E4.0 FISH RESOURCES

This chapter of the Klamath Hydroelectric Project (Project) (Federal Energy Regulatory Commission [FERC] Project No. 2082) Exhibit E provides a report on the fish resources potentially affected by the Project as stipulated in the *U.S. Code of Federal Regulations*: Title 18 Section 4.51(f)(3).

> The report must discuss fish, wildlife, and botanical resources in the vicinity of the Project and the impact of the Project on those resources. The report must be prepared in consultation with any state agency with responsibility for fish, wildlife, and botanical resources, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service (if the Project may affect anadromous fish resources subject to that agency's jurisdiction), and any other state or federal agency with managerial authority over any part of the Project lands. Consultation must be documented by appending to the report a letter from each agency consulted that indicates the nature, extent, and results of the consultation. The report must include:
>
> (i) A description of the fish, wildlife, and botanical resources of the project and its vicinity, and of downstream areas affected by the project, including identification of any species listed as threatened or endangered by the U.S. Fish and Wildlife Service (See 50 CFR 17.11 and 17.12)
>
> (ii) A description of any measures or facilities recommended by the agencies consulted for the mitigation of impacts on fish, wildlife, and botanical resources, or for the protection or improvement of those resources
>
> (iii) A statement of any existing measures or facilities to be continued or maintained and any measures or facilities proposed by the applicant for the mitigation of impacts on fish, wildlife, and botanical resources, or for the protection or improvement of such resources, including an explanation of why the applicant has rejected any measures or facilities recommended by an agency and described under paragraph (f)(3)(ii) of this section
>
> (iv) A description of any anticipated continuing impact on fish, wildlife, and botanical resources of continued operation of the project, and the incremental impact of proposed new development of project works or changes in project operation, and
>
> (v) The following materials and information regarding the measures and facilities identified under paragraph (f)(3)(iii) of this section:
>
> (A) Functional design drawings of any fish passage and collection facilities, indicating whether the facilities depicted are existing or proposed (these drawings must conform to the specifications of Sec. 4.39 regarding dimensions of full-sized prints, scale, and legibility)
>
> (B) A description of operation and maintenance procedures for any existing or proposed measures or facilities

(C) An implementation or construction schedule for any proposed measures or facilities, showing the intervals following issuance of a license when implementation of the measures or construction of the facilities would be commenced and completed

(D) An estimate of the costs of construction, operation, and maintenance, of any proposed facilities, and of implementation of any proposed measures, including a statement of the sources and extent of financing; and

(E) A map or drawing that conforms to the size, scale, and legibility requirements of Sec. 4.39 showing by the use of shading, cross-hatching, or other symbols the identity and location of any measures or facilities, and indicating whether each measure or facility is existing or proposed (the map or drawings in this exhibit may be consolidated).

A Fish Resources Final Technical Report (FTR) has been prepared to provide the detailed analysis of the fish resources issues. The information in this chapter of Exhibit E provides an overview and summary of the information contained in the Fish Resources FTR, which is incorporated by reference.

E4.1 HISTORICAL FISH RESOURCES IN THE KLAMATH RIVER BASIN

This section describes historical fish resources and results of previous fisheries investigations in the Project study area. It also describes some of the general attributes of the fish assemblages that are present. The discussion begins with a general overview of the Project area and its fish assemblages, then describes the fish resources in the proposed Project river reaches, reservoirs, and major tributaries. The area of focus for this Exhibit does not include the East Side and West Side developments (Link River area) and the Keno Development (Keno reservoir and Keno reach). These developments are not part of the proposed Project.

E4.1.1 Project Study Area

The Project study area contains six river reaches and six reservoirs on the mainstem 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. Table E4.1-1 lists and briefly describes the six river reaches and six reservoirs, proceeding downstream from Upper Klamath Lake/Agency Lake, as well as important tributaries in the study area upstream and downstream of Iron Gate dam.

Upper Klamath Lake/Agency Lake and the Klamath River downstream of Iron Gate dam represent the upper and lower bounds of the Project 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. Historical fisheries descriptions and assessments presented in the following text address the 38.2-mile-long segment of the Klamath River and important tributaries (Spencer, Shovel, and Fall creeks) between the top of the J.C. Boyle reservoir at RM 228.3 and Iron Gate dam at RM 190.1 (the proposed Project area). This segment consists of 23 miles of river reaches and 15.2 miles of reservoirs. It contains four of the five generating facilities associated with PacifiCorp's proposed Project. The fifth generating facility is located on Fall Creek, a tributary entering the Klamath River at RM 196.3. Historical fisheries descriptions also include, as relevant to the Project, the 190-mile-long 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, water quality, and fish passage barriers associated with the Project may have on downstream fisheries and aquatic habitat.

Table E4.1-1. River reaches, reservoirs, and major tributaries proceeding downstream within the Klamath Hydroelectric Project study area.

River Reach (RR), Reservoir (R), or Tributary (T)	Approximate River Mile (RM)	Description and Location
Upper Klamath Lake/Agency Lake (R)	RM 254.3 – 282.3	Approximately 28 miles from upper end of Agency Lake to Link River dam on Upper Klamath Lake
Wood River (T)	RM 282.3	Tributary to Agency Lake at RM 282.3
Williamson River (T)	RM 272.3	Tributary to Upper Klamath Lake at RM 272.3
Link River (RR)	RM 254.3 – 253.1	1.2 miles long, connecting Upper Klamath Lake to Lake Ewauna on Klamath River
Keno Reservoir (Lake Ewauna) (R)	RM 253.1 – 233.0	20.1 miles long from headwaters of Lake Ewauna to Keno dam
Klamath River – Keno Reach (RR)	RM 233.0 – 228.3	4.7 miles long, between Keno dam and headwaters of J.C. Boyle reservoir
J.C. Boyle Reservoir (R)	RM 228.3 – 224.7	3.6 miles from headwaters to J.C. Boyle dam
Spencer Creek (T)	RM 227.6	Tributary to J.C. Boyle reservoir at RM 227.6
Klamath River – J.C. Boyle Bypass Reach (RR)	RM 224.7 – 220.4	4.3 miles long, between J.C. Boyle dam and J.C. Boyle powerhouse
Klamath River – J.C. Boyle Peaking Reach (RR)	RM 220.4 – 203.1	17.3 miles long, between J.C. Boyle powerhouse and Copco No. 1 reservoir
Oregon/California Border	RM 209.3	State line in J.C. Boyle peaking reach at RM 209.3
Shovel Creek (T)	RM 206.5	Tributary to J.C. Boyle peaking reach at RM 206.5
Long Prairie Creek (T)	RM 203.3	Tributary to J.C. Boyle peaking reach at RM 203.3
Copco No. 1 Reservoir (R)	RM 203.1 – 198.6	4.5 miles from headwaters to Copco No. 1 dam and powerhouse
Copco No. 2 Reservoir (R)	RM 198.6 – 198.3	0.3 mile from Copco No. 1 dam and Powerhouse to Copco No. 2 dam
Klamath River – Copco No. 2 Bypass Reach (RR)	RM 198.3 – 196.9	1.4 miles long, between Copco No. 2 dam and Copco No. 2 powerhouse
Iron Gate Reservoir (R)	RM 196.9 – 190.1	6.8 miles from headwaters and Copco No. 2 powerhouse to Iron Gate dam
Fall Creek (T)	RM 196.3	Tributary to Iron Gate reservoir at RM 196.3
Jenny Creek (T)	RM 194.0	Tributary to Iron Gate reservoir at RM 194.0
Klamath River (RR)	RM 190.1 – 0.0	190.1 miles from Iron Gate dam to Klamath River mouth
Shasta River (T)	RM 176.6	Tributary to Klamath River at RM 176.6
Scott River (T)	RM 143.0	Tributary to Klamath River at RM 143.0
Salmon River (T)	RM 66.0	Tributary to Klamath River at RM 66.0
Trinity River (T)	RM 40	Tributary to Klamath River at approximately RM 40

E4.1.2 Overview

Table E4.1-2 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 E4.1-2 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 E4.1-2, together with these species' origin (native or introduced), status (protected or not, game or nongame), 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 E4.1-2. In their classification of fish species' attributes, Zaroban et al. (1999) categorized water temperature preferences as cold, cool, or warm, and the overall pollution tolerance of a fish species as sensitive (S), tolerant (T), or intermediate (I).

As shown in Table E4.1-2, 28 species of fish representing eight taxonomic families are known to occur in the Klamath River and reservoirs upstream of Iron Gate dam. Fourteen of these species are native to the Klamath River drainage and occur primarily in river reaches, while the remaining 14 species have been introduced and occur primarily in Project area reservoirs (PacifiCorp, 2000). Native species listed in Table E4.1-2 that occur upstream of Iron Gate dam include all of the lamprey (three known species), all of the sucker (four species), three species of sculpin, three species of carp and minnow, and one salmonid (redband/rainbow trout[1]). Introduced species listed in Table E4.1-2 that occur upstream of Iron Gate dam include all of the sunfish (seven species), all of the bullhead catfish (three species), two species of carp and minnow, one percid (yellow perch), and one salmonid (brown trout).

Seven 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 trout, Klamath largescale sucker, Klamath lamprey, blue chub, 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 and fathead minnow) are classified as game fish (Oregon Department of Fish and Wildlife [ODFW], 1997). (See Table E4.1-2.)

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[1] 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.

Table E4.1-2. 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, S	Cool	I	R	--
Pacific lamprey	*Lampetra tridentata*	N	N, S	Cool	I	--	A
Sturgeons	**Acipenseridae**						
Green sturgeon	*Acipenser medirostris*	N	S	Cold	S	--	A
White sturgeon	*Acipenser transmontanus*	N	G	Cold	I	--	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, S	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 catfishes	**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	--
Smelts	**Osmeridae**						
Surf smelt	*Hypomesus pretiosus*	N	G	Cold	S	--	O
Delta smelt	*Hypomesus transpacificus*	I	T,S	--	--	--	R

Table E4.1-2. 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]
Longfin smelt	*Spirinchus thaleichtys*	N	G	Cool	I	--	O
Eulachon	*Thaleichthys pacificus*	N	G	Cool	I	--	A
Trouts 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	*Oncorhyncus kisutch*	N	G, T, S	Cold	S	--	R, A
Coastal rainbow trout/steelhead	*Oncorhyncus mykiss*	N	G, S	Cold	S	--	R, A
Redband rainbow trout	*Oncorhyncus mykiss gairdneri*	N	G, S	Cold	S	R	--
Sockeye salmon	*Oncorhyncus 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
Silversides	**Atherinidae**						
Topsmelt	*Atherinops affinis*	N	G	--	--	--	O
Sticklebacks	**Gasterosteidae**						
Threespine stickleback	*Gasterosteus aculeatus*	N	N	Cool	T	--	R
Sculpins	**Cottidae**						
Sharpnose sculpin	*Clinocottus acuticeps*	N	N	--	--	--	O
Coastrange 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
Klamath Lake sculpin	*Cottus princeps*	N	N	Cold	I	R	--
Slender sculpin	*Cottus tenuis*	N	N, S	Cool	I	R	--

Table E4.1-2. 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]
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 = nongame, 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.

All 14 of the native fish species upstream of Iron Gate dam exhibit either a cool (12 species) or cold (2 species) water temperature preference. In addition, except for blue chub and tui chub, which are pollution tolerant, all native fish species exhibit either an intermediate (10 species) or sensitive (two species) pollution tolerance value. 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. (See Table E4.1-2.)

