrant trap in Spencer Creek. The trap captured 4,218 fry and 25,618 juveniles (yearlings) (Figure 2.7-3). Peak downstream movement of fry occurred in August and September 1991. Peak movement of juveniles occurred in May 1991. It is evident from these data that emergent trout fry remain in Spencer Creek for several months and most remain for 1 year before moving downstream to the Klamath River. The downstream movement of advanced fry in late summer and fall from Spencer Creek is similar to the observed timing of fry movement downstream through J.C. Boyle dam (City of Klamath Falls, 1986).

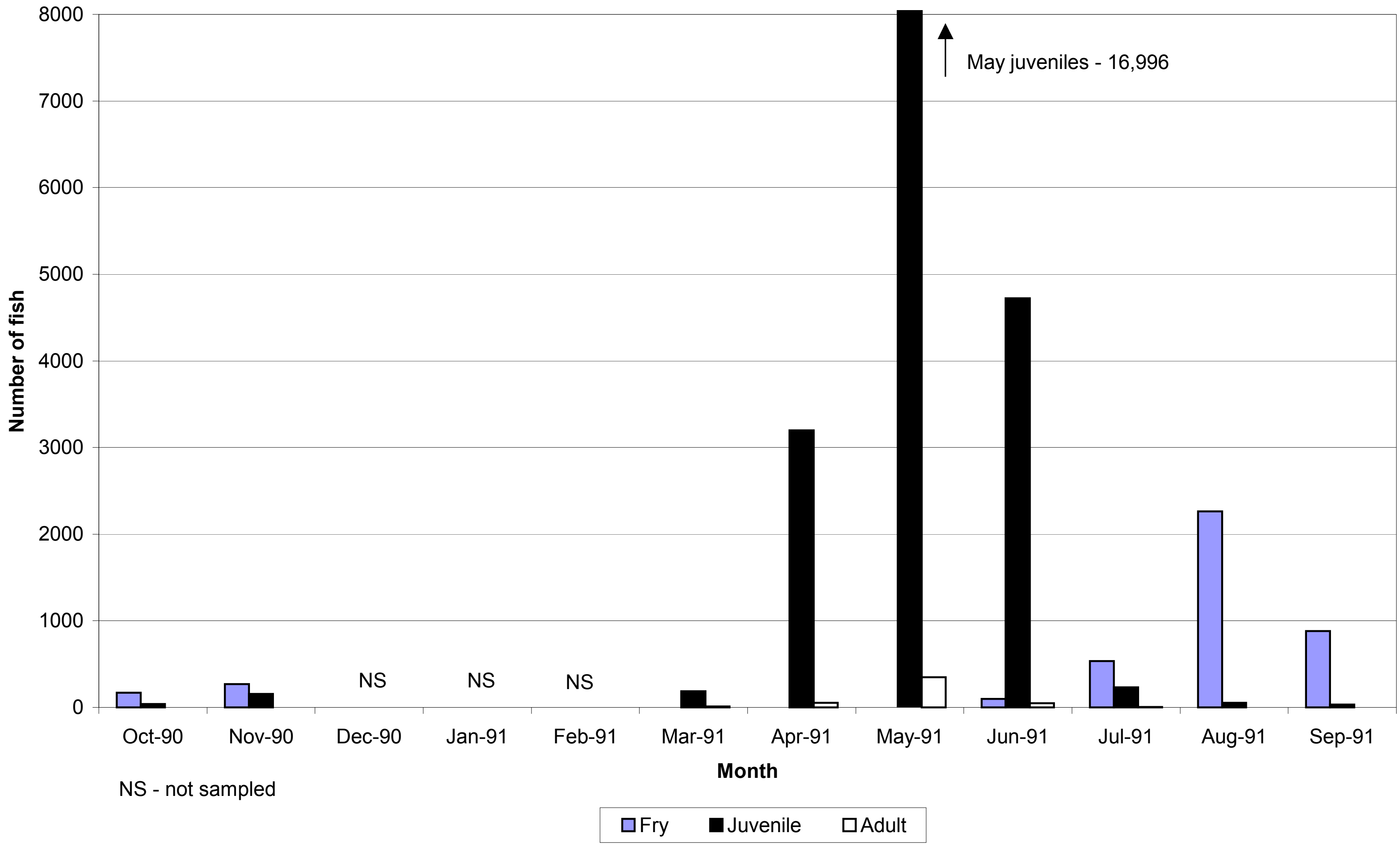


Figure 2.7-3. Downstream movement of redband/rainbow trout in Spencer Creek (1990–1991).

2.7.5.3 Shovel Creek

Shovel Creek, located in California, is known to be an important spawning tributary for rainbow trout occurring in the J.C. Boyle peaking reach, especially for the California portion (CDFG, 2000). Shovel Creek is the only known trout spawning tributary to the Klamath River between J.C. Boyle dam and Copco No. 1 dam (Beyer, 1984). Shovel Creek enters the Klamath River from the south/southeast at RM 206.5, approximately 3 miles downstream from the Oregon/ California border. J.C. Boyle dam is approximately 18 miles upstream and Copco No. 1 dam is approximately 8 miles downstream from the mouth of Shovel Creek.

Shovel Creek is approximately 12.7 miles long (Beyer, 1984). A fish-barrier falls, 5.6 feet high with a 1-foot-deep pool at its base, is approximately 2 miles upstream from the creek mouth. Shovel Creek elevation drops 292 feet in the first mile (5.5 percent gradient) below the falls and an additional 157 feet in the mile farthest downstream (3.0 percent gradient) (Beyer, 1984). Stream discharge is primarily from precipitation and snowmelt, although several perennial springs contribute to creek flow. Winter and spring flooding are common, with flows reaching an estimated 105 to 175 cfs. However, during summer, irrigation diversions in the lower mile can reduce creek flow to approximately 2 cfs (Beyer, 1984).

Surveys of Shovel Creek by CDFG (1991) indicated that the rainbow trout population is healthy, instream cover for fish (boulders, woody debris) is excellent; and invertebrate production and aquatic vegetation also is excellent. CDFG (2000) commented that Shovel Creek appears to support a healthy population of spawning rainbow trout. However, the barrier falls located approximately 2 miles above the mouth of Shovel Creek block all further upstream spawning migrations by rainbow trout in this Klamath River tributary. In addition, Beyer (1984) noted that insufficient spawning gravel (a potential of 140 square yards total in the accessible stream reach) is a limiting factor for trout in Shovel Creek. Of this total, Beyer (1984) reported that only 64 square yards of spawning gravel was at water depth and velocity known to be suitable for spawning.

Movements of adult rainbow trout from the Klamath River into and out of Shovel Creek were monitored in 1982 using a weir containing upstream and downstream traps (Beyer, 1984). The weir was placed in Shovel Creek about 60 meters upstream from the mouth of the creek. Adult rainbow trout moved upstream into Shovel Creek to spawn from late March to mid-June, peaking in late April and mid-May (see Figure 2.7.4). Below normal temperatures in 1982 may have delayed spawning runs into Shovel Creek, which typically begin about mid-February and peak from mid-March to mid-April (Beyer, 1984; CDFG, 2000). Downstream movement of spent adults occurred from early April through mid-June, peaking from mid-May to mid-June (Beyer, 1984). The estimated number of upstream migrant trout spawners in 1982 was 1,187 fish (Beyer, 1984).

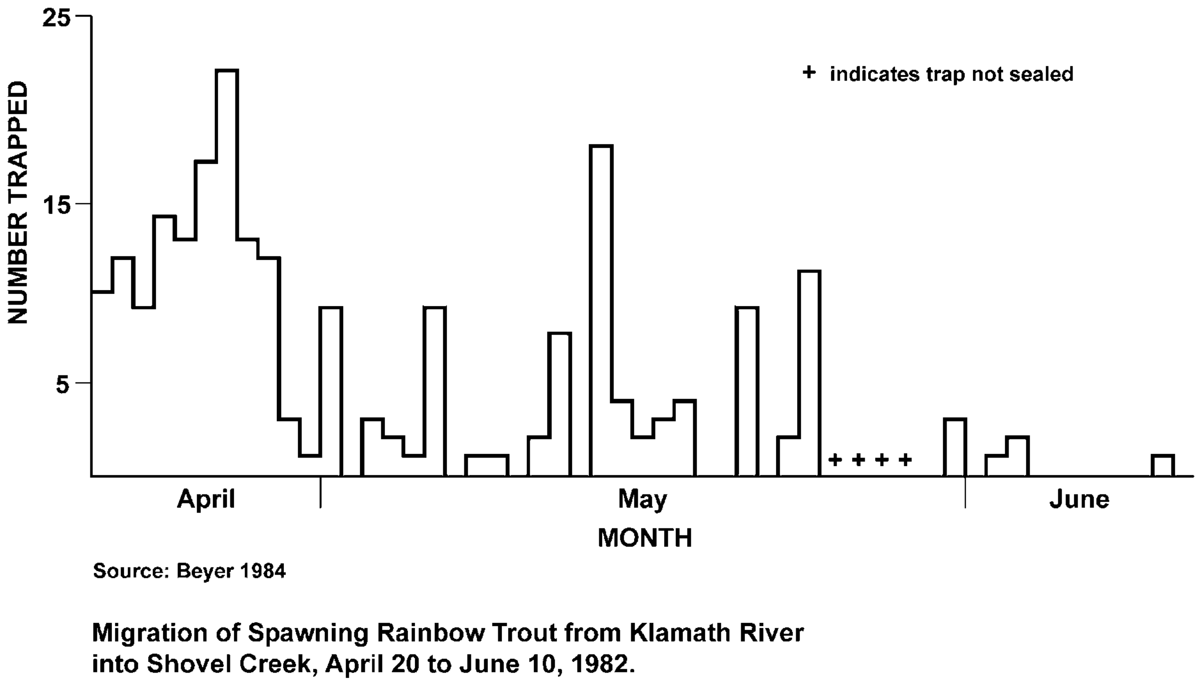
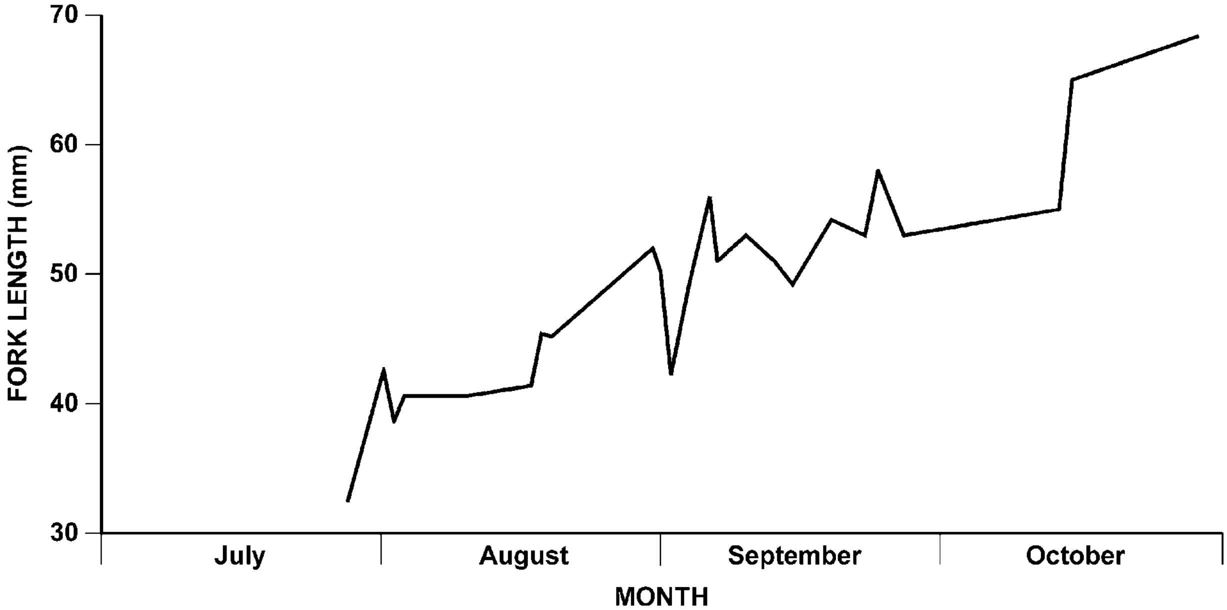


Figure 2.7-4. Migration of Spawning Rainbow Trout from Klamath River into Shovel Creek, April 20 to June 10, 1982.

Average FL of fish captured during the 1982 spawning run were 7.5 inches (age 1+), 9.1 inches (age 2+), 13.2 inches (age 3+), and 15.0 inches (age 4+) (Beyer, 1984). Individual FL of mature migrants varied from 5.5 inches to 22.4 inches. Most males captured (78 percent) were 2 years and older while most females captured (88 percent) were 3 years and older (Beyer, 1984). Field observations and scale examinations of Shovel Creek mature migrants indicated few repeat spawners and high spawning mortality (Beyer 1984).

Lengths of mature migrant rainbow trout captured in Shovel Creek during the 1982 spawning run and of rainbow trout creeled in the Klamath River, California, in the J. C. Boyle peaking reach during 1981 and 1982 were generally similar, although some statistical differences were noted (Beyer, 1984). Back-calculated average FL at annulus formation of mature migrants in Shovel Creek were 4.0 inches (age 1+), 7.6 inches (age 2+), 11.6 inches (age 3+), and 14.1 inches (age 4+). Back-calculated FL of creeled rainbow trout in the Klamath River were 4.2 inches (age 1+), 8.2 inches (age 2+), 11.1 inches (age 3+), and 13.8 inches (age 4+). Beyer (1984) reported that creeled fish were significantly larger, statistically, than mature migrants at ages 1 and 2. Mature migrants were slightly larger than creeled fish at ages 3 and 4 but were not reported to be significantly larger (Beyer, 1984).

Outmigrations of age 0+ rainbow trout from Shovel Creek in 1982 were monitored beginning in late July. Two downstream fry traps were placed in the weir located in Shovel Creek just above the mouth (Beyer, 1984). Rainbow trout fry emerged from the gravel over at least a 3-week period until about late June. FL at emergence was approximately 0.8 inch. Average FL of age 0+ outmigrants captured in fry traps increased about 0.4-inch per month from approximately 1.6 inches in late July to 2.8 inches in late October (see Figure 2.7-5).



Source: Beyer 1984

Average Fork Length of Age-0 Emigrants Trapped Near Mouth of Shovel Creek, California, 1982.

Figure 2.7-5. Average Fork Length of Age-0 Emigrants Trapped Near Mouth of Shovel Creek, California, 1982.

Movements of age 0+ rainbow trout from Shovel Creek into the Klamath River extended from late July to late October 1982, peaking in late August (Figure 2.7-6). The maximum population estimate for outmigrating age 0+ rainbow trout in Shovel Creek in 1982 was 32,903 fish. These findings contrast with the capture of only 104 age 1+ and older immature rainbow trout outmigrants in the Shovel Creek fry traps from April through November in 1982, with a maximum of 278 juveniles estimated to be present in the creek in April 1982. In addition, 93 percent of the age 1+ and older outmigrants moved downstream from mid-April to mid-June prior to any outmigrations of age 0+ fish (Beyer, 1984). These immature outmigrants consisted of 75 percent age 1+ fish and 25 percent age 2+ fish.

Results of other investigations in or near Shovel Creek provide additional information on rainbow trout using this drainage. The City of Klamath Falls (1986) reported rainbow trout fry and juveniles were present in electrofishing collections from the Klamath River downstream of Shovel Creek in September 1984. These fish likely included immature outmigrants from Shovel Creek. The CDFG (2000) reported that most rainbow trout emigrate from Shovel Creek to the Klamath River in late summer and fall as YOY rather than as newly emerged fry in the spring. The CDFG (2000) estimated that Shovel Creek contained a healthy, relatively large number of rainbow trout spawners exceeding 250 to 300 adult pairs during the 1985 through 1990 spawning seasons.

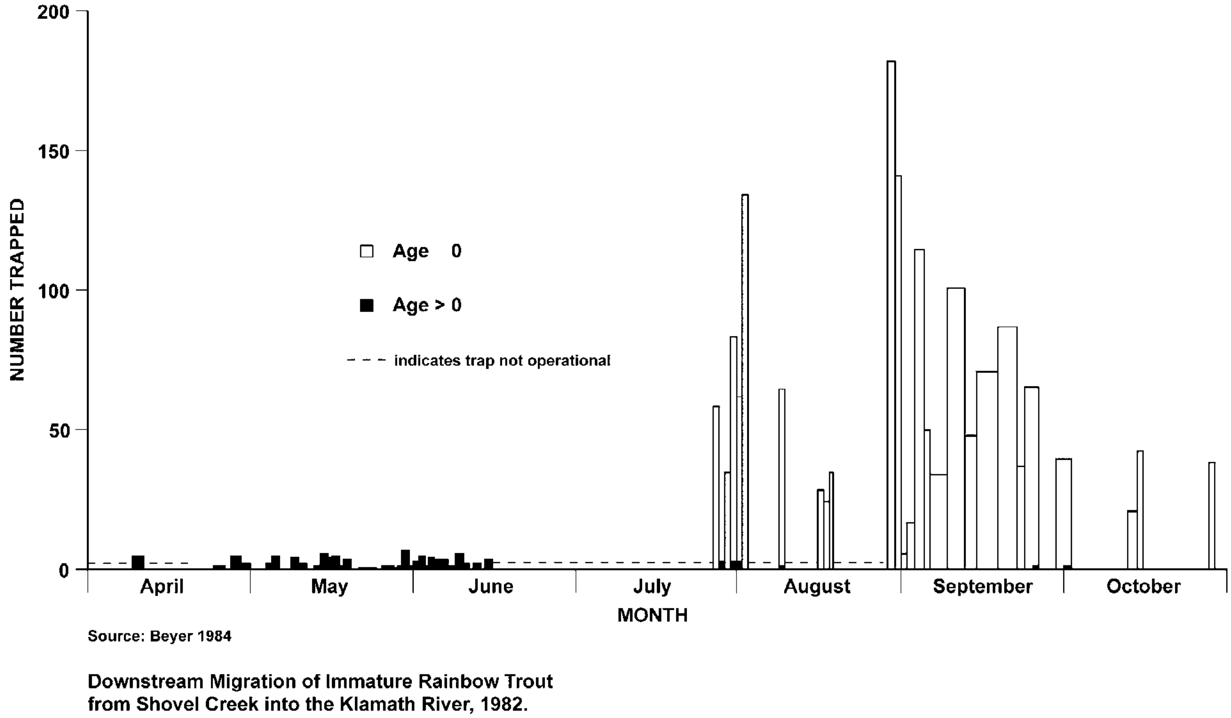


Figure 2.7-6. Downstream Migration of Immature Rainbow Trout from Shovel Creek into the Klamath River, 1982.