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 a cool water preference, and one species (brown trout) 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. (See Table E4.1-2.)

An estimated 44 fish species representing 16 taxonomic families occur in the Klamath River drainage system downstream of Iron Gate dam. 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. (See Table E4.1-2.)

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 River 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]) . (See Table E4.1-2.)

Three of the 44 species present downstream of Iron Gate dam have federal ESA and state of California ESA (CESA) status and are native. They are: the shortnose sucker, which is listed as endangered (ESA/CESA[2]); the delta smelt, which is listed as endangered (ESA/CESA); and the coho salmon, which is listed as threatened (ESA) and threatened candidate (CESA). Within the Klamath River drainage, this coho salmon evolutionarily significant unit (ESU) consists of naturally spawning populations. Pacific lamprey and green sturgeon are undergoing a status review by National Oceanic and Atmospheric Administration (NOAA) Fisheries to determine whether or not federal listing as an endangered or threatened species is warranted. The remainder of the fish species occurring downstream of Iron Gate dam is approximately evenly divided

[2] The shortnose sucker is also listed on California's Fully Protected Species list.

between game species (primarily salmonid and sunfish) and nongame species (primarily minnow and sculpin). (See Table E4.1-2.)

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 water 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, and kokanee), which prefer cold water and exhibit intermediate or sensitive pollution tolerance values.

E4.1.3 Mainstem Klamath River

Results of previous fisheries investigations in the proposed Project river reaches, identified in Section E4.1.1 and listed in Table E4.1-1, are described in the following text. Results for all Project areas, including Link River and Keno, are available in the Fish Resources Final Technical Report (FTR).

E4.1.3.1 Klamath River—J.C. Boyle Bypass Reach

Description of the Reach

The J.C. Boyle bypass reach of the Klamath River is 4.3 miles long. It extends from the 68-foot-high J.C. Boyle dam at RM 224.7 to the discharge from the 80-megawatt (MW) J.C. Boyle powerhouse at RM 220.4. The dam has a 569-foot-long fish ladder, plus a juvenile fish bypass system at the powerhouse canal intake (PacifiCorp, 2000, 2002). Other operational measures associated with J.C. Boyle dam are described in Section E4.2.2.

This reach of the Klamath River has a relatively steep gradient of about 2 percent. The river channel is narrow (approximately 100 feet 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 by the presence of J.C. Boyle dam (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 bypass reach during summer is quite warm (exceeds 70 degrees Fahrenheit [°F]), highly productive, and often degraded—the same as noted for upstream reservoirs on the Klamath River during summer (ODFW, 1997). Springs within the bypass reach begin entering the river about 0.5 mile downstream of J.C. Boyle dam and contribute an estimated 220–250 cubic feet per second (cfs) of cool (about 48°F), clear groundwater to the river flow (City of Klamath Falls, 1986; PacifiCorp, 2002). 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 320 cfs, and water temperature is about 55°F (ODFW, 1997). ODFW (1997) observed that dual opposing effects of the springs during summer are to cool and make water temperatures more suitable for trout, but to dilute the productivity of water discharged from J.C. Boyle reservoir.

Historical Fisheries Information

The J.C. Boyle bypass reach is within the ODFW Wild Trout Management Area. From 1979 through 1984, annual angler catch rates in the bypass reach averaged 0.62 redband trout 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 trout per hour in the Klamath River between the powerhouse and the Oregon/Washington state line. Trout caught in the bypass reach tend to be smaller than those caught in the upstream Keno reach and the downstream peaking reach (ODFW file data).

Other fish species present in the J.C. Boyle bypass probably include many of the native species listed in Table E4.1-2. In addition, 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).

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 redband trout were dominated by age 0+ to age 2+ fish (City of Klamath Falls, 1990). Slightly smaller fish at ages 1 and 2 were observed in the 0.5-mile upper section of the bypass reach than those observed 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 trout from the J.C. Boyle bypass reach is thought to occur in Spencer Creek, which flows into J.C. Boyle reservoir, and to a limited extent in the mid-section of the bypass reach (City of Klamath Falls, 1986). Some trout have been observed spawning in the bypass reach, but suitable spawning gravel is scarce (City of Klamath Falls, 1986; ODFW, 1997). Peak spawning by redband trout in this area of the Klamath River basin extends from about mid-March to mid-April (Beyer, 1984; Hanel and Gerlach, 1964). Most redband trout that migrate upstream past J.C. Boyle dam to 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 trout, which originated from spawners in Spencer Creek, begin to move downstream through the screen bypass system at J.C. Boyle dam to the bypass reach upstream of the springs (City of Klamath Falls, 1990). Many YOY redband 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 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).

E4.1.3.2 Klamath River—J.C. Boyle Peaking Reach

Description of the Reach

The J.C. Boyle peaking reach of the Klamath River is 17.3 miles 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 of this river reach are in Oregon and have been federally designated as a Wild and Scenic River. The downstream 6.2 miles are in California. Key tributaries to this river reach are Rock Creek at RM 213.9 and Shovel Creek at RM 206.5. Instream flows, ramping rates, and other operational measures associated with the J.C. Boyle peaking reach are described in Section E4.2.2.

The City of Klamath Falls (1986) described substrate and habitat types in the Oregon and California portions of this river reach. 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 heavily armored with boulders and large cobbles and contains a few small pockets of tightly embedded gravel behind boulders. Riparian bank cover in the Oregon portion is generally good, but does reflect 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 behind 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). Some cattle grazing effects also are prevalent in the segment.

Daily river flow fluctuations have affected 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 the 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 the river channel shoreline, thereby limiting aquatic insects and other benthic invertebrate populations to riverbed locations that remain wet during the low-flow period of the daily flow cycle. Still, the river produces 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 and warm water from J.C. Boyle reservoir. When power generation ceases, water entering the peaking reach consists primarily of the cooler and less productive water from the bypass reach.

Historical Fisheries Information

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 Klamath and Klamath-pit brook); sculpins (perhaps marbled, only); and Klamath speckled dace (City of Klamath Falls, 1986). Brown trout, an introduced species, occasionally have been reported by anglers in the Klamath River between the Oregon/California state line and Copco 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 is likely limited to the downstream emigration of juveniles and adults from upstream basin habitat, with no documented rearing or spawning by listed suckers in this reach. Although no direct evidence, such as visual verification of spawning by listed suckers in the peaking reach has occurred, data collected by Beak Consultants (1987) during radiotelemetry studies found movement of Lost River and Klamath smallscale suckers into the first riffle above Copco reservoir. Suckers were identified to be congregating in the lower J.C. Boyle peaking reach during the last 2 weeks of April and subsequently moved back into the reservoir several weeks later. The U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG) performed electrofishing in the same area in 1989 and found suckers to be in spawning condition during the same time period that movement of suckers into the peaking reach occurred during the Beak Consultants studies in 1987 (Beak Consultants, 1993). This suggests that sucker spawning may be occurring in the J.C. Boyle peaking reach, and that the Copco reservoir populations of Lost River and Klamath smallscale suckers may be derived at least partially from these spawning events. The Lost River sucker has a strong preference for lakes.

Information on fish species composition and relative abundance from previous electrofishing studies in three sections of the J.C. Boyle peaking reach in 1984 show that Klamath smallscale sucker was always the most abundant species and redband trout was among the three most abundant species collected throughout the reach (City of Klamath Falls, 1986). The three most abundant species captured in the upper 6 miles of the peaking reach were Klamath smallscale sucker (46 percent of the total), redband trout (24 percent), and tui chub (14 percent). Continuing downstream, approximately 5 miles to near the Oregon/California state line, the three most abundant species collected were Klamath smallscale sucker (40 percent of the total), Klamath speckled dace (31 percent), and redband trout. From approximately the Oregon/California state line to Copco No. 1 reservoir, the three most abundant species collected were Klamath smallscale sucker (41 percent), yellow perch (28 percent, non-native species), and rainbow trout (20 percent). The proximity of Copco reservoir to the most downstream 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 ODFW (ODFW, 1997). The primary fisheries management objective is to sustain populations of wild redband trout. CDFG similarly manages the California portion of the peaking reach. 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, productive 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 since 1974 (City of Klamath Falls, 1986). Adult steelhead were stocked in the Oregon portion of the Klamath River 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 trout (ODFW, 1997).

The redband trout population in this river reach has been described as highly productive and self sustaining (National Park Service, 1994). Population estimates for adult redband trout (longer than 197 millimeters [mm] [7.8 inches]) in August 1984 were 890 fish per mile in the upper 6 miles of this reach and 1,911 fish per mile in the next 5 miles downstream to near the

Oregon/California state line (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 trout population in the J.C. Boyle peaking reach of the Klamath River supports a high quality recreational fishery. Annual angler catch rates in the Oregon portion of the peaking reach from 1979 to 1984 averaged 0.77 redband trout per hour. These catch rates are comparable to or exceed those of other high quality trout streams 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, averaging 0.59 rainbow trout per hour during 1974 to 1977, 1981, and 1982. 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 apparently no or little spawning habitat for trout in the peaking reach (City of Klamath Falls, 1986; Henriksen et al. 2002). Gravel accumulation in this reach is very limited because J.C. Boyle dam blocks gravel recruitment, there are few tributary streams to contribute gravel, and the steep gradient limits accumulation. The lack of redband 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 over 200 millimeter (mm) fork length from the Klamath River downstream of the J.C. Boyle powerhouse were tagged (City of Klamath Falls, 1986). ODFW monitored fish passage at the J.C. Boyle fish ladder in late 1988 and throughout 1989. None of the tagged fish were observed in the fish ladder. Of those fish sampled in the ladder, most (64 percent) were less than 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.

E4.1.3.3 Klamath River—Copco No. 2 Bypass Reach

Description of the Reach

The Copco No. 2 bypass reach of the Klamath River is 1.4 miles long. It extends from the 38-foot-high 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 occasionally pool habitat. The riparian zone is well developed, but has been influenced by the altered flow regime. PacifiCorp currently releases 5 to 10 cfs from Copco No. 2 dam to the bypass reach during summer. There are no mandatory minimum flow or ramping rate requirements for the bypass reach (PacifiCorp, 2000, 2002).

Copco No. 2 dam is located only 0.3 mile downstream of Copco No. 1 dam, being separated by the small 40-acre Copco No. 2 reservoir. There is essentially no river 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 both Copco reservoirs during summer is generally impacted owing to 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 similar to that in the reservoir (PacifiCorp, 2000, 2002). Operational measures associated with Copco No. 1 and Copco No. 2 dams are described in Section E4.2.2.

Historical Fisheries Information

Prior to 2001 no fisheries studies had been conducted in the Copco No. 2 bypass reach. The low base flow (approximately 10 cfs) and proximity to Copco No. 1 and No. 2 reservoirs and upper Iron Gate reservoir likely influence the fish community in this reach. Native species, such as rainbow trout, sculpin, speckled dace, chub, and sucker, probably occur in this short reach. Sunfish, perch, shiner, and minnow originating from the nearby reservoirs also may be present certain times of the year.

E4.1.3.4 Klamath River—Downstream of Iron Gate Dam

Description of the Reach

Iron Gate dam, located at RM 190.1, is the downstream-most hydroelectric facility of the Project and the downstream-most dam on the Klamath River. The Klamath River downstream of Iron Gate dam to the mouth is designated under state and federal Wild and Scenic River Acts. The entrance to the powerhouse penstock is covered with 4-inch 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, 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 rearing areas between Iron Gate dam and Copco dam, PacifiCorp constructed the Iron Gate fish hatchery in 1966, as stipulated in the current Project FERC license (CH2M HILL, 1985; PacifiCorp, 2002). Other operational measures, including instream flow releases and ramping rates associated with the Iron Gate dam, are described in Section E4.3.2.