2.7.6 Special Status Species

2.7.6.1 Lost River Sucker

Lost River sucker is a species endemic to the Upper Klamath River basin and has limited distribution. Lost River sucker was first listed as a state threatened species in 1974 by the state of California. In 1988, the species became listed as a federally endangered species. In 1991 Oregon listed the species as endangered. In 2002, a petition was presented to the USFWS to delist the Lost River sucker (67 FR 93, May 14, 2002). The USFWS concluded that there was not sufficient scientific or commercial information to warrant the delisting of Lost River sucker from the federal list of endangered species.

The following sections present general information on the Lost River sucker species. Distribution or other information regarding Lost River sucker specific to the Project area is presented in other sections of this report, such as the reporting of sampling data of the various river and reservoir areas.

Classification and Identification

Because Lost River sucker, as well as shortnose sucker, have limited distribution and populations in the Upper Klamath River basin, proper identification of these species is an important aspect in their management because they can closely resemble other Klamath basin sucker species, particularly in the larval and juvenile life stages. Following is an overview of the historic classification of Lost River sucker along with some information regarding the identification of these fish.

Classification. The Lost River sucker has gone through many changes in its taxonomic classification since it was first described by Cope (1879) and these reclassifications have resulted in some confusion when reviewing the scientific literature of these fish. Cope classified the Lost River sucker as *Chasmistes luxatus* based on specimens examined from Upper Klamath Lake, Oregon. In 1891, Eigenmann (1891) reclassified the Lost River sucker as *Catostomus rex* based on specimens collected from the Lost River, Oregon, and Tule Lake, California. Seale (1896) created a monotypic genus (*Deltistes*) for the Lost River sucker based on its gill raker morphology and also reverted to *luxatus* for its species name. However, Miller (1959) believed that gill raker characteristics were not always diagnostic for the identification of Lost River sucker, and subsequently placed the sucker back in the genus of *Catostomus*, but kept the species name of *luxatus*. Miller and Smith (1967) recognized characteristics of the genus *Deltistes*, described by Seale (1896), in their examination of fossil fish and they concluded that there was one living example of this genus, the Lost River sucker. Miller and Smith kept the species name *luxatus* in their reclassification of the Lost River sucker. In 1970, the publication A List of Common and Scientific Names of Fishes from the United States and Canada (Bailey et al. 1970) distributed by the American Fisheries Society, listed the Lost River sucker as *Catostomus luxatus*, but no reason was given for its reclassification from what Miller and Smith had described. This name again appeared in the 1980 edition of the American Fisheries Society publication (Robbins et al. 1980). In the most recent publication of Common and Scientific Names of Fishes from the United States and Canada (Robins et al. 1991), the Lost River sucker is listed as *Deltistes luxatus*.

Identification. Much concern has been expressed about the ability of researchers to identify juvenile Lost River suckers sampled in the Klamath River basin. The need to identify and separate juvenile suckers into distinct species is necessary for determining their distribution and reproductive success in the various waters. A general description of the morphological characteristics of juvenile Lost River suckers less than 3.9 inches (100 mm) in standard length (SL) is provided by Bond (1989):

"The lobes of the lower lip are well-separated by a gap and are seldom in contact with each other. A raised ridge or frenum exists between the lobes. The head is long in length. The caudal peduncle is long and slender and its least depth is about equal to the distance from the back edge of the eye to the upper end of the opercular opening. The depressed anal fin does not reach past the narrowest part of the caudal peduncle. The pigmentation of the fish is rather pale, with brownish mottling or speckling that does not contrast heavily with the ivory or tan background. Gill rakers usually number 25 to 33 and tend to be triangular in shape with smooth edges. Lateral line scales number from 76 to 86."

Although adult Lost River suckers are easier to identify than the juveniles by morphological characteristics, there are varying opinions on some of the specific characteristics stated throughout the literature. The Lost River sucker is distinguished by its long snout (Cope, 1879; Andreasen, 1975; Moyle, 1976) and a wide median notch in the lower lip that has one or two large papillae between the notch and the edge of the lower lip (Andreasen, 1975). Lateral line scale counts differ between researchers, with Gilbert (1897) reporting between 76 and 81, Andreasen (1975) between 79 to 83, and Moyle (1976) between 82 to 88. Gill raker numbers also vary in reports; from 27 to 28 reported by Andreasen (1975) to 24 to 33 by Moyle (1976). The gill rakers are short and triangular in shape (Moyle, 1976) and are widely spaced and smooth on the edges (Andreasen, 1975). Moyle describes the small hump on the snout of the Lost River sucker as a key characteristic to its identification, but Andreasen (1975) reports that the hump, which is caused by the premaxillary spines, is an artifact of preservation and is not seen in live specimens. Like most suckers, the coloration of their body is dark on the back and sides, and fades to white or yellow on the belly (Moyle, 1976).

Life History and Habitat Requirements

Distribution. The Lost River sucker is native to Upper Klamath Lake (Williams et al. 1985) and most of its tributaries, which include the Williamson, Sprague, and Wood rivers; and Crooked, Seven Mile, Four Mile, Odessa, and Crystal creeks (Stine, 1982). It is also native to the Lost River system, Lower Klamath Lake, Sheepy Lake (Williams et al. 1985), and Tule Lake (Stine, 1982).

The Lost River sucker's present distribution is not well known, but it still occurs in Upper Klamath Lake and its tributaries (Buettner and Scoppettone, 1990), Clear Lake reservoir, and its tributaries, and the Upper Klamath River including Copco reservoir. Juvenile suckers are suspected to have been observed in the Wood River and Crooked Creek**.**

Age and Growth. Age and growth information on the Lost River sucker is limited because of the difficulty in reading annuli from scales, which often are fractured (Golden, 1969; Sonnevil, 1972). Apparently the best method for obtaining age and growth information for catostomid fish is by using the opercula bone (Scoppettone, 1988).

Lost River sucker is a long-lived species, with the oldest individual recorded as 43 years old, which was sampled from Upper Klamath Lake (Scoppettone, 1988). Lost River sucker is one of the largest sucker species and may grow up to 3.3 feet (1 m) in total length (Moyle, 1976). Sexual maturity for suckers sampled in Upper Klamath Lake occurs between the ages of 6 to 14 years, with most maturing at 9 years (Buettner and Scoppettone, 1990). Growth in Lost River suckers sampled from Upper Klamath Lake occurs mainly during the first 8 to 10 years of life (Buettner and Scoppettone, 1990).

Spawning. Spawning for Lost River sucker has been observed by various researchers to occur between March and May (Moyle, 1976). Water temperatures during their spawning in streams and lakes have been reported between 5.5 and 16°C (Golden, 1969; Andreasen, 1975; Buettner and Scoppettone, 1990). Observations of Lost River suckers spawning in the tributaries of Upper Klamath Lake found that most spawned at a depths between 8.3 to 27.6 inches (21 to 70 cm) and in water velocities ranging from 12.2 to 35.4 inches/sec (31 to 90 cm/sec) (Buettner and Scoppettone, 1990). The best substrate for Lost River sucker spawning is believed to be those areas that are dominated by gravel with little sand (Klamath Tribe, 1987).

Lost River sucker spawning behavior has been documented for both riverine and lacustrine habitat (Buettner and Scoppettone, 1990). In river habitat, Lost River suckers have been observed spawning in groups of two to four fish and in lake habitat up to eight fish have been observed spawning together (Buettner and Scoppettone, 1990). The usual behavior is for one female to be flanked by two males on a chosen spawning site, but up to seven males have observed with a female (Buettner and Scoppettone, 1990). Males usually remain on or near the selected spawning site throughout the breeding period, with females only moving into the area during actual spawning (Buettner and Scoppettone, 1990). No aggressive behavior has been observed in spawning Lost River suckers, and spawning acts last only about 2 to 5 seconds

(Buettner and Scoppettone, 1990). Lost River suckers spawn near the bottom of streams and lakes and when gravel is available they will bury their eggs in the substrate (Buettner and Scoppettone, 1990). Fecundity in Lost River suckers has been reported at 44,000 to 218,000 eggs for fish measuring between 20.4 to 29.5 inches (518 to 750 mm) FL (Golden, 1969; Buettner and Scoppettone, 1990).

Lost River sucker eggs have been observed to hatch in 8 days in an average water temperature of 56.3°F (13.5°C) under laboratory conditions and swim-up of larvae occurred after 10 days (Coleman and McGie, 1988). Larval migration from adult spawning streams occurs mainly during the night hours (Beak, 1987, 1988) and juveniles typically move to near-shore areas when they migrate down to a body of water (Buettner and Scoppettone, 1990).

Limiting Factors

At the time of the federal listing of Lost River sucker (and shortnose sucker), the following were recognized threats to the species (67 FR 93, May 14, 2002):

- Drastically reduced adult populations and lack of significant recruitment
- Over-harvesting by sport and commercial fishing
- Potential competition with introduced exotic species
- Lack of regulatory protection (since rectified with the listing)
- Hybridization with other sucker species
- Large summer die-offs caused by declines in water quality in Upper Klamath Lake

Passage Barriers and Requirements

In general, most sucker species are considered to be fairly poor at navigating typical fish passage facilities, such as ladders or weirs. This is mostly the result of their inability or reluctance to transverse vertical barriers. In addition, there is little available information regarding the specific criteria needed to successfully pass suckers across upstream barriers. This subject relative to the Klamath basin suckers has been discussed at length in the biological opinions (BOs) issued by the USFWS for PacifiCorp and USBR operations at Link River dam and is discussed more fully in Section 2.5. In summary, the USBR is in the process of updating the fish ladder at Link River dam with a design that is more conducive to sucker passage. Options for passage at the other Project facilities are discussed in Section 2.5.

2.7.6.2 Shortnose Sucker

Shortnose sucker is a species endemic to the Upper Klamath River basin (including Upper Klamath Lake and some of its tributaries) and is limited in its distribution in the region. Shortnose sucker was first listed as a state-threatened species in the same year as the Lost River sucker (1974). In 1988, it was listed as a federally endangered species. In 1991, Oregon listed the species as endangered**.** In 2002, a petition was presented to the USFWS to delist the shortnose sucker (67 FR 93, May 14, 2002). The USFWS concluded that there was not sufficient scientific or commercial information to warrant the delisting of shortnose sucker from the federal list of endangered species.

Classification and Identification

Classification. The shortnose sucker has not been subject to as many extreme changes in its taxonomic classification as the Lost River sucker. Andreasen (1975) presents a detailed description of the scientific naming of the shortnose sucker over time as he did with the Lost River sucker, and much of what follows is summarized from his work.

The original taxonomic description of the shortnose sucker was made by Cope (1879) from fish he had collected from Upper Klamath Lake, Oregon. It was classified as *Chasmistes brevirostris*. Cope (1881) then placed the shortnose sucker in a new genus (*Lipomyzon*), based on the characteristics of its pharyngeal teeth. However, in 1884, Cope (1884) decided that pharyngeal teeth characteristics of the shortnose sucker did not warrant a new genus, and it was placed back into the genus *Chasmistes*. Fowler (1914), in his review of catostomid fishes, evidently did not realize that Cope had returned the shortnose sucker to the genus of *Chasmistes* and he published the classification as *Lipomyzon brevirostris*. In 1952, however, the shortnose sucker was described as *Chasmistes brevirostris,* based on personal communication between R.R. Miller and C.E. Bond (see Andreasen, 1975). The shortnose sucker has since retained this taxonomic classification (Robins et al. 1991).

Identification. As with the Lost River sucker, the ability to identify juvenile shortnose suckers is equally difficult and important. Bond (1989) provides a general morphological key to juvenile shortnose suckers less than 3.9 inches (100 mm). For adults the following identification is used.

The lobes of the lower lip are well-separated by a gap and are seldom in contact with each other. A raised ridge or frenum between the lobes is present. The head is short and deep in comparison with that of juvenile Lost River suckers. The body is robust and the caudal peduncle is shorter and deeper than that described for the Lost River sucker. The caudal peduncle's least depth is greater than the distance from the back edge of the eye to the upper end of the opercular opening. The depressed anal fin reaches to below the beginning of the caudal fin. The fish's pigmentation is dark with gray to black mottling contrasting with a light gray background. The lower portion of the body is nearly white. The gill rakers usually number between 33 and 48 and their edges are armed with processes that become increasingly branched in larger specimens. Lateral line scales number from 74 to 83.

The morphological characteristics of the adult shortnose sucker provide as much discrepancy in the literature as does the Lost River sucker. In general, the shortnose sucker is distinguished by its large head, oblique, terminal mouth and thin lips that have minute or absent papillae (Moyle, 1976). Andreasen (1975) describes the shortnose sucker as having approximately 78 lateral line scales and 40 gill rakers. Moyle (1976) reports findings of shortnose suckers with 73 to 82 lateral line scales and 34 to 49 gill rakers. Shortnose suckers are dark in color on the back and are silvery to white on the underbelly (Moyle, 1976).

Life History and Habitat Requirements

Distribution. The only known native historical distribution of the shortnose sucker is in Upper Klamath Lake and its tributaries (Miller and Smith, 1981; Williams et al. 1985). Shortnose suckers have been collected from numerous other areas in the Klamath River basin, such as the Lost River, Clear Lake Reservoir, and Tule Lake, but it is hypothesized that they gained access to the Lost River, and subsequently the other areas, by way of the A-canal of the Klamath

Irrigation District (Williams et al. 1985). Shortnose suckers also have been collected from Copco reservoir on the Upper Klamath River, but they are not native to this area. The Copco reservoir population of shortnose suckers is presumed to have come from Upper Klamath Lake**.**

Age and Growth. The difficulty in aging shortnose suckers has been related to the fracturing of the fishes scales, which has been observed with Lost River sucker (Sonnevil, 1972). By examining the opercular bone, Scoppettone (1988) found that the oldest shortnose sucker he examined was 33 years old when it was taken from Copco reservoir. Sexual maturity for shortnose suckers appears to occur between ages 5 and 8 years with most maturing at age 6 or 7 years (Buettner and Scoppettone, 1990). Buettner and Scoppettone (1990) found that for female shortnose suckers sampled from Upper Klamath Lake, most growth occurred in the first 6 to 8 years of life. After that, growth rates decreased and it was felt that this was related to the fish reaching sexual maturity.

Spawning. Moyle (1976) reports that researchers have observed shortnose suckers spawning in April and May in the waters of the Klamath River basin. Shortnose suckers have been observed in their spawning migrations up streams when water temperatures were between 41.9 to 62.6°F (5.5 and 17°C) (Andreasen, 1975; Buettner and Scoppettone, 1990). Most shortnose suckers spawning in the tributaries of Upper Klamath Lake have been observed in water depths ranging from 8.3 to 23.6 inches (21 to 60 cm) and in a water velocities of 1.3 to 3.6 ft/sec (41 to 110 cm/sec) (Buettner and Scoppettone, 1990). The spawning behavior for shortnose suckers is similar to what was described for Lost River suckers (Buettner and Scoppettone, 1990). Fecundity for shortnose suckers has been reported between 18,000 and 46,000 eggs for suckers measuring about 14.2 to 17.5 inches (360 mm to 445 mm) FL (Buettner and Scoppettone, 1990).

After migrating from the shortnose sucker spawning tributaries, juveniles are thought to inhabit near-shore areas similar to that of Lost River suckers (Buettner and Scoppettone, 1990).

Limiting Factors

The presumed limiting factors for shortnose suckers is the same as those listed for Lost River suckers in Section 2.7.3.2.

Passage Barriers and Requirements

Information pertaining to fish passage for shortnose suckers is the same as that presented for Lost River suckers in Section 2.7.3.2.

2.7.6.3 Lamprey

This section discusses the three native species of lamprey that occur in the Klamath River or Upper Klamath Lake in the Project area. They are Pacific lamprey (*Lampetra tridentata*), Klamath lamprey (*Lampetra similis*), and Pit-Klamath brook lamprey (*Lampetra lethophaga*). In the upper basin there is also another lamprey referred to as the "Klamath Lake lamprey," which once was thought to be a landlocked Pacific lamprey, but may be a separate species (Reid, 2003). All are members of the family *Petromyzontidae*. Pacific lamprey is much more widely distributed than the other species and is found downstream (anadromous populations) of Iron Gate dam on the mainstem Klamath River (Moyle, 1976; ODFW, 1997). Landlocked populations of Pacific lamprey also are reported to occur upstream of Lewiston and Trinity dams in the Upper Trinity River subbasin (KRBFTF, 1991). In the Klamath River system, Pit-Klamath brook lamprey occurs only upstream of Iron Gate dam, and generally in the same water bodies as landlocked Pacific lamprey (ODFW, 1997). Klamath River lamprey occur above and below Iron Gate dam. All of these species of lamprey have been categorized as generally having a cool-water temperature preference, and an intermediate tolerance of increased siltation, turbidity and water temperature, and reduced dissolved oxygen levels (Zaroban et al. 1999).

Two additional lamprey species, Miller Lake lamprey (*Lampetra minima*) and unnamed lamprey No. 1 (*Lampetra folletti*), were reported to occur in the Klamath River basin (Kostow, 2002). The Miller Lake lamprey also may occur in the Upper Klamath River and in Spencer Creek (Reid, 2003). However, either they have not been reported from the Klamath River or Upper Klamath Lake in the Project area or their taxonomy is uncertain; therefore, this species is not described in this document. The Miller Lake lamprey was believed extirpated (poisoned) from Miller Lake in 1958, but was rediscovered in the 1990s.This species is distributed in the Miller Lake basin; upper Klamath Marsh, and the Williamson River above the marsh; and in Sycan Marsh and the Sycan River above the marsh (Kostow, 2002). Unnamed lamprey No. 1 was described once as being distributed in the Lost River. Currently, it is unknown whether unnamed lamprey No. 1 is present or ever was present in the Klamath River basin (Kostow, 2002).