A recently conducted geomorphic study provided a detailed description of conditions from Iron Gate dam to the mouth of the Klamath River (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 reach where most anadromous fish spawning occurs in the mainstem Klamath River, riverbed substrate contains a wide range of sizes, is relatively loosely packed, and is easily excavated by spawning fish.

Ayres Associates (1999) 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, defined as extending from Iron Gate dam downriver approximately 150 miles to Weitchpec (Klamath River Basin Fisheries Task Force [KRBFTF], 1991), the mainstem Klamath River can be impacted 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 due to the U.S. Bureau of Reclamation (USBR) Klamath Irrigation Project's operation, together with water allocation practices in the Shasta and Scott river basins, have generally resulted in increased winter flows and reduced summer flows in the mainstem Klamath River within the Mid-Klamath subbasin compared with pre-development conditions.

In response to NOAA Fisheries concerns 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 U.S. Forest Service (USFS) Tree of Heaven Campsite in 1998 following a reduction of inflow to, and outflow from, the Iron Gate facility. Stranding occurred in an artificial spawning channel that had been created by CDFG at this site in the late 1970s. The flow reduction that isolated this channel occurred as a result of a natural hydrologic event beyond the flow control of Iron Gate dam.

Historical Fisheries Information

Species composition and several attributes of the fish assemblage in the Klamath River drainage downstream of Iron Gate dam are listed in Table E4.1-2 and described in Section E4.1.2. The following discussion focuses on the status of anadromous populations in this reach of river, especially those species using the Klamath River just downstream of Iron Gate dam 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 are also 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 Fish

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 are presently inaccessible to anadromous species (Hardy and Addley 2001; Fortune et al. 1966). The City of Klamath Falls (1986), citing studies by Fortune et al. (1966), reported that the primary anadromous species historically using the Upper Klamath River basin were Chinook salmon (probably spring-run and fall-run fish) and steelhead (possibly summer-run and winter-run fish) that appeared in the fall and again in the spring. Chinook salmon and steelhead spawning and rearing in the Upper Klamath River basin occurred primarily in the Sprague, Williamson, and Wood rivers and in Spencer Creek (City of Klamath Falls, 1986). Hardy and Addley (2001) added that coho salmon also may have historically occurred in the Upper Klamath River basin, although there are no conclusive records. Pacific lamprey historically were afforded access throughout the Klamath River, extending to Upper Klamath Lake. Upstream migrations by anadromous species into the Upper Klamath basin were blocked by the completion of Copco No. 1 dam in 1918 and Iron Gate dam in 1962.

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 fisheries 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).[3]
- 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, as well as returns to Iron Gate fish hatchery, for steelhead, 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. Hardy and Addley (2001) reported that miles of suitable habitat available to these three species in the Mid-Klamath subbasin total approximately 168 miles for fall- and spring-run Chinook salmon, 250 miles for steelhead, and 190 miles for coho salmon. CH2M HILL (1985) reported that the most important fall-run 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 river reach, and in Bogus Creek downstream of Iron Gate dam. Hardy and Addley (2001) reported that about 50 percent of the fall-run Chinook salmon spawning that occurs in the mainstem Klamath River occurs in this 13.5-mile reach.

[3] In 2001, the California Fish and Game Commission designated coho salmon in the Klamath River as a candidate species under the California Endangered Species Act (CESA). In 2002, the Commission found that coho warranted designation as a threatened species under CESA, but declined to list the species. In November 2003, the California Department of Fish and Game released its Draft Recovery Strategy for the Coho Salmon, including the Klamath River system.

Steelhead

Steelhead runs in the Klamath River basin prior to the 1900s may have exceeded several million fish (Hardy and Addley, 2001). Subsequent steelhead runs in the Klamath and Trinity river systems declined steadily to an estimated 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 (NOAA Fisheries, 1998). Numbers of adult summer steelhead in the Klamath River 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 (NOAA Fisheries, 1998).

As previously noted, NOAA Fisheries 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, 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. USFS biologists also 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 (NOAA Fisheries, 1994).

A production goal of the Iron Gate fish hatchery is to produce and release 200,000 winter-run 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 fish 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 (Section E4.3.2). A total of 532 steelhead returned to Iron Gate fish hatchery in 2001, the largest number since 1989, when a total of 759 fish returned.

Chinook Salmon

Fall-run Chinook numbers have declined drastically over much of the last century, and spring-run Chinook, which were considered to be more abundant than summer/fall-run fish prior to 1900, today consist of only remnant numbers (Hardy and Addley, 2001). The total estimated catch and escapement of all Chinook salmon in the Klamath River between 1915 and 1928 averaged between 300,000 and 400,000 fish annually. Between 1978 and 1995, the average annual escapement of wild and hatchery-produced fall-run 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 River basin Chinook salmon spring run, which utilizes 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 fish 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. Numbers of fall-run Chinook adults returning to Iron Gate fish hatchery have ranged from 365 fish in 1966 (CH2M HILL, 1985) (see Section E4.3.2) to a combined total for 2001 and 2002 of 111,042 Chinook. KRBFTF (1991) reported that fall-run Chinook salmon arrive at Iron Gate fish hatchery from approximately mid-September through mid-November, peaking in abundance about mid-October.

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.

Iron Gate fish 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 fish hatchery have been highly variable, ranging from 2 fish in 1966 during the first year of hatchery operation to 4,097 fish in 1997 (see Section E4.3.2).

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 basin still support coho populations that may be native, while native coho runs are greatly diminished in Lower Klamath River 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, interaction with hatchery fish, overexploitation, and climatic factors (Brown et al. 1994).

Other Species of Importance

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 downstream of Iron Gate dam (PacifiCorp, 2000), and 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.

There also are no quantitative data on populations of green sturgeon in the Mid-Klamath subbasin. CH2M HILL (1985) reported that while green sturgeon have access upriver as far as Iron Gate dam, most adults do not migrate above Ishi Pishi Falls (RM 66.1) during their spawning migrations from the ocean. The National Research Council (2003) reported there is some evidence that populations of green sturgeon are in decline, but that reduced commercial harvest may have alleviated this decline somewhat. NOAA Fisheries rejected a petition in 2003 to have green sturgeon listed as a threatened species under the ESA (National Research Council, 2003).

The federally and state-designated endangered shortnose sucker also is reported to occur in the Klamath River downstream of Iron Gate dam (see Table E4.1-2). 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 Project dams (Henriksen et al. 2002).

Major Tributaries

Major tributaries entering the Klamath River downstream of Iron Gate dam are the Shasta River at RM 176.6, the Scott River at RM 143.0, the Salmon River at RM 66.0, and the Trinity River at approximately RM 40. All of these tributaries enter the Klamath River in what the KRBFTF (1991) defined as the Mid-Klamath subbasin. Anadromous fish production in each tributary subbasin is generally reduced compared to estimated historical levels (CH2M HILL, 1985; KRBFTF, 1991; Hardy and Addley, 2001; National Research Council, 2003).

The National Research Council (2003) reviewed factors in the Klamath River basin that likely are most limiting to anadromous fish species. Emphasis was placed on coho salmon, spring-run Chinook salmon, and summer-run steelhead because of the magnitude of risk these populations currently face. However, all anadromous species would benefit from improved tributary 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 (and actions) 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.

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-run Chinook habitat, 38 miles of coho habitat, and 55 miles of fall-run steelhead habitat in the Shasta River subbasin (Hardy and Addley, 2001). Habitat values for fall-run 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 River subbasin is contingent on flow and water quality, both of which may be inadequate in dry years (National Research Council, 2003).

Numbers of fall-run Chinook spawning 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-run 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-run 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 has been accomplished by coordinating closure of all irrigation diversions on specific days so that river flows increase and flush young Chinook salmon out of the Shasta River before late summer when water quality problems develop that can impact spawning success and fry survival (Klamath Resource Information System, 2003).

Fall-run 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 may not accurately represent population numbers. 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 were approximately 900 adult coho salmon in 1978 and 5,657 adult steelhead in 1940 (Klamath Resource Information System, 2003). Very few coho salmon adults (less than 15 annually) and steelhead adults were 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 CDFG 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 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 most likely principal causes of decline of salmonid production in the Shasta River subbasin are a substantial reduction of flows by water withdrawal and associated poor water quality (National Research Council, 2003). Reduced river flows from May through October of average and dry water years may restrict access by fall-run Chinook salmon to the lower Shasta River (CH2M HILL, 1985). Low river flows also can reduce the suitability of rearing habitat for juvenile coho salmon and steelhead. A major problem for salmonid production in the Shasta River subbasin is high water temperatures, especially from late June through early September (National Research Council, 2003).

Scott River Subbasin

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

Trend data for numbers of adult fall-run Chinook salmon in the Scott River subbasin indicated a general decline from the 1960s to the 1990s, while trends for coho salmon and fall-run steelhead in the Scott River subbasin were likely similar to the overall trends for the rest of the Klamath River basin (Hardy and Addley, 2001). CDFG estimated that in the early 1960s there were approximately 8,000 adult fall-run 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-run 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 River subbasin is reported to be the largest contributor of natural fall-run Chinook spawners of any Klamath River basin tributary (except the Trinity River) or the mainstem Klamath River (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 River subbasin during spawning surveys in December 2001 and January 2002; spawning occurred primarily in December (Maurer and Kilgore, 2002). Only 19 coho salmon were observed during spawning surveys in the Scott River subbasin in December 2002 and January 2003, although field viewing conditions were poorer than in 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 (Chesney and Yokel, 2003).

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 CDFG estimate, reported there are approximately 140 miles of fall-run Chinook salmon spawning and rearing habitat in the Salmon River subbasin.

CH2M HILL (1985) stated that fall-run 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-run 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-run Chinook spawners were present in the Salmon River in 1999 (CDFG fish counts). In 2002, the Klamath River basin Chinook salmon spring run was estimated to be just over 1,000 fish (Andersson, 2003). West (1991) estimated that the 180 adult spring-run Chinook salmon that escaped 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-run 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 through 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-run 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.

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 River subbasin, 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 fish 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 fish hatchery produces spring- and fall-run Chinook salmon, coho salmon, and steelhead (CH2M HILL, 1985).

The Trinity River fish hatchery releases approximately 1 million juvenile spring-run Chinook salmon and roughly 1 to 3 million juvenile fall-run 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-run Chinook salmon each year apparently consists primarily of returning Trinity River fish hatchery fish (National Research Council, 2003). In addition, approximately one-third of the adult Chinook fall run in the Trinity River is reported to consist of returning Trinity River fish hatchery fish (National Research Council, 2003). Total fall-run 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 fish 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 fish hatchery produces about 800,000 winter-run steelhead smolts each year. Steelhead smolts are released in late March and most of them reach the estuary in late April along with wild steelhead smolts (National Research Council, 2003). 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.

Anadromous salmonids historically and currently spawning and rearing in the Lower, Middle, and South Fork Trinity River subbasins include spring- 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 a severe flood in 1964 (CH2M HILL, 1985).

Compared to historical levels, overall anadromous salmonid population in the Trinity River subbasin show generally downward trends (Hardy and Addley, 2001). KRBFTF (1991) reported that current runs of spring-run Chinook salmon in the Trinity River subbasin are supported in large part by the Trinity River fish hatchery, which was founded using ancestral spring-run Chinook salmon stocks. In addition, wild coho stocks have declined approximately 96 percent from historical levels in the Trinity River, and hatchery-produced fish now likely 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-run steelhead, have declined to a few hundred individuals of wild origin.

Factors limiting anadromous fish production in the Trinity River subbasin 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 riparian encroachment into the stream channel and losses of rearing habitat (CH2M HILL, 1985; Hardy and Addley, 2001). 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 comparable to historical levels because of recent habitat improvement projects (Hardy and Addley, 2001).

Mid-Klamath River Subbasin

Anadromous species use the Klamath River basin and subbasins throughout the year. Periods of use are briefly and very generally described below for spring- and fall-run Chinook salmon; coho salmon; spring/summer-, fall-, and winter-run steelhead; green sturgeon; and Pacific lamprey. Table E4.1-3 depicts life stage periodicities for some of these anadromous species plus several other species in the more upstream reaches of the Klamath River basin in the vicinity of the Project area.

Adult spring-run 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; National Research Council, 2003). Spring-run Chinook often hold, spawn, and rear in upstream reaches of tributaries that are inaccessible to fall-run Chinook later in the year because of low flows and high temperatures in downstream tributary reaches (National Research Council, 2003). Adult fall-run 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 age 3 fish, with age 2 and age 4 fish

Table E4.1-3. Estimated fish periodicity on the Klamath River.

Numbers in Table E4.1-3 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 E4.1-3. Estimated fish periodicity on the Klamath River.

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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 river 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.

[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 Iron Gate dam, potentially five lamprey species reside in the Upper Klamath River 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 River basin above Klamath Falls and the Klamath River lamprey distribution is from Upper Klamath River basin down to Copco dam. The Miller Lake lamprey

Table E4.1-3. Estimated fish periodicity on the Klamath River.

Numbers in Table E4.1-3 represent periods of use: 2 = 2-week period; 4 = 4-week period; circled number indicates peak use.

was thought to be endemic to Miller Lake (Upper Klamath River basin) and was extirpated from Miller Lake by ODFW in 1958 and declared extinct in 1973. However, this species was rediscovered in the 1990s and the expanded distribution includes Miller Lake basin, Upper Klamath Marsh, and the Klamath River above the marsh. The other two recognized species in the Upper Klamath River basin include the nonparasitic lamprey (*Lamptera folletti*) and the parasitic species currently called *Lamptera tridentata. L. folletti* was described in 1976 with a distribution in Lost River and the Klamath River 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 landlocked 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 River basin, but its range is reported to be Sacramento River to southeast 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 River basin contains four recognized species of catostomids: Klamath smallscale sucker, Klamath largescale sucker, shortnose sucker, and Lost River sucker. Both the shortnose sucker and the Lost River sucker are federally listed endangered species and this table represents their life history strategies (USFWS, 1993).

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U.S. Fish and Wildlife Service. 1993. Recovery Plan for Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*). Region One, Portland, Oregon.

also present (National Research Council, 2003). Migrating adults hold in pools of the mainstem Klamath River 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-run Chinook salmon were first recorded entering the Shasta River on September 11, peaked on October 1, and 95 percent of the run had entered the river by October 27. From 1993 through 1996, fall-run 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-run Chinook salmon incubate for 50 to 60 days, with young emerging from the gravels from early November to late February and later. In the mainstem Klamath River, young emerge from early February through early April, while in the Shasta River, young fall-run Chinook have been captured as early as mid-January (National Research Council, 2003). Outmigrations of juvenile fall-run 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 River (KRBFTF, 1991; Hardy and Addley, 2001). Type III fall-run Chinook juveniles, which are reported to only rarely occur in the Klamath River 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 river 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-run 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-run Chinook juveniles in the mainstem Klamath River 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. Days at liberty in the estuary between mark and recapture dates 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 age 3 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 River 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- and winter-run individuals, and summer steelhead (stream maturing fish) that include spring- 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 the mainstem Klamath River (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-runs of 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 1 to 3 years, but usually 2 years, then outmigrate toward the ocean 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 River 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 (CH2M HILL, 1985). 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 during 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 in the ocean before entering the Klamath River to spawn (KRBFTF, 1991).

E4.1.4 Klamath River Reservoirs

Results of previous fisheries investigations in the proposed Project reservoirs identified in Section E4.1.1 and listed in Table E4.1-1 are described in the following text. Results for all areas, including Keno reservoir, are available in the Fish Resources FTR.

E4.1.4.1 J.C. Boyle Reservoir

The wide and shallow J.C. Boyle reservoir 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. Similar to upstream conditions, the generally poor water quality is further impaired by periodic algae blooms.

The fish resources in the J.C. Boyle 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 (Desjardins and Markle, 2000). 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 2 years of sampling. It is possible that this reservoir is seeded with juvenile suckers from Upper Klamath Lake. Tui chubs were the most dominant adult native species caught, and redband trout were the fifth most abundant species collected. The most dominant non-native species caught were bullheads, which ranked fourth in overall species abundance. See Section E4.2.1 for a detailed discussion of existing fish resources in the reservoir.

E4.1.4.2 Copco No. 1 and No. 2 Reservoirs

Copco No. 1 reservoir (Copco reservoir) is deeper than the J.C. Boyle reservoir. It is located in a relatively steep canyon and contains several coves with more gradual slopes. The reservoir has large areas of thick aquatic vegetation in shallow areas, and nearshore riparian habitat is generally 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 into Copco No. 2 reservoir; therefore, there is essentially no river habitat downstream from Copco No. 1 dam.

The Copco No. 2 reservoir is approximately one-quarter mile long, with very steep sides. Since access to the site is very limited and most of the water is diverted into the Copco No. 2 powerhouse, no fisheries studies were done in this reach. It is assumed that the fishery and water quality would reflect that of Copco Reservoir.

Copco reservoir contains a diverse fishery, including both warm and cold water species, although warm water fish are the most abundant. Electrofishing by CDFG (unpublished file data) in 1987 through 1989 captured 17 species in Copco Lake, with yellow perch the most common (62 percent) followed by golden shiner (15 percent) and largemouth bass (14 percent). Non-native species comprised 97 percent of the total catch. A recent sucker study using multiple fish capture methods (Desjardins and Markle, 2000) found that more than 60 percent of the fish in the reservoir are non-native species, with bullheads and yellow perch being the most abundant non-native species. Suckers were the most abundant native species. Few trout are caught in the reservoir. Copco No.1 reservoir does, however, appear 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 E4.2.1 for a detailed discussion of existing fish resources in the reservoir.

E4.1.4.3 Iron Gate Reservoir

Iron Gate reservoir is similar to Copco reservoir in that it is in a deep and relatively steep canyon, although there are fewer coves and low-slope shore areas. As with Copco reservoir, Iron Gate experiences water quality impacts 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 Copco reservoir. There are few trout and large numbers of non-native fish, mostly yellow perch and crappie, along with bullheads. Electrofishing by CDFG (unpublished file data) in 1988 found a similar fish community as that in Copco reservoir, with the catch dominated by yellow perch followed by sunfishes (22 percent) and largemouth bass (13 percent). Non-native species comprised 96 percent of the total catch. Non-native fish comprised approximately 77 percent of adult fish captured in the reservoir in 1998 and 1999 (Desjardins and Markle, 2000). Iron Gate reservoir provides a popular fishery for yellow perch and is also the site of largemouth bass fishing tournaments in the summer. See Section E4.2.1 for a detailed discussion of existing fish resources in the reservoir.

E4.1.5 Klamath River Tributaries (within the Project Area)

E4.1.5.1 Spencer Creek

Spencer Creek is a tributary (RM 227.6) to the J.C. Boyle reservoir and plays a role in sustaining redband trout populations below J.C. Boyle dam, although apparently much less so than in the past. ODFW (1997) stated that historically, redband trout rearing in the Klamath River in Oregon spawned in Spencer Creek. Fish ladder counts in 1959 at J.C. Boyle dam, which had been completed 1 year earlier, showed an estimated upstream passage of 5,529 redband trout. Most of the movement occurred in the spring, peaking in April, and again in the fall, mostly September and October. In 1961 and 1962 estimated trout movement through the dam declined to 3,882 and 2,295, respectively (Hanel and Gerlack, 1964). The fish ladder was not monitored again until 26 years later from 1988 through 1991. The actual numbers of trout passing through the ladder each of these 4 years was 507, 588, 412, and 70, respectively. The seasonal pattern of fish movement through the ladder was similar in all years.

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 and peaking reaches. In 1990, 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. The Spencer Creek trap collected 926 adult redband trout from March 4 through May 8. 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, ODFW operated an upstream trap at a weir constructed across Spencer Creek. A total of 1,813 adult redband trout were captured (see Table E4.1-4) (Buchanan et al. 1991). Of these, 67 percent were observed in April. Also in 1991, ODFW operated a downstream migrant trap in Spencer Creek. The trap captured 4,218 fry and 25,618 juveniles (yearlings) (see Figure E4.1-1). Peak downstream movement of fry occurred in August and September. Peak movement of juveniles occurred in May. It is evident from these data that emergent trout fry remain in Spencer Creek for several months and most remain for 1 year prior to 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).

Table E4.1-4. Upstream migrating redband 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

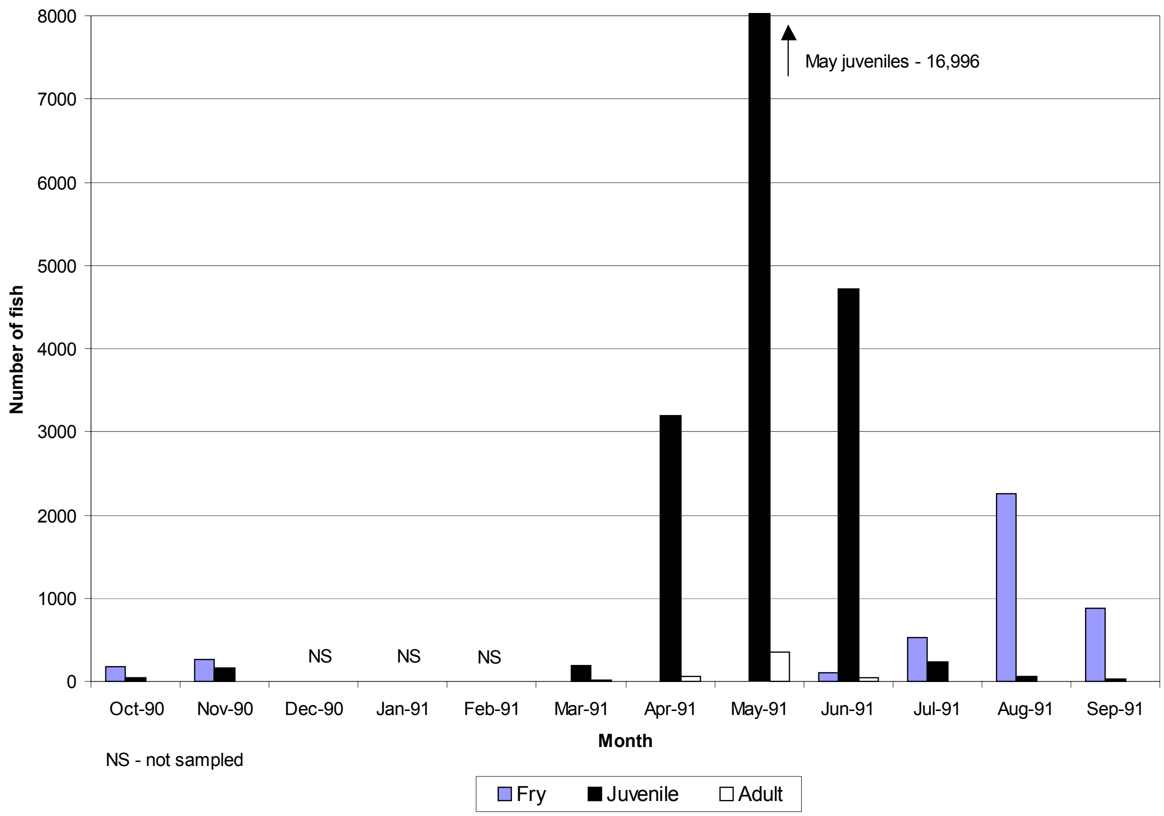


Figure E4.1-1. Downstream movement of redband trout in Spencer Creek (1990-1991).