The following text provides overview discussions of Klamath lamprey and Pit-Klamath brook lamprey, but focuses on Pacific lamprey because of both its wide-spread distribution and presence of anadromous life forms in the Klamath River basin, and because of the continued importance of Pacific lamprey to tribal cultures in the Klamath basin. In addition, and in contrast to most species of salmonids, little is known and few quantitative data exist on the current status and population trends of Pacific lamprey in many drainages, including those in the Klamath River basin (CH2M HILL, 1985; KRBFTF, 1991; Larson and Belchik, 1998; Hardy and Addley, 2001). Larson and Belchik (1998) stressed the continued importance of Pacific lamprey to the Yurok Tribe in northwestern California, but expressed concern that no efforts have been made to determine factors contributing to its apparent decline in the Klamath River basin during the past few decades. The following text includes the current information on lamprey regarding distinguishing characteristics, distribution and status, life history and habitat requirements, limiting factors including passage barriers and requirements, and importance of lamprey to humans.

Klamath River Lamprey

The Klamath River lamprey occurs in the Klamath River basin downstream to Happy Camp on the Klamath River and in the Trinity River (Kostow, 2002). This species is known to inhabit Upper Klamath Lake, the Klamath River, and Spencer Creek (ODFW, 1997). Details on the life history of Klamath lamprey are generally unknown, but it is believed to be similar to those of its sister species, Pacific lamprey (ODFW, 1997; Kostow, 2002). The life history of Pacific lamprey is described in some detail later in this report.

Klamath lamprey is parasitic and non-anadromous (Kostow, 2002). The species occurs as resident as well as riverine individuals. Adult Klamath lamprey are much smaller than Pacific lamprey, and range in length from approximately 6.3 to 7.9 inches (160 to 200 mm). Adults spawn during the spring and can produce from 8,000 to 18,000 eggs per female. Ammocoetes (burrowing juveniles) are reported to metamorphose in the fall, spend 12 to 15 months in

Klamath Lake where they exhibit parasitic feeding habits, then spawn in the spring (Kostow, 2002).

Pit-Klamath Brook Lamprey

The Pit-Klamath brook lamprey occurs in the Upper Klamath River basin upstream of Klamath Falls, generally in many of the same water bodies where landlocked Pacific lamprey occurs (ODFW, 1997). This species also is found in the Pit River in northern California and in the Goose Lake basin in southeastern Oregon (Moyle, 1976; Kostow, 2002).

Details on the life history of Pit-Klamath brook lamprey, as those of Klamath lamprey, are generally unknown. Pit-Klamath brook lamprey is reported to be a non-parasitic resident species, with the gut atrophied in adults (Moyle, 1976; Kostow, 2002). Adults range in length from approximately 3.9 to 7.9 inches (100 to 200 mm) and can produce from 900 to 1,100 eggs per female. Spawning occurs in the spring, although reproductive individuals have been observed during the summer and fall (Moyle, 1976; Kostow, 2002). Burrowing juveniles (ammocoetes) are reported to be filter feeders, spending at least 4 years in this life stage. Primary habitat of Pit-Klamath brook lamprey appears to be cool, clear streams or springs with sandy-muddy bottoms or edges, but this species also is found in gravel and cobble. Ammocoetes burrow into the soft mud substrates among aquatic plants and in open low-energy environments (Moyle, 1976).

Pacific Lamprey

Distinguishing Characteristics. Pacific lamprey belong to a primitive but specialized scientific family of aquatic vertebrates (*Petromyzontidae*) whose bodies appear eel-like, but lack the jaws and paired fins of true eels (Moyle, 1976). The body of the Pacific lamprey is elongate and cylindrical, and the skin is smooth and without scales (Scott and Crossman, 1973). The two dorsal fins are slightly separated, and the second dorsal fin is connected to the caudal fin. The anal fin is conspicuous in females, but is absent in males (Moyle, 1976). Adults vary in color from blue-black to dark brown and are lighter ventrally (Scott and Crossman, 1973). Adult Pacific lamprey in the Klamath River are dark bluish-gray when they enter freshwater, but are red, dark brown, or gray when they spawn (Larson and Belchik, 1998).

The survival of most species of predatory lamprey has depended on their ability to attach to prey, such as fish, and to use their sucker-like mouth to rasp a hole and remove blood and body fluids from the host (Scott and Crossman, 1973). Sharp horny plates or teeth are present in all areas of the sucking disc (Moyle, 1976). The genus name of Pacific lamprey, *Lampetra*, is derived from the Latin words *lambere* (to suck) and *petra* (stone), indicating the lamprey's ability to attach to stones in streams with their sucker-like mouth. The species name, *tridentata*, translates as three-toothed, in reference to the three principal sharp cusps on the lamprey's tooth plate. The usual length of anadromous Pacific lamprey is up to 26.8 inches (680 mm) (Scott and Crossman, 1973). Moyle (1976) observed that any large adult lamprey in California exceeding 15.7 inches (400 mm) total length is a Pacific lamprey.

Distribution and Status. Anadromous Pacific lamprey is widely distributed throughout the western United States and western Canada, and exhibits extensive upstream spawning migrations (Scott and Crossman, 1973; Moyle, 1976). Pacific lamprey occurs in most Pacific coast streams from Unalaska Island (the Aleutians) south to the Santa Ana River, California, although large spawning runs are unusual south of Monterey Bay (Scott and Crossman, 1973; Moyle, 1976).

Pacific lamprey have been captured in the Pacific Ocean from off the coasts of Japan to Baja, California, and have been observed as far inland as central Idaho (Moyle, 1976; Simpson and Wallace, 1978). Pacific lamprey migrates into all major Pacific coast rivers and tributaries in the range and can penetrate to headwaters if no migratory barriers exist.

In the Klamath River basin, anadromous Pacific Lamprey occurs downstream of Iron Gate dam on the Klamath River and Lewiston dam on the Trinity River (Moyle, 1976; KRBFTF, 1991; ODFW, 1997). The potential for spawning migrations into the Upper Klamath River basin by anadromous species such as Pacific Lamprey was halted by the completion of Copco No. 1 dam at RM 198.6 in 1918 and the completion of Iron Gate am at RM 190.1 in 1962. The current distribution of anadromous Pacific lamprey in the Klamath River basin potentially includes much of the mainstem Klamath River from its mouth upstream to Iron Gate dam, and portions of many major and smaller drainages to the mainstem Klamath River below Iron Gate dam, including the Shasta, Scott, Salmon, and Trinity River subbasins (CH2M HILL, 1985; Hardy and Addley, 2001).

Adult Pacific lamprey have not been observed in the fishways at Iron Gate dam or at the Iron Gate fish hatchery (Rushton, 2003). However, juvenile lamprey, less than about 12 inches (304.8 mm) long, occasionally are observed attached to adult salmon returning to the hatchery.

The historical distribution of anadromous Pacific lamprey in the Klamath River basin is uncertain given the lack of documenting data. However, based on the ability of this species to migrate long distances upstream in the absence of migratory barriers (Scott and Crossman, 1973; Moyle, 1976, Simpson and Wallace, 1978), it is likely that anadromous Pacific lamprey historically was distributed throughout the Klamath River basin. Coots (1955, in Larson and Belchik, 1998) reported that before the construction of dams on the Upper Klamath River, lamprey used areas above Iron Gate dam for spawning and rearing. Other anadromous species, such as Chinook salmon, historically migrated as far upstream as Upper Klamath Lake and its tributaries before the construction of Copco No. 1 dam (Fortune et al. 1966). The current distributions of Pacific lamprey in the Klamath River basin downstream of Iron Gate dam generally are believed to be at least as extensive as those of anadromous salmonids (CH2M HILL, 1985). Close et al. (1995), citing Simpson and Wallace (1978), observed similarly that in the Columbia and Snake River basins the historical distribution of Pacific lamprey was coincident wherever salmon occurred. In addition, Kan (1975, in Close et al. 1995) suggested that the important factor determining regional distribution of Pacific lamprey was access to suitable habitat rather than distance from the ocean. These observations suggest that anadromous Pacific lamprey probably occurred historically in much of the Upper Klamath River basin.

Populations of anadromous Pacific lamprey are declining in much of their range in the western United States. In Oregon, Pacific lamprey became a conservation concern in the early 1990s when tribal managers and the ODFW staff noted perilously low population levels of this species (Kostow, 2002). The most precipitous declines of Pacific lamprey in Oregon appear to be in the Upper Columbia and Snake River basins (Close et al. 1995; Kostow, 2002), although there is evidence of Pacific lamprey decline in the lower Columbia River and along the Oregon coast, as well (Kostow, 2002). Oregon listed Pacific lamprey as a sensitive species in 1993 and provided this species further legal protection in 1996 through the implementation of Oregon Administrative Rule (OAR) 635-044-0130. This regulation requires that permits be issued by the Oregon Fish and Wildlife Commission before certain non-game species, including Pacific lamprey, can be harvested (Kostow, 2002). Anadromous Pacific lamprey also has been designated as a federal species of concern (PacifiCorp, 2000).

On January 23, 2003, 11 conservation organizations filed a petition with the Secretary of the Interior under the ESA to list as threatened or endangered and designate critical habitat for Pacific lamprey (as well as River lamprey (*Lampetra ayresi*), western brook lamprey (*Lampetra richardsoni*), and Kern brook lamprey (*Lampetra hubbsi*)) found in California, Oregon, Washington, and Idaho. Excluded from this petition are all resident lamprey found upstream of Iron Gate dam, in the Upper Klamath River basin, as well as Klamath River lamprey found below Iron Gate dam. The petition cites broad declines in the numbers and distribution of the petitioned species of lamprey and lists various factors believed to be limiting lamprey success. Factors limiting Pacific lamprey success are discussed in the limiting factors section of this report.