E4.1.5.2 Shovel Creek

Shovel Creek, located in California, is considered 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 border. J. C. Boyle dam is approximately 18 miles upstream and Copco No. 1 dam approximately 8 miles downstream from the mouth of Shovel Creek.

Shovel Creek is approximately 12.7 miles long (Beyer, 1984). A 5.6-foot-high fall with a 1-foot deep pool at its base provides a fish passage barrier approximately 2 miles upstream from the creek mouth. Creek elevation drops 292 feet in the first mile (5.5 percent gradient) below the falls and an additional 157 feet in the downstream-most mile (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) indicate healthy rainbow trout populations, excellent instream cover for fish (boulders, woody debris), and excellent invertebrate production and aquatic vegetation. CDFG (2000) commented that Shovel Creek appears to support a healthy population of spawning rainbow trout. However, the barrier falls 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 under 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 (m) upstream of the creek mouth. Adult rainbow trout were found to have moved upstream into Shovel Creek to spawn from late March to mid-June, peaking in late April and mid-May (Figure E4.1-2). 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).

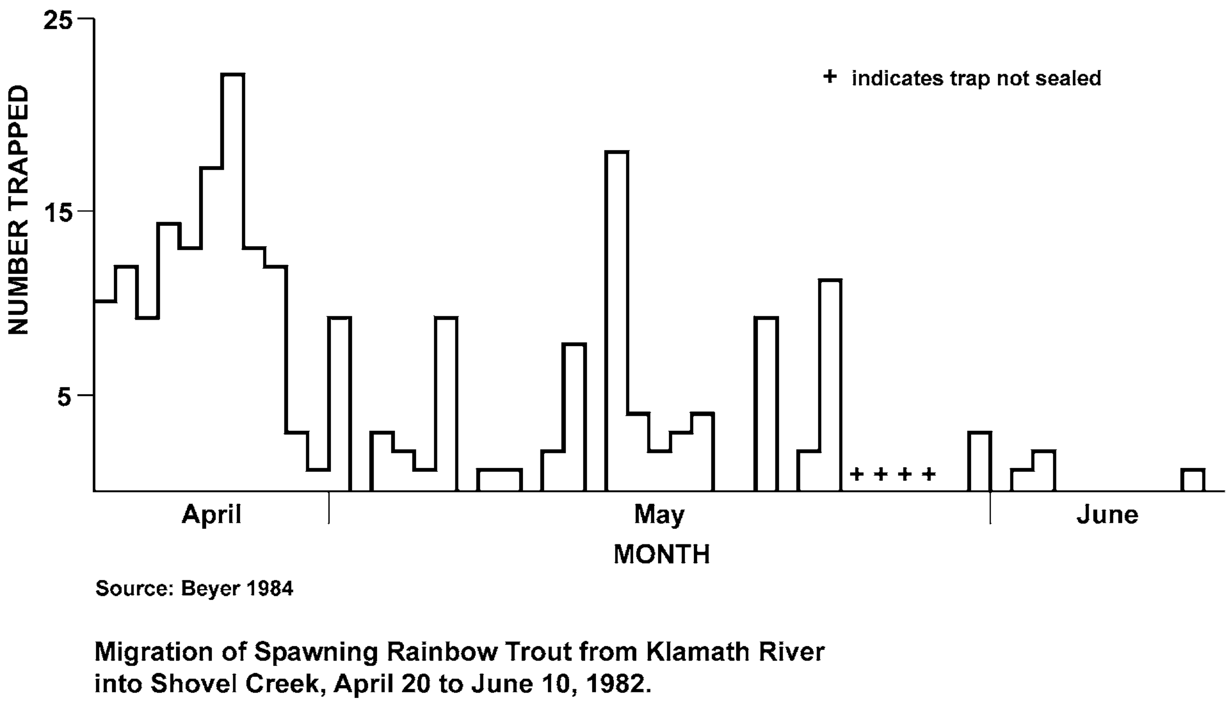
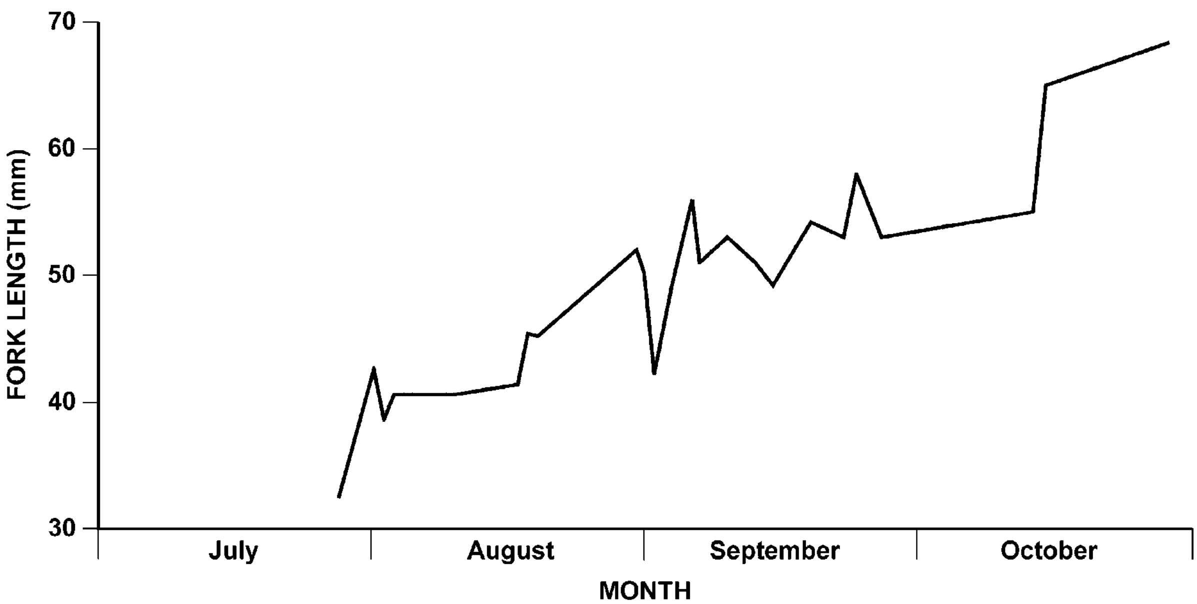


Figure E4.1-2. Migration of spawning rainbow trout from Klamath River into Shovel Creek, April 20 to June 10, 1982. (Beyes, 1984)

Average fork lengths 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 inches (age 4+) (Beyer, 1984). Individual fork lengths of mature migrants varied from 5.5 inches to 22.4 inches. Most of the males captured (78 percent) were age 2+ fish while most of the females captured (88 percent) were age 3+ fish (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 fork lengths at annulus formation of mature migrants in Shovel Creek were 4 inches (age 1), 7.6 inches (age 2), 11.6 inches (age 3), and 14.1 inches (age 4). Back-calculated fork lengths 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 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 its mouth (Beyer 1984). Rainbow trout fry emerged from the gravel over at least a 3-week period until about late June. Fork length at emergence was approximately 0.8 inch. Average fork length 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 (Figure E4.1-3).



Source: Beyer 1984

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

Figure E4.1-3. Average fork length of age 0+ emigrants trapped near mouth of Shovel Creek, California, 1982. (Beyes, 1984)

Movements of age 0+ rainbow trout from Shovel Creek into the Klamath River extended from late July to late October, peaking in late August (Figure E4.1-4). 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.

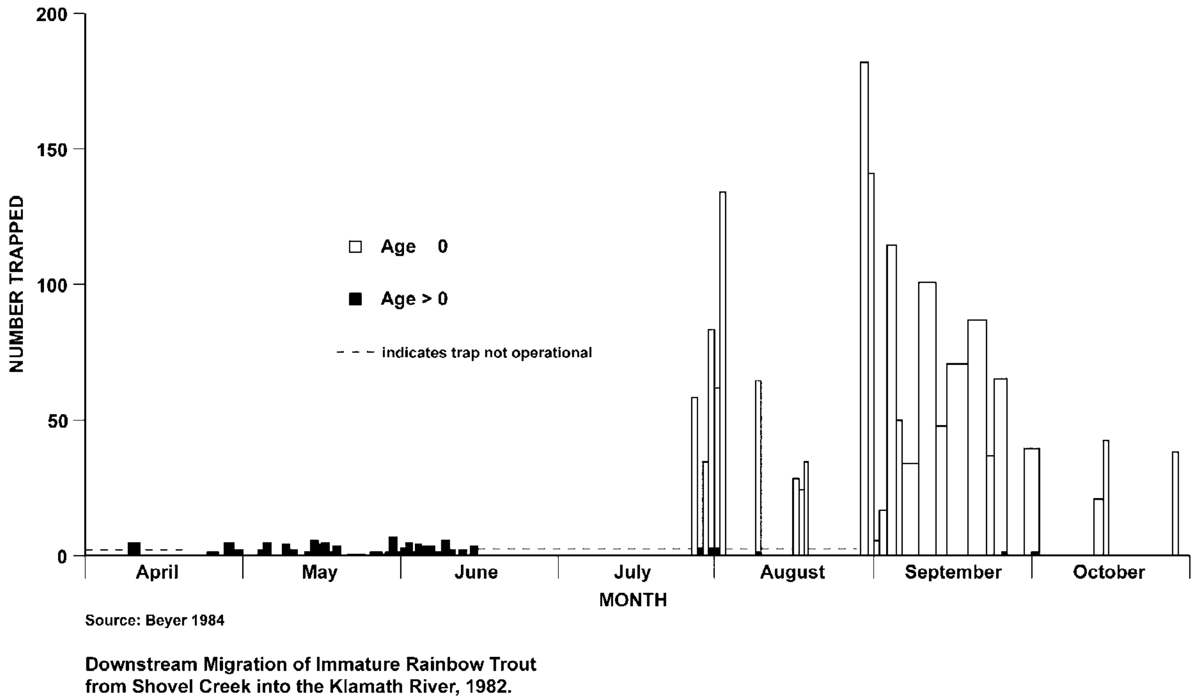


Figure E4.1-4. Downstream migration of immature rainbow trout from Shovel Creek into the Klamath River, 1982.

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.

E4.1.5.3 Fall Creek

Fall Creek is a tributary to the Iron Gate reservoir. It enters at RM 196.3, approximately 0.6 mile 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 (ROR) mode. There have been no investigations on Fall Creek, but it is likely that some of the native, riverine species of fish discussed previously for the Klamath River, including rainbow trout, use portions of Fall Creek. This predominantly spring-fed tributary may provide refugia for rainbow trout from Iron Gate reservoir during summer when water quality conditions decline.

E4.1.5.4 Other Small Tributaries

Unnamed Tributary #1

This very small intermittent tributary, located below the J.C. 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 capture some surface runoff during storm events. Gravel is the dominant 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, suggest 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 Oregon/California 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.

E4.2 EXISTING FISH RESOURCES AND FACTORS AFFECTING FISH RESOURCES

During 2001 and 2002, PacifiCorp conducted a general fisheries assessment of the riverine sections and reservoirs within the Project area. While most of the effort in riverine sections focused on trout and suckers, collections of all other fish species were used to describe the general fish community in each Project reach. The purpose of the assessment was to provide baseline information for describing the existing condition of the fishery that can be used in conjunction with other information to help assess the effects of Project operations on the fisheries resource. Results of the various fisheries studies that were conducted to characterize existing conditions are presented in the following text; for study areas outside the proposed Project see the Fish Resources Final Technical Report.

E4.2.1 Existing Fish Resources

E4.2.1.1 River Fisheries Studies

Fisheries reconnaissance investigations were conducted in the Project area during fall 2001. Full sampling efforts involving river field activities were conducted during spring, summer, and fall 2002. Fish collection was done primarily via electrofishing and hook-and-line sampling, although baited minnow traps were used where site conditions were conducive to that sampling gear. Backpack electrofishing and hook-and-line sampling were used to sample riffle/run/pool habitat in shallow reaches. Boat electrofishing was used to sample accessible areas with deeper riffle/run/pool habitat. To allow relative comparison of fisheries catch data among Project reaches, sampling was standardized according to method, sampling time or effort expended, and area or length of habitat sampled. Field crews followed the electrofishing guidelines established by the NOAA Fisheries (NOAA Fisheries, 2000).

Four general river reaches defined by Project features were sampled: J.C. Boyle bypass reach, J.C. Boyle peaking reach, Copco No. 2 bypass reach, and Fall Creek bypass reach. Within the major reaches, specific sampling segments were identified on the basis of habitat mapping, agency consultation, and observations during the October 2001 reconnaissance effort. These segments primarily represented different channel types defined by geomorphic features and gradient. For the proposed Project, segments in each reach included:

J.C. Boyle bypass reach

Upper – uppermost 1.0 mile (above springs)
Lower – lower 3.0 miles to powerhouse

J.C. Boyle peaking reach

RM 220.4 to RM 217.0 (powerhouse to Old Powerhouse Road bridge)
RM 217.0 to RM 214.3 (Old Powerhouse Road bridge to top of Caldera Rapid)
RM 209.4 to RM 203.5 (Old Hoover Ranch bridge to Copco reservoir)

Copco No.2 bypass reach

Entire 1.0 mile reach

Fall Creek bypass reach

Dam to gradient drop (approximately 3,000 feet)

Also, backpack electrofishing was used at the mouth of Spencer Creek and in other fine-sediment depositional areas along river margins during summer and fall 2002 in attempts to capture lamprey, which may be found in these habitat types. Table E4.2-1 summarizes riverine field sampling effort, techniques, and locations sampled in the proposed Project area. For information on Link River and Keno areas, see the Fish Resources FTR.

Table E4.2-1. Summary of field sampling efforts in Klamath River reaches.

Location	Sampling Effort (days/season)[1]	Techniques	Habitats	State
Keno Reach	4/4	Backpack electrofishing, angling, and other[2]	Riffle, run, pool	Oregon
J.C. Boyle Bypass Reach	4/4	Backpack electrofishing, angling, and other[2]	Riffle, run, pool	Oregon
J.C. Boyle Peaking Reach	4/4	Backpack electrofishing, angling, boat electrofishing, and other[2]	Riffle, run, pool	Oregon/ California
Copco No. 2 Bypass Reach	1/4	Backpack electrofishing and angling	Riffle, run, pool	California
Fall Creek Bypass Reach	1/4	Backpack electrofishing	Riffle, run, pool	California

[1] Samples were collected during fall 2001 and during spring, summer, and fall 2002.
[2] Other includes the use of minnow traps where applicable.

J.C. Boyle Bypass Reach

The J.C. Boyle bypass reach was sampled using backpack electrofishing and angling during fall 2001 and spring, summer, and fall 2002. Minnow traps were set during spring, summer, and fall 2002. Fry distribution and relative abundance studies were also conducted in the J.C. Boyle bypass and peaking reaches in 2003. A technical report was completed that documents the methods and findings of these studies and is included in the Fish Resources FTR as Appendix 3A. A summary of the results are presented in the following J.C. Boyle peaking reach section. Fourteen species were captured during the sampling events; half were native species and half were non-native species (Table E4.2-3). Species with special status that were collected included redband trout, shortnose sucker, and lamprey.

Table E4.2-3. Fish species collected, all methods, all seasons, J.C. Boyle bypass reach.

Fish Species Common Name
Redband trout*
Blue chub*
Tui chub*
Speckled dace*
Sculpin spp. *
Lamprey*
Shortnose sucker*

Table E4.2-3. Fish species collected, all methods, all seasons, J.C. Boyle bypass reach.

Fish Species Common Name
Largemouth bass
Sacramento perch
Bluegill
Pumpkinseed
Crappie spp.
Fathead minnow
Bullhead spp.

*Native species

Backpack Electrofishing

Fifteen species were captured during backpack electrofishing; seven were native species. Special status species that were captured included redband trout, lamprey, and shortnose sucker. Lamprey and shortnose sucker represented only a small portion of the total catch in the bypass reach; shortnose sucker were only captured in small numbers during fall 2001 and lamprey in small numbers during fall 2002. Redband trout were captured during every sampling event and constituted a substantial portion of the catch most seasons (see Tables E4.2-4 and E4.2-5). The results of seasonal sampling and upper versus lower segment sampling in the J.C. Boyle bypass reach are discussed below.

Table E4.2-4. Catch per unit effort (fish per hour) by near-shore backpack electrofishing: J.C. Boyle bypass reach, fall 2001.

Fish Species Common Name	Catch per Unit Effort
Redband trout*	112
Tui chub*	16
Speckled dace*	24
Sculpin (marbled)*	16
Shortnose sucker*	8

*Native species

Table E4.2-5. Catch per unit effort (fish per hour) by near-shore backpack electrofishing for each season, segments combined: J.C. Boyle bypass reach, 2002.

Fish Species Common Name	Spring	Summer	Fall
Redband trout	3.3	23.5	28.9
Blue chub	2.6	1.1	2.8
Tui chub	2.0	4.3	1.7
Speckled dace	-	37.4	17.8
Sculpin (marbled)	19.8	48.1	18.9
Lamprey	-	-	0.6
Largemouth bass	-	-	1.7

Table E4.2-5. Catch per unit effort (fish per hour) by near-shore backpack electrofishing for each season, segments combined: J.C. Boyle bypass reach, 2002.

Fish Species Common Name	Spring	Summer	Fall
Sacramento perch	-	-	0.6
Bluegill	-	-	7.2
Pumpkinseed	4.0	-	5.0
Black crappie	-	-	0.6
White crappie	-	-	0.6
Fathead minnow	-	-	0.6
Bullhead spp.	1.3	3.2	8.3

Seasonal Results

During fall 2001, five native species were captured (see Table E4.2-4). The most frequently caught species was redband trout, followed by speckled dace.

During spring 2002, six species were captured, four of which were native (Table E4.2-5). The most frequently captured species was sculpin, and the least frequently captured species were non-native bullheads.

During summer 2002, six species were captured, five of which were native (see Table E4.2-5). The most frequently captured species were sculpin, speckled dace, and redband trout. The least frequently captured species were non-native bullheads.

The greatest number of species was captured during fall 2002, with a total of 14 species collected, six of which were native (see Table E4.2-5). The most frequently captured species were native redband trout, sculpin, and speckled dace. The least frequently caught species were sunfish, a variety of non-native fish.

The pattern of seasonal catches by backpack electrofishing in the J.C. Boyle bypass reach appears to be fairly consistent. For the most part, native species dominated the catch with redband trout, sculpin, and dace being the most abundant. Summer was the only season during which redband trout were not a substantial part of the catch.

Upper Segment versus Lower Segment

In comparing backpack electrofishing results between the upper and lower reaches, only the 2002 data were considered and the seasonal data were combined for each of the reaches. In the upper segment, 13 species were captured, six of which were native (see Table E4.2-6). In the lower segment eight species were captured, five of which were native.

As with the seasonal analysis, sculpin, dace, and redband trout were among the most frequently caught species overall in both the upper and lower segments. The only noticeable difference was that the upper segment had a lower catch per unit effort (CPUE) for redband trout and a higher CPUE for speckled dace. In addition, the upper segment had many more non-native species, although in low numbers. This is most likely a result of fish moving out of J.C. Boyle reservoir. All of these species (sunfish), except for bullheads, are considered lake or reservoir fish and it is very unlikely that there are resident populations of these species in the upper segment of the

J.C. Boyle bypass reach. Water in the upper portion of the bypass reach comes from the fish ladder and fish bypass discharge, along with a small amount of spillage over the dam. These avenues would be the source of these non-native fish.

Angling

Angling was conducted in the J.C. Boyle bypass reach during fall 2001 and spring, summer, and fall 2002. Two species, redband trout and blue chub, were collected during the sampling events. Overall, a total of 262 redband trout were caught in the bypass reach, some during every sampling event. However, only two blue chub were captured, one each during spring and summer 2002.

Table E4.2-6. Catch per unit effort (fish per hour) by near-shore backpack electrofishing: J.C. Boyle bypass reach, 2002.

Fish Species Common Name	All Seasons/ Segments Combined	Upper Segment				Lower Segment			
		All Seasons	Spring	Summer	Fall	All Seasons	Spring	Summer	Fall
Redband trout	18.6	12.2	4.6	16.9	12.1	22.6	3.1	27.6	53.5
Blue chub	2.4	4.9	9.2	2.8	4.7	0.8	1.5	-	-
Tui chub	-	5.5	9.2	11.3	2.8	0.4	0.8	-	-
Speckled dace	15.8	38.3		90.1	28.9	1.5		5.2	1.4
Sculpin (marbled)	25.6	17.0	4.6	36.6	13.1	31.1	22.3	55.2	27.5
Lamprey	0.2	0.6			0.9		-	-	-
Largemouth bass	0.7	1.2	-	-	1.9	0.4	-	-	1.4
Sacramento perch	0.2	0.6	-	-	0.9	-	-	-	-
Bluegill	3.1	7.9	-	-	12.1	-	-	-	-
Pumpkinseed	3.5	7.9	27.6	-	6.5	0.8	-	-	2.7
Black crappie	0.2	0.6	-	-	0.9	-	-	-	-
White crappie	0.2	0.6	-	-	0.9	-	-	-	-
Fathead minnow	0.2	-	-	-	-	0.8	-	-	1.4
Bullhead spp.	4.7	12.2	9.2	8.4	14.0	-	-	-	-

During fall 2001, 14 redband trout were captured in the bypass reach. They ranged in length from 143 mm to 222 mm and averaged 179 mm. During spring 2002, 32 trout were captured, ranging in length from 127 mm to 300 mm and averaging 191 mm. During summer 2002, a total of 34 trout were captured, ranging in length from 130 mm to 315 mm and averaging 190 mm. The greatest number of trout was captured during fall 2002 (182 trout); the fish ranged in length from 144 mm to 301 mm and averaging 182 mm.

Minnow Traps

Minnow traps were set in the J.C. Boyle bypass reach during spring, summer, and fall 2002. Sculpin was the only species captured (other than a few unidentified species). Only seven sculpins were captured throughout the minnow trap sampling (four in the spring, one in the summer, and two in the fall).