Larson and Belchik (1998) stated that, in California, runs of anadromous Pacific lamprey in the Klamath River gradually have diminished during the past few decades, although little quantitative evidence is available for estimating the degree of decline. CH2M HILL (1985) commented similarly that although anadromous production generally has declined from historical levels in the Klamath River basin, there are few or no data available for the mainstem Klamath River and its subbasins with which to quantitatively assess the status and population trends of Pacific lamprey. Larson and Belchik (1998) used interviews with Yurok tribal fishers and elders to gather anecdotal information on run sizes of Pacific lamprey in the Klamath River. They reported that during the extremely large Pacific lamprey runs in the past, approximately 1,500 lamprey have been caught by one person in 1 day. Many of the Yurok tribal members interviewed recalled that Pacific lamprey declined gradually in the late 1980s, while several others said lamprey declined as early as the 1950s and 1960s. Lamprey catch per effort by tribal members in recent years has ranged from zero to 100 lamprey per day or per night, with many tribal fishers regarding 20 lamprey as an extremely good catch (Larson and Belchik, 1998). It was reported that in 1994 and 1995, respectively, 2,099 and 4,592 Pacific lamprey were trapped in the Klamath River at RM 50, and 5,606 and 2,100 were trapped in the Trinity River at RM 21.

<u>Life History and Habitat Requirements.</u> Adult Pacific lamprey are reported to usually move from the ocean into spawning streams between April and September, depending on geographic location (Moyle, 1976; Scott and Crossman, 1973). In the Klamath River basin, Larson and Belchik (1998) reported that Yurok tribal elders stated that adult Pacific lamprey enter the Klamath River throughout the year, and that lamprey entering during the summer are heavily parasitized or “wormy.” The USFWS (USFWS, 1960, in Larson and Belchik, 1998) stated that adult Pacific lamprey enter the Klamath River in two major peaks, one during the winter and the other in spring. The Yurok Tribal Fishers Program has documented lamprey entering the Klamath River from October through April, often peaking in December or January (Hardy and Addley, 2001).

It is uncertain whether Pacific lamprey exhibit homing behavior like that of adult anadromous salmonids during upstream spawning migrations. Studies in the Great Lakes by Bergstedt and Seelye (1995) indicate that sea lamprey (*Petromyzon marinus*) essentially have no homing behavior, but rather are attracted by chemical stimuli associated with concentrations of ammocoetes present in the streams. This finding has led to speculation that Pacific lamprey also have no homing behavior and, therefore, no distinct population structure among drainages

(Kostow, 2002). However, other studies cited by Kostow (2002) describe broad patterns of geographic and regional differences among Pacific lamprey suggesting that there may be some homing tendencies to major river basins.

Adult Pacific lamprey entering freshwater are usually a maximum of 6 to 7 years of age, having spent the previous 6 to 40 months in the ocean parasitizing large fish and other marine vertebrates (Scott and Crossman, 1973; Moyle, 1976; KRBFTF, 1991; Kostow, 2002). Adults are sexually immature when they first enter freshwater and cease feeding as they begin upstream migrations toward their spawning areas (Scott and Crossman,1973; Larson and Belchik, 1998). Spawning migrations can extend many hundreds of miles, with rates of travel estimated as approximately 3 to 5 miles (4.8 to 8 km) per day (Close et al. 1995). Lamprey move upstream by alternately swimming, then attaching to stones to maintain their position and rest. They have been described as weak swimmers compared to other fish, but with a darting swimming speed of approximately 7 feet per second (2.1 m/sec) and using their ability to cling to objects, can move upstream over waterfalls and other obstacles (Scott and Crossman, 1973; Bell, 1986; KRBFTF, 1991; Close et al. 1995). Lampreys often migrate for several months (and often at night and in surges rather than continuously) before they spawn, seeking cover under stones and logs until they become sexually mature (Moyle, 1976). After completing part of their upstream migration, lamprey are believed to overwinter before spawning the following spring (Kostow, 2002).

Pacific lamprey in the Klamath River basin are believed to spawn primarily from April to July (Hardy and Addley, 2001). Spawning in the Trinity River and its tributaries occurs mainly from April through June (CH2M HILL, 1985), although spawning migrations into the upper Trinity have been observed as late as August and September (Moffett and Smith, 1950, in KRBFTF, 1991). Spawning occurs in sandy gravel at the upstream edge of riffles (Moyle, 1976), generally in water 1.3 to 3.3 feet (0.4 to 1 m) deep with velocities between 1.6 and 3.3 feet per second (0.5 to 1 m/sec) (Close et al. 1995). Spawning often occurs near silty pools and banks that provide habitat for burrowing juveniles (ammocoetes), and suggesting that adults may be attracted to chemical stimuli produced by ammocoetes rearing nearby (Kostow, 2002).

The male and female lamprey construct a shallow depression by removing larger stones, which accumulate at the downstream edge of the spawning nest. Eggs and milt are released over the completed nest and the fertilized eggs adhere to the downstream stones. Silt, sand, and gravel loosened by the adults following spawning cover the fertilized eggs. Adults may spawn several times over the same nest until spent, and females may release from 15,000 to 240,000 eggs, depending on their size. Adult lamprey are reported to die shortly after completing spawning (Scott and Crossman, 1973; Moyle, 1976; KRBFTF, 1991; Hardy and Addley, 2001; Kostow, 2002).

Eggs incubate for approximately 2 to 3 weeks, depending on water temperature, before hatching (Scott and Crossman, 1973). The larvae or ammocoetes soon emerge from the substrate and drift into backwater areas downstream of the spawning nest where they burrow tail first into mud or soft sand. There, they begin filter feeding on detritus and algae at the substrate’s surface (Moyle, 1976; Larson and Belchik, 1998). Ammocoetes may spend up to 5 or 6 years in the substrate before metamorphosing (transforming) into adults, becoming parasitic in their feeding behavior, and beginning their downstream migrations toward the ocean (Scott and Crossman, 1973). After 3 to 7 years, ammocoetes reach lengths of approximately 5.5 to 6.3 inches (140 to 160 mm) and begin metamorphosing into adults, developing large eyes, a sucking disc, silver sides, and a dark blue back (Moyle, 1973). Outmigration of juveniles in the Klamath River basin is believed to occur typically during late summer although movements during March have been associated with high spring flows (Hardy and Addley, 2001). Transformed lamprey destined for the ocean, as well as some ammocoetes not yet transformed and destined for lower basin reaches, are reported to drift downstream with the current, primarily at night (Close et al. 1995; Kostow, 2002).

The timing of lamprey entering the ocean is reported to typically vary from late fall to spring, perhaps depending on environmental conditions and whether populations are coastal or inland (Close et al. 1995; Kostow, 2002). Pacific lamprey initially entering the ocean move quickly offshore into waters up to 230 feet (70 m) deep; larger individuals may move farther offshore and spend more time at sea, perhaps up to 40 months (Kostow, 2002). Despite their reportedly wide marine distribution, adult Pacific lamprey probably normally remain near the mouths of their spawning streams in estuarine and other near-coast areas where their prey is most abundant (Moyle, 1976). As described previously, individuals may spend up to about 3.5 years in the ocean parasitizing large fish and other large vertebrates, occasionally even whales, before returning to freshwater as adults. Despite their predaceous habits, Pacific lamprey appear to have little effect on fish populations (Moyle, 1976).

Predators of Pacific lamprey while at sea include marine mammals and larger fish. Predators on Pacific lamprey eggs, larvae, and ammocoetes include a variety of resident and anadromous fish species and various gulls and terns (Close et al. 1995; Kostow, 2002). Larson and Belchik (1998) reported that stomachs of some trapped juvenile steelhead have been full of lamprey ammocoetes, indicating lamprey ammocoetes may be an important food source for juvenile salmonids. Pacific lamprey are important in various aspects of numerous tribal cultures, and also are used as bait in fishing for various species, such as sturgeon (Scott and Crossman, 1973; Moyle, 1976; Close et al. 1995; Larson and Belchik, 1998).

A species once thought to be a landlocked form of Pacific lamprey in the Klamath River basin upstream of Iron Gate dam become sexually mature when about 1 foot (0.3 m) long (ODFW, 1997). They migrate from the Klamath River and from Upper Klamath and Agency lakes to the lower reaches of major tributaries where they spawn. Ammocoetes remain in the stream substrate for 2 to 3 years before moving downstream from natal habitat and becoming parasitic in their feeding habits (ODFW, 1997). They are reported to rear in lakes and rivers, preying on fish such as trout and suckers, until they mature, spawn, and then die. KRBFTF (1991) reported that these populations of lamprey in the Upper Trinity subbasin prey heavily on kokanee and other resident fish in Lewiston and Trinity lakes.