Fry Distribution and Relative Abundance

Fry distribution and relative abundance studies were conducted in the J.C. Boyle bypass and peaking reaches in 2003. The discussion of fry for both these reaches is presented in the J.C. Boyle peaking reach discussion below.

J.C. Boyle Peaking Reach

The J.C. Boyle peaking reach was sampled using backpack electrofishing and angling during fall 2001 and spring, summer, and fall 2002. Boat electrofishing was conducted during fall 2002. Minnow traps and snorkeling were used to gather additional information during summer and fall 2002. Fry distribution and relative abundance studies were also conducted in the peaking reach (and bypass) in 2003. A technical report was completed that documents the methods and findings of these studies and is included in the Fish Resources FTR as Appendix 3C. A summary of the results for both the peaking and bypass reaches are presented in the following section. Nine species were captured from all sampling events, and all were native species (Table E4.2-7).

Table E4.2-7. Fish species collected, all methods, all seasons: J.C. Boyle peaking reach.

Fish Species Common Name
Redband/rainbow trout[1]
Blue chub[1]
Tui chub[1]
Chub spp. [1]
Speckled dace[1]
Sculpin spp. [1]
Lamprey[1]
Shortnose sucker[1]
Klamath sucker spp.[2]
Unknown sucker spp. [1]
Unknown species

[1] Native species
[2] Klamath largescale and/or smallscale sucker

Backpack Electrofishing

Five species, all native, were captured during the combined backpack electrofishing efforts in the peaking reach. Special status species captured included redband/rainbow trout and shortnose sucker. Shortnose sucker were only captured during fall 2001 (see Tables E4.2-8 and E4.2-9). The results of seasonal sampling and upper versus lower segment sampling in the J.C. Boyle peaking reach are discussed below.

Table E4.2-8. Catch per unit effort (fish per hour) by near-shore backpack electrofishing: J.C. Boyle peaking reach, fall 2001.

Fish Species Common Name	Catch per Unit Effort
Redband/rainbow trout*	112
Tui chub*	16
Sculpin (marbled)*	16
Shortnose sucker*	8

*Native species

Table E4.2-9. Catch per unit effort (fish per hour) by near-shore backpack electrofishing for each season, segments combined: J.C. Boyle peaking reach, 2002.

Fish Species Common Name	Spring*	Summer	Fall
Redband/rainbow trout	-	63.2	2.9
Blue chub	10.3	-	-
Tui chub	24.1	-	-
Speckled dace	68.8	497.7	261.4
Sculpin (marbled)	31.0	144.8	116.2
Unknown sucker spp.	-	-	59.5

*California segment of peaking reach not sampled.

Seasonal Results

During fall 2001 sampling, five species were captured (see Table E4.2-8). The most frequently caught species was trout, followed by sculpin, tui chub, and shortnose sucker.

During spring 2002, four species were captured, with speckled dace and sculpin being the most frequently caught (see Table E4.2-9). Spring was the only season during which redband/rainbow trout were not caught in the J.C. Boyle peaking reach.

During summer 2002, three species were captured (see Table E4.2-9). The most frequently caught species by far was sculpin, followed by speckled dace and redband/rainbow trout.

During fall 2002, four species were caught, with speckled dace and sculpin being the most frequently captured (see Table E4.2-9).

The pattern of seasonal catches by backpack electrofishing in the J.C. Boyle peaking reach appears to be fairly consistent. Only native species were present in the catch and, other than during fall 2001, speckled dace and sculpin dominated the catch.

Oregon Segment versus California Segment

In comparing backpack electrofishing results between the Oregon (upper) and California (lower) reaches, only the 2002 data were considered and the seasonal data were combined for each of the reaches. In the Oregon segment, five species were captured; in the California segment, only three species were captured (Table E4.2-10).

As with the seasonal data, sculpin and speckled dace were generally the most frequently captured species in both segments. The only noticeable difference was that the CPUE for redband/rainbow trout was considerably higher in the California segment than the Oregon segment and redband/rainbow trout were captured in all seasons sampled (the California segment was not sampled during spring 2002). In addition, redband/rainbow trout were only captured in the Oregon segment during fall 2002. Another interesting note is that none of the non-native species that were captured in the upstream J.C. Boyle bypass reach were captured in either segment of the J.C. Boyle peaking reach during backpack electrofishing.

Table E4.2-10. Catch per unit effort (fish per hour) by near-shore backpack electrofishing: J. C. Boyle peaking reach, 2002.

Fish Species Common Name	All Seasons/ Segments Combined	Oregon Segment				California Segment			
		All Seasons	Spring	Summer	Fall	All Seasons	Spring	Summer	Fall
Redband/rainbow trout	19.1	1.0	-	-	1.9	71.9	Not sampled	126.9	6.3
Blue chub	4.4	5.9	10.3	-	-	-		-	-
Tui chub	5.2	6.9	24.1	-	-	-		-	-
Speckled dace	286.3	193.8	68.8	314.9	218.8	555.4		681.9	404.2
Sculpin (marbled)	106.0	126.6	31.0	204.7	150.9	46.0		84.6	-
Unknown sucker spp.	30.2	40.5	-	-	77.3	-		-	-

<u>Boat Electrofishing</u>

Boat electrofishing was conducted in the J.C. Boyle peaking reach during fall 2002 (see Table E4.2-11). Five species were captured: redband trout, speckled dace, sculpin spp., and Klamath largescale and smallscale suckers. A few unidentified species also were captured that were presumably chub and/or minnow species. Suckers and trout were the most frequently captured fish, comprising more than 75 percent of the total catch. For analysis purposes, the data were divided into an Oregon reach and a California reach. The catch rates for suckers and trout were higher in the California portion of the peaking reach, but more species were caught in the Oregon portion. This was similar to results from backpack electrofishing efforts.

Table E4.2-11. Comparison of total catch and catch per unit effort during drift-boat electrofishing in Oregon and California segments: J. C. Boyle peaking reach, fall 2002.

Fish Species Common Name	Oregon Reach		California Reach		Combined Reaches	
	Catch	Catch per Unit Effort	Catch	Catch per Unit Effort	Total Catch	Total Catch per Unit Effort
Redband/rainbow trout	8	25.3	20	27.9	28	26
Speckled dace	7	22.1	2	2.8	9	9
Sculpin (marbled)	1	3.16	--	--	1	3
Lamprey	1	3.16	--	--	1	3
Klamath sucker spp.[1]	3	9.5	43	60	46	45
Unknown species [2]	4	12.6	1	1.4	5	5

[1] Klamath largescale and/or smallscale sucker
[2] Most likely fathead minnows and/or chubs

Angling

Angling was conducted in the peaking reach during fall 2001 and spring, summer, and fall 2002. The only species captured was redband/rainbow trout. Overall, 187 trout were captured in the J.C. Boyle peaking reach.

During fall 2001, 29 trout were captured, ranging in length between 156 mm and 412 mm and averaging 270 mm. During spring 2002, 48 trout were captured, ranging in length between 145 mm to 393 mm and averaging 242 mm. During summer 2002, 32 trout were captured, ranging in length between 180 mm and 407 mm and averaging 270 mm. During fall 2002, 78 trout were captured, ranging in length between 136 mm and 381 mm and averaging 249 mm.

Minnow Traps

Minnow traps were set during summer and fall 2002 in the J.C. Boyle peaking reach. No fish were caught in the summer, and only four speckled dace were caught in the fall.

Snorkeling

Snorkeling was conducted in the Oregon and California segments of the J.C. Boyle peaking reach during summer and fall 2002. A total of 165 fish were observed during the summer; only four fish were observed in the fall. During the summer, most fish observed were redband/rainbow trout (45), followed by sculpin (56), and sucker (37). Two speckled dace also were observed along with 25 unidentified fish. During fall, one redband/rainbow trout, one sculpin, and two other unidentified fish were observed.

Fry Distribution and Relative Abundance

Past studies have documented trout spawning and fry rearing in the Project area tributaries, particularly Shovel Creek (Beyer, 1984) and Spencer Creek (various ODFW reports). Most trout fry tend to remain in these tributaries through the summer, and through the winter in Spencer Creek, before migrating to the Klamath River. PacifiCorp's relicensing studies (e.g., trout movement) observed spawning in the J.C. Boyle bypass reach. Trout spawning has not been documented in the J.C. Boyle peaking reach. Sampling efforts in the peaking reach in 2001 and 2002 yielded few fry observations.

To further assess fry in the J.C. Boyle bypass and peaking reaches, a fry distribution and relative abundance study was conducted from May through August 2003 (depending on the location). The purposes of these studies were to:

- Assess the relative distribution and abundance of trout fry (< 5 centimeters [cm])
- Compare index densities of trout fry among different stream margin edge types (SMETs)
- Compare index densities of fry along specific margin areas immediately before, during, and after a peaking event

The following is a summary of the results of the trout fry study. The complete technical report for the fry distribution and abundance study is presented in the Fish Resources FTR, Appendix 3C.

Electrofishing was conducted along stream margins of the Upper Klamath River Project area at 26 locations: six in the J.C. Boyle bypass reach and 10 each in the Oregon peaking and California peaking reaches.

All margin units in the J.C. Boyle bypass reach and Oregon peaking reach were sampled six times at bi-weekly intervals from late May to mid-August 2003. The California peaking units were sampled bi-weekly in July with a fourth sample collected in early September. Single-pass electrofishing was conducted using backpack electroshockers and a crew of two to four biologists. Lengths and weights were recorded for all captured trout fry, other species were enumerated. Trout fry in the bypass reach were fin-clipped to determine patterns of residency or movement among index locations. Some fry in the California peaking reach were also fin-clipped immediately prior to a peaking flow event, then the margin units were resampled after the flow increase to determine short-term residency. Multiple-pass electrofishing was also conducted within a subset of the single-pass margin units. Multiple-pass data were used to generate estimates of abundance using removal-depletion estimators, which were then compared to index estimates based on the first (i.e., single) pass data alone.

A total of 1,212 fry were captured by single-pass electrofishing at 26 index locations, representing 61 individual margin units. Fry were common along margins in the bypass reach downstream of the spillway, where index densities were 1 to 3 fry/100 ft^2. In the Oregon peaking reach, fry were captured in low numbers (0.1 to 0.3 fry/100 ft^2) in the upper five index locations closest to the bypass reach, but fry were rarely observed in the downstream sites near Frain Ranch. In the California peaking reach, fry were common at most index locations below Shovel Creek (0.2 to 1 fry/100 ft^2), but were not observed at sites above the spawning tributary.

The observed differences in fry densities among the 26 index locations appeared to be strongly influenced by proximity to known spawning locations. Highest densities occurred downstream of known spawning areas in the J.C. Boyle bypass reach and in the California peaking reach, whereas index locations upstream or well downstream of recruitment sources had the lowest fry densities. Aside from the effect of distance to spawning area, considerable variation in fry densities remained even among closely spaced index locations. Differences in margin habitat characteristics could help explain such variability in fry densities.

Correlation analysis was used to select an initial set of predictor variables for input into a stepwise regression procedure. The response variable was log-transformed expanded fry densities (see below for an explanation of expanded densities), with the four selected predictor variables (in order of inclusion with regression coefficient): average velocity (0.6038), log distance to upstream spawning area (-0.8607), maximum depth (-0.2765), and dominant substrate type (0.0556). Overall, the regression model was highly significant ($P<0.001$) and explained 76 percent of the observed variation in fry densities among the included margin units.