<u>Limiting Factors.</u> CH2M HILL (1985), KRBFTF (1991), and Hardy and Addley (2001) described several human-caused and natural factors that have contributed to the decline of anadromous salmonids in the Klamath River basin. Because of some similarities in distribution, life histories, and habitat requirements, many of these factors also likely have contributed to the decline of Pacific lamprey in the Klamath River basin. These limiting factors were summarized by Hardy and Addley (2001) and include the following:

- Past and some ongoing land use practices associated with logging, mining, stream habitat alterations, and agriculture
- Construction of dams and diversions

- Altered streamflow regimes
- Overharvest of stocks in the ocean and river
- Climatic change, floods, droughts, fires, and El Niño
- Changes in water quality and temperature
- Introduced species
- Predation, disease, and poaching

The Klamath River basin was primarily in a natural state before approximately 1800, but by the mid-1800s anadromous salmonid stocks were being adversely affected by accelerated logging, mining, and commercial fishing. Since that time the factors listed above have cumulatively contributed to limiting conditions for many aquatic resources in the Klamath River basin (Hardy and Addley, 2001).

A status review of Pacific lamprey in the Klamath River basin recently was conducted by Larson and Belchik (1998). The authors stated that the limited information on Pacific lamprey populations in the Klamath River basin reflects data gaps on this species' population trends and on human factors affecting these trends. They commented that despite the lack of quantitative data, it is apparent that Pacific lamprey have declined dramatically in the Klamath River basin and suggested this is generally a result of habitat degradation and "poor" ocean conditions. The factors potentially responsible for the decline of Pacific lamprey in the Klamath River basin are believed to be similar to factors identified as responsible for the decline of salmon and steelhead runs (Larson and Belchik, 1998). These factors include large-scale landscape changes that have resulted in the alteration and elimination of crucial habitats, alteration in flows and water quality in the mainstem Klamath River and its tributaries, a decrease in the prey base, and blockage of formerly accessible spawning and rearing habitat by dams and reservoirs.

Larson and Belchik (1998) recommended gathering the following information (presented verbatim) to understand which factors have been specifically responsible for the decline of Pacific lamprey in the Klamath River basin:

- Determine basic distribution, abundance, and habitat requirements of the Pacific lamprey in the Klamath River basin.
- Distribution within subbasins and habitat usage of juvenile and adult Pacific lamprey should be determined for the entire Klamath River basin.
- Recent efforts to quantify abundance and timing of juvenile outmigration should continue, and adult catch per effort also should continue to be monitored on the Klamath River.
- Temperature and water quality tolerances of juvenile and adult lamprey should be investigated to determine if these factors are impacting the Klamath River lamprey runs.

Limiting or potentially limiting factors similar to those for the Klamath River basin were identified as contributing to the decline of Pacific lamprey in the Columbia River basin (Close et al. 1995). The following five broad categories of limiting factors were identified:

- Poor habitat conditions from improper land use practices that affect sediment delivery, water temperature, and other instream and riparian characteristics
- Fish poisoning operations from the 1940s through the 1980s directed at non-game or "rough" fish species
- Water pollution from various contaminants
- Effects of dams and altered flow regimes
- The effects of ocean conditions and harvest, perhaps manifested as reduced prey abundance for lamprey and/or increased predator abundance on lamprey (Close et al. 1995).

Various dam-related effects on lamprey were identified. They not only included direct blockage of lamprey upstream migrations at some locations, but also entrainment of individuals migrating toward sea, impingement on traveling screens designed to bypass anadromous salmonids, altered flow regimes below dams and delayed outmigration, and the presence of obstacles such as grates or velocity barriers in fish ladders that inhibited upstream migrations by forcing lamprey to use their sucking mouth to climb up the walls of fish ladders to the next resting pool (Close et al. 1995).

Close et al. (1995) concluded it is unlikely that restoration of Pacific lamprey would impede the recovery of Columbia River salmonids because these species have co-evolved in the same community, there is no evidence that lamprey significantly adversely affect salmonids, and adult lamprey in the ocean prefer to feed on mid-water species, such as Pacific hake and walleye pollock.

Most recently, Kostow (2002) discussed the natural history, status, and analysis of management issues for Oregon lampreys. Actions recommended for improving ODFW information about lampreys were directed at species identification; species distribution; species abundance and/or densities; species ecology, life history, and biodiversity; and the effects of harvest.

<u>Passage Barriers and Requirements.</u> The downstream passage around dams and diversion structures can be a significant hazard for lamprey because ammocoetes and recently transformed individuals are weak swimmers and subject to flow velocity and direction (Kostow, 2002). Lamprey moving downstream can be impinged and/or partially entrained on fish screens at higher approach velocities and die, or they can attach to fish screens at lower approach velocities and be crushed by the gatewells or screen cleaners. Outmigrants also can be lost in small orifices of dams, diverted into irrigation ditches, or entrained through turbines—although turbine mortality rates may be less for lamprey than juvenile salmonids because of differences in body structure and shape (Kostow, 2002).

Dams, road culverts, and other barriers such as tide gates, hatchery weirs, and diversion structures can impede upstream passage by lamprey. Because of their relatively weak swimming ability, lamprey must find rough surfaces in low to moderate water velocities to which they can attach while moving upstream. Dams not intended to pass fish, road culverts with smooth surfaces, velocity barriers, and/or a hanging entrance, and any other barrier with a sharp lip, high water velocity, smooth surface, or hanging downstream drop more than several inches high will prevent or constrain lamprey upstream passage. Providing the means for lamprey to climb around these features may simply require piling rocks to one side with a gentle overflow of water (Kostow, 2002).

In addition to these constraints, fish ladders at dams do not always ensure upstream passage of lamprey. Kostow (2002), citing studies by Slatick and Basham (1985) and Ocker et al. (2001), reported that lamprey are able to use fishways at Columbia and Snake River dams regardless of their length and slope, but that certain areas of the fishways seem to pose passage problems. Areas of fish ladders that seemed most difficult for lamprey to pass were where lips or gratings had to be crossed, where water velocity was high, such as at entryways and over diffuser gratings, and areas that were lighted at night. These difficult areas of passage correspond to biological characteristics of lamprey that include their weak swimming ability, the need to attach to surfaces to rest, and a strong avoidance of light (negative phototaxis). There is no specific research indicating that Pacific lamprey are negatively phototaxic to passage in fish ladders, but they tend to be more nocturnal in their general movements (Moser, 2003). Kostow (2002) suggested that upstream passage by lamprey through fishways might be improved without interfering with salmonid passage by providing roughened surfaces that lamprey could easily attach to, rest, and climb along during their upstream migration. However, there has been no research on whether a rough or smooth surface is better for lamprey attachment, and they are commonly observed on both types of surfaces (Moser, 2003).

Studies on the upstream passage efficiency of radio-tagged Pacific lamprey have been conducted at hydropower dams on the lower Columbia River (Moser et al. 2002). The estimated upstream passage efficiency of lampreys (percent) and median time of passage (days) was 38 to 47 percent and 4.4 to 5.7 days at Bonneville dam and 50 to 82 percent and 2.0 to 4.0 days at The Dalles dam. Estimated passage efficiency was lower at John Day dam, but was based on relatively few fish. After entering the fishways at the three Columbia River dams, the greatest obstacles to upstream passage of adult Pacific lamprey were negotiating the collection channels and transition areas that lacked attachment sites for lamprey, and passing through the Bonneville dam counting stations. The ability for lamprey to find attachment sites, especially in areas with high velocities, is necessary for upstream passage. Even in low velocity areas, upstream passage efficiency is low in areas with floor gratings, which do not allow lamprey attachment (Moser et al. 2002).

No specific criteria or written guidelines have yet been developed by fisheries management agencies that ensure successful upstream passage of adult Pacific lamprey past dams (Moser, 2003). However, research to date indicates several factors at fishways, many of which were described above, pose obstacles to lamprey during their upstream migrations. Examples include areas with floor gratings, velocities exceeding approximately 8 feet (2.4 m) per second, areas with 90-degree configurations, and serpentine weirs that lamprey are more easily stuck in than slot weirs (Moser, 2003). Research on ways to improve the upstream passage of Pacific lamprey is continuing.

Importance to Humans. Numerous authors have described the importance of Pacific lamprey to humans. Pacific lamprey always have been an important food source for Native Americans of the Klamath River basin (KRBFTF, 1991). On the Klamath River in northwestern California, Pacific lamprey continue to be of great cultural importance to the Yurok Tribe (Larson and Belchik, 1998). Native Americans from the Pacific Coast and interior Columbia River basin have harvested Pacific lamprey for subsistence, ceremonial, and medicinal purposes for many generations (Close et al. 1995). Lamprey have been harvested by Pacific Northwest tribes for centuries, and are prized for their taste and considered a delicacy (Larson and Belchik, 1998). Pacific lamprey are fatty and highly nutritious, and are valued as a traditional food source by Native Americans (Kostow, 2002). For centuries, the indigenous people of British Columbia have harvested Pacific lamprey for food and used them smoked, sun-dried, or salted (Scott and Crossman, 1973).

Lamprey also are considered a delicacy in some European cuisines, and are used by Asian cultures as a source of essential oils for traditional medicines (Kostow, 2002). Pacific lamprey harvested at Willamette Falls, Oregon, in the 1940s were used as a source of vitamins as well as anticoagulants. Pacific lamprey also are commonly used for scientific study and dissection in biology and anatomy classes. In addition, Pacific lamprey have been harvested and used or marketed as bait in fishing for various species, such as sturgeon (Kostow, 2002). Other uses of lamprey have included as bait for trapping coyote, and as a protein food for livestock, poultry, and in fishmeal fed to hatchery-reared juvenile salmon (Close et al. 1995).

2.7.6.4 Coho Salmon

Coho salmon are a native anadromous salmonid fish to the Klamath River system. The specific coho salmon stock in the Klamath system belong to the southern Oregon/northern California (SONC) ESU as defined by NOAA Fisheries. The SONC coho salmon were listed as threatened species under the ESA in June 1997. Before 1977, and in subsequent documentation regarding the listing of this stock of coho, much has been written regarding the life history and factors affecting the populations. The following write-up describing the general information, life history, and limiting factors of the SONC stock of coho salmon has been taken directly from one of the more recent documents: <u>The Biological Opinion of Klamath Operations </u>(NOAA Fisheries, 2002).

The coho salmon was historically widely distributed throughout the North Pacific Ocean from central California to Point Hope, Alaska, through the Aleutian Islands, and from Anadyr River, Russia, south to Hokkaido, Japan. During the twentieth century, naturally producing populations of coho salmon have declined or have been extirpated in California, Oregon, and Washington. The coho salmon status review identified six distinct ESUs in these states and noted that natural runs in all ESUs are substantially below historical levels (Weitkamp et al. 1995).

Coho salmon occur in the mainstem Klamath River year round, and coho also inhabit a number of Klamath tributaries (Henriksen, 1995;Yurok Tribe, 2001; CDFG, 2002, Klamath River file data). Between Iron Gate dam and Seiad Valley, coho salmon populations are known to occur in Bogus Creek, Little Bogus Creek, Shasta River, Humbug Creek, Little Humbug Creek, Empire Creek, Beaver Creek, Horse Creek, and Scott River.

Limited information exists regarding coho salmon abundance in the Klamath River basin. Adult and juvenile coho salmon are observed in tributaries and the mainstem of the Klamath River; however, these observations often occur incidentally to their main purpose of determining fall Chinook salmon escapement. Most observations of adult coho salmon occur at weir, hatchery and tribal fishery locations. After the counting of fall Chinook ends, the weirs are removed before high winter flows. Therefore, counting efforts may not include a portion of the coho salmon migration because coho spawning is known to extend later into the season than the Chinook spawning. Spawning and carcass surveys have been conducted in tributaries and the mainstem Klamath River.

Life History and Habitat Requirements

In contrast to the life history patterns of other Pacific salmonids, coho salmon generally exhibit a relatively simple 3-year life cycle. They spend approximately 18 months in freshwater and 18 months in salt water (Shapovalov and Taft, 1954). The primary exception to this pattern are "jacks," which are sexually mature males that return to freshwater to spawn after only 5 to 7 months in the ocean. Most coho salmon enter rivers between September and February and spawn from November to January (Hassler, 1987), and occasionally into February and March (Weitkamp et al. 1995). Coho salmon river entry timing is influenced by many factors, one of which appears to be river flow (Sandercock, 1991). In general, earlier migrating fish spawn farther upstream in a basin than later migrating fish, which enter rivers in a more advanced state of sexual maturity (Sandercock, 1991).

Spawning is concentrated in riffles or in gravel deposits at the downstream end of pools with suitable water depth and velocity. Coho salmon eggs incubate for approximately 35 to 50 days between November and March. The duration of incubation may change depending on ambient water temperatures (Shapovalov and Taft, 1954).

Successful incubation depends on several factors including dissolved oxygen levels, temperature, substrate size, amount of fine sediment, and water velocity. Fry (YOY) start emerging from the gravel 2 to 3 weeks after hatching (Hassler, 1987). Following emergence, fry move into shallow areas near the streambanks. As coho salmon fry grow larger, they disperse upstream and downstream, and establish and defend a territory (Hassler, 1987). During the summer, coho salmon fry prefer pools and riffles featuring adequate cover, such as large woody debris, undercut banks, and overhanging vegetation. Juvenile coho salmon prefer to over-winter in large mainstem pools, backwater areas and secondary pools with large woody debris, and undercut bank areas (Hassler, 1987; Heifetz et al. 1986).

Juveniles primarily eat aquatic and terrestrial insects (Sandercock, 1991). Typically, coho salmon rear in freshwater for up to 15 months, then migrate to the ocean as smolts between March and June (Weitkamp et al. 1995). Coho salmon smolts have been observed emigrating through the Klamath River estuary in mid-to late May when water temperature ranged from 53.6 to 68°F (12 to 20°C) (CDFG, 2002, Klamath River file data). While living in the ocean, coho salmon typically remain closer to their river of origin than do Chinook salmon (Weitkamp et al. 1995). Coho salmon typically spend two growing seasons in the ocean before returning to their natal streams to spawn as 3-year-olds.

Limiting Factors

All SONC coho salmon populations in the ESU are depressed relative to their past abundance, based on the limited data available (60 FR 19 38011, July 25, 1995; 62 FR 24588, May 6, 1997). The Klamath River population is heavily influenced by hatchery production, and a large component of the population is of hatchery origin, apparently with limited natural production. The apparent declines in production suggest that the natural population may not be self-sustaining (62 FR 24588, May 6, 1997). These declines in natural production are related, at least in part, to degraded conditions of the essential features of spawning and rearing habitat in many areas of the SONC coho salmon ESU. Poor survival of coho fry and juveniles in the mainstem Klamath River, as indicated by upriver versus downriver trapping results, suggests that degraded mainstem rearing habitat is limiting coho production. Existing information also indicates that adult coho salmon are present in the mainstem Klamath River from early September through January and juvenile coho salmon are present in the mainstem Klamath River throughout the year, including the summer months.

The SONC coho salmon ESU was listed as threatened because of numerous factors, including several long-standing, human-induced factors (e.g., habitat degradation, harvest, water diversions, and artificial propagation), that exacerbate the adverse effects of natural environmental variability (e.g., floods, drought, poor ocean conditions). Habitat factors that may contribute to the decline of coho salmon in the SONC ESU include changes in channel morphology, substrate changes, loss of instream roughness and complexity, loss of estuarine habitat, loss of wetlands, loss and/or degradation of riparian areas, declines in water quality, altered stream flows, impediments to fish passage, and elimination of habitat.

The major activities identified as responsible for the decline of coho salmon in Oregon and California include logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, water withdrawals, and unscreened diversions for irrigation (62 FR 24588, May 6, 1997). Coho salmon harvested by California Native American tribes in the northern California portion of the SONC ESU are primarily incidental to larger Chinook salmon subsistence fisheries in the Klamath and Trinity Rivers; in neither basin is tribal harvest considered to be a major factor for the decline of coho salmon. Harvest management practiced by the tribes is conservative and has resulted in limited impacts on the coho salmon stocks in the Klamath and Trinity Rivers (62 FR 24588, May 6, 1997).

In contrast, overfishing in non-tribal fisheries is believed to have been a significant factor (62 FR 24588, May 6, 1997). Disease and predation are not believed to be major causes in the species decline; however, they may have substantial impacts in local areas. Artificial propagation is also a factor in the decline of coho salmon because of the genetic impacts on indigenous, naturally reproducing populations, disease transmission, predation of wild fish, depletion of wild stock to enhance brood stock, and replacement rather than supplementation of wild stocks through competition and the continued annual introduction of hatchery fish.

Although artificial propagation may be a factor in the decline of coho salmon in California, the degree of this impact is unknown. The state of California operates two hatcheries in the Klamath River basin: Iron Gate fish hatchery on the Klamath River and Trinity River fish hatchery on the Trinity River. Both facilities were constructed to mitigate for lost habitat upstream resulting from dam construction, are operated in a manner minimizing impacts on naturally spawning fish, and use strict production constraints not to exceed their mitigation goals. Although the biological assessment (USBR, 2002) indicates that few natural coho salmon remain in the tributaries and that tributary coho populations are dominated by hatchery production, it does not provide any evidence to support this conclusion. According to CDFG, all Trinity River and Iron Gate hatchery coho production has been marked (maxillary clip) every year since 1996. None of the 57 coho spawner carcasses examined during spawner surveys conducted in the Scott River basin during December 2000 and 2001 bore any hatchery marks. Preliminary 2001 data from adult coho surveys on the Shasta River using a video camera at the Shasta racks, counts of spawned-out fish that washed back to the racks, and carcass surveys in the Shasta River found only six adults out of a total of 291 that were of hatchery origin (i.e., Iron Gate fish hatchery). These data suggest that the Shasta River coho populations are relatively free of hatchery influence and that hatchery coho stray little during adult spawning runs.

Existing regulatory mechanisms, including land management plans (e.g., National Forest Land Management Plans, State Forest Practice Rules), Clean Water Act Section 404 activities, urban growth management, and harvest and hatchery management all contributed to varying degrees to the decline of coho salmon due to lack of protective measures, the inadequacy of existing measures to protect coho salmon and/or its habitat, or the failure to carry out established protective measures. Since the listing of the SONC coho salmon ESU, no new threats have been identified.

In summary, the status of coho salmon populations in this ESU are depressed relative to their past abundance, based on the limited data available. In the 1940s, estimated abundance of coho salmon in this ESU ranged from 50,000 to 125,000 native coho salmon, while in 1996, it was estimated that there were probably less than 6,000 naturally produced coho salmon throughout the range of the ESU (61 FR 56138, October 31, 1996).

Passage Barriers and Requirements

The passage barriers and requirements of fish passage for coho salmon are discussed fully in Section 1.5. In general, coho salmon are precluded from passing upstream of Iron Gate dam in the Klamath River system.