Temporal variation in fry index densities was evaluated by comparing densities per location over time, and by calculating an average density among index locations by reach for each sampling period. The mean fry density by sampling period showed a minor decrease through the summer in all three reaches. Length-frequency data from captured fry showed a prominent recruitment of very small fry in late July in each reach. Trout spawning observations in the J.C. Boyle bypass reach revealed a protracted spawning period of over 2 months in duration with at least two peaks in activity. Although an extended spawning period is not known to occur in Shovel Creek, fry do emigrate from the spawning tributary into the mainstem throughout the late summer months. The minor decrease in fry index densities despite growth of fry into the next size class ("juveniles" at 50+ mm) may be attributable to the continued recruitment of small fry into the peaking reaches throughout the summer.

Fry densities were compared between paired margin units either with or without vegetative instream cover in the Oregon and California peaking reaches (the J.C. Boyle bypass reach only contained vegetated margin units). Fry index densities calculated from single-pass electrofishing suggested that fry were more common along vegetated margins in Oregon, but were more common along non-vegetated units in California. Comparative expanded densities in the California peaking reach were nearly equal in vegetated and non-vegetated units, but when the peaking reaches were combined the overall expanded densities in vegetated units was 1.5 times greater than densities in non-vegetated units ($P=0.07$, Wilcoxon's signed rank test).

Most of the trout fry captured in the bypass reach and some fry captured in the California peaking reach were fin-clipped according to index location. Of approximately 400 fin-clipped fry, 23 were recaptured in the same location and one was recaptured in a downstream location. In the J.C. Boyle bypass reach, seven clipped fry were recaptured immediately after flows increased from 325 to 520 cfs, 2 days after marking. Eight other recaptures were made in the bypass reach following an interval of at least 2 weeks. In the California peaking reach, 73 fry were marked during low flow (320 cfs) and nine were recaptured in the same locations either later the same day or on the following day after flows were peaked to over 1,500 cfs.

<u>Copco No.2 Bypass Reach</u>

Fish sampling in the Copco No. 2 bypass reach consisted of backpack electrofishing during fall 2001 and spring, summer, and fall 2002. Angling was also conducted in the reach during spring and fall 2002. Collectively, sampling captured eight different fish species, five of which were native (see Table E4.2-12). The only special status species captured was rainbow trout.

Table E4.2-12. Fish species collected, all methods all seasons: Copco No. 2 bypass reach, 2001-2002.

Fish Species Common Name
Rainbow trout*
Blue chub*
Tui chub*
Speckled dace*
Sculpin spp.*
Largemouth bass
Crappie spp.
Yellow perch

*Native species

Backpack Electrofishing

During fall 2001, only three species were captured (tui chub, speckled dace, and sculpin spp.) by backpack electrofishing (see Table E4.2-13). Of these, speckled dace and sculpin were the most abundant. During spring 2002, again only three species were captured (sculpin spp., speckled dace, and yellow perch). Speckled dace was the most abundant species collected. In the summer, five species were caught, which included those captured in the spring plus rainbow trout and blue chub. Speckled dace and sculpin again were the most abundant species collected. During fall 2002, five species also were captured and consisted of speckled dace, sculpin, rainbow trout, black crappie, and largemouth base, in order of relative abundance.

Table E4.2-13. Catch per unit effort (fish per hour) by backpack electrofishing: Copco No. 2 bypass reach, 2001-2002.

Fish Species Common Name	Fall 2001	Spring 2002	Summer 2002	Fall 2002
Rainbow trout	---	---	8.9	21.1
Blue chub		---	3.0	---
Tui chub	95.4	---	---	---
Speckled dace	254.3	447.4	608.9	473.0
Sculpin (marbled)	278.1	109.2	404.9	165.7
Largemouth bass	---	---	---	6.0
Black crappie	---	---	---	15.1
Yellow perch	---	20.8	5.9	---

The predominant species in all seasons in the Copco No. 2 bypass reach are speckled dace and sculpin. Game fish (trout and bass) appear to occur in the reach only sporadically. Based on the sampling results, game fish most likely enter the bypass reach from the downstream reservoir (and possibly, but highly unlikely, from the upstream reservoir). Based on sampling results, it appears that trout would primarily move into this reach in the fall, which is when water conditions would be more favorable.

Angling

Angling yielded few fish in the Copco No. 2 bypass reach. Only three fish were captured during spring 2002, one each of largemouth bass, yellow perch, and speckled dace. During fall 2002, three rainbow trout were captured.

Fall Creek

Backpack electrofishing and angling (fly fishing) were the only methods used to sample fish in the bypass reach of Fall Creek. Electrofishing was conducted during fall 2001 and spring, summer, and fall 2002. Angling was conducted only during summer 2002. The only species captured using both methods was rainbow trout. A total of 74 trout were captured by electrofishing for all seasons combined, and eight trout were captured by angling during summer.

The calculated backpack electrofishing CPUE values were highest during fall 2001 and lowest during fall 2002 (see Table E4.2-14). Based on these results, there does not appear to be any seasonal trend regarding the relative abundance of rainbow trout in the bypass reach of Fall Creek. However, sampling results seem to indicate that rainbow trout are the only fish species of any consequence in the bypass reach, as other species were commonly caught by electrofishing in other studied river reaches in the Project area.

Table E4.2-14. Backpack electrofishing results: Fall Creek, 2001-2002.

Season	Date	Electrofishing time (hrs)	No. Redband Trout Caught	Catch per Unit Effort
Fall 2001	17-Oct	0.13	12	90
Spring 2002	24-Jun	0.25	16	64
Summer 2002	16-Aug	0.46	24	52
Fall 2002	24-Oct	0.53	22	42

In addition to the above efforts, limited sampling was conducted in Fall Creek upstream of the diversion structure (during fall 2001) and in the diversion canal (during fall 2002) by backpack electrofishing. Again, the only species captured was rainbow trout. Upstream of the diversion, a total of seven trout were caught with a calculated CPUE of about 42 fish per hour. In the canal, 66 trout were caught with a calculated CPUE of about 141 fish per hour. It should be noted, that while the CPUE in the canal appears much greater than that in the bypass reach, as well as upstream of the diversion, it may simply be a function of the canal being easier to sample. There is little structure in the canal, except for a few boulders, that fish could use to actively or passively avoid capture. In addition, the canal is very narrow with little riparian vegetation, which allowed easy sampling access (i.e., line-of-sight and netting).

E4.2.1.2 Reservoir Fisheries Studies

Descriptions of reservoir fish communities are based on the use of six different gear types (trammel, trap, dip, and larval drift nets; beach seine; and larval trawl) to sample larval, juvenile, and adult fishes in J. C. Boyle, Copco, and Iron Gate reservoirs in 1998 and 1999. Keno reservoir investigations were conducted as part of PacifiCorp's Project relicensing studies, and results are presented in the Fish Resources FTR. Recent investigations in J. C. Boyle, Copco, and Iron Gate reservoirs by Oregon State University and PacifiCorp (Desjardins and Markle, 2000), which focused on the endangered shortnose and Lost River suckers and targeted a full range of fish sizes, also provide information on the overall fish community in each of these reservoirs. Table E4.2-15 lists sampling gears and targeted life stages in J.C. Boyle, Copco, and Iron Gate reservoirs. Results of these fisheries studies are discussed in the following text. In 2003, PacifiCorp also sampled the deep areas of Copco and Iron Gate reservoirs to better characterize the open water fish community and assess vertical distribution of fish relative to stratification and water quality conditions. Results of this particular study are presented in a separate report included in the Fish Resources FTR as Appendix 3F.

Table E4.2-15. Sampling gear and targeted life stages: J.C. Boyle, Copco, and Iron Gate reservoirs, 1998 and 1999.

Gear Type	Dimensions	Sampling Depth	Sampling Time	Targeted Life Stage
Trammel Net	300 feet long	To 20 feet	Night	Adult
Trap Net	3-foot x 15-foot opening; 25-foot lead	3 to 20 feet	Day, mostly night	Adult and juvenile
Beach Seine	20 feet	To 6 feet	Day	Juvenile
Larval Trawl	2-foot x 4-foot opening; 8-foot length	1.5 to 5 feet	Day, mostly night	Larval and juvenile
Dip Net		Shallow	Day	Larval and juvenile
Larval Drift Net	1.5-foot diameter	Surface	Night	Larval and juvenile

J.C. Boyle Reservoir

Table E4.2-16 summarizes catch data by gear type in J. C. Boyle reservoir during 1998 and 1999. Information is presented on the number of each species collected each year by gear type and gear types combined, together with the corresponding level of sampling effort. Scientific names of fish listed in Table E4.2-16 are provided in Table E4.1-2. The eight taxonomic categories of multiple species listed in Table E4.2-16 (for example, lamprey spp., chub spp., and sucker spp.) reflect taxonomic difficulties in distinguishing species differences among small specimens.

More than 7,000 fish representing 23 taxonomic categories were collected in J. C. Boyle reservoir (Desjardins and Markle, 2000) (see Table E4.2-16). Approximately 3,000 fish representing 20 taxa and approximately 4,000 fish representing 20 taxa were collected in 1998 and 1999, respectively. The six most abundant taxa collected overall in 1998 were chub spp. (666 individuals), pumpkinseed (421), sunfish spp. (402), tui chub (266), bullhead spp. (263), and fathead minnow (238). These six taxa collectively accounted for 75 percent of the total catch in 1998. Four of these taxa also were among the six most abundant taxa collected in the reservoir in 1999, which included chub spp. (1,105 individuals), fathead minnow (682), bullhead spp. (508), Klamath speckled dace (500), sucker spp. (282), and tui chub (240). These six taxa together made up 82 percent of the total catch in J. C. Boyle reservoir in 1999 (see Table E4.2-16).

Table E4.2-16. Number of fish collected in J.C. Boyle reservoir by gear type during 1998 and 1999.

*Targeted life stage in parentheses after gear type (A = adult, J = juvenile, L = larvae)**

Species	Trammel Net (A)		Trap Net (A, J)		Beach Seine (J)		Larval Trawl (J, L)		Dip Net (J, L)		Larval Drift Net (J, L)		Total	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Lamprey spp.	2	0	4	3	0	0	0	0	0	0	0	1	6	4
Tui chub	123	166	133	70	10	2	0	2	0	0	0	0	266	240
Blue chub	39	30	25	87	8	5	2	0	0	0	0	0	74	122
Chub spp.	0	0	0	402	13	633	618	34	35	36	0	0	666	1,105
Golden shiner	0	0	0	0	0	1	0	1	0	3	0	0	0	5
Fathead minnow	0	0	5	280	65	190	168	14	0	198	0	0	238	682
Klamath speckled dace	0	0	0	61	8	62	11	28	0	349	0	0	19	500
Klamath smallscale sucker	62	97	2	26	0	0	0	0	0	0	0	0	64	123
Klamath largescale sucker	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Shortnose sucker	5	13	0	31	0	0	0	0	0	0	0	0	5	44
Lost River sucker	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Sucker spp.	4	2	0	8	75	105	49	34	0	126	5	7	133	282
Bullhead spp.	167	207	88	290	7	11	1	0	0	0	0	0	263	508
Redband trout	33	24	1	3	0	0	0	0	0	0	2	1	36	28
Sculpin spp.	0	0	0	0	0	25	0	7	0	0	0	0	0	32
Sacramento perch	8	4	178	31	0	0	0	0	0	0	0	0	186	35
Pumpkinseed	1	1	415	59	5	89	0	2	0	0	0	0	421	151
Bluegill	0	0	0	0	2	0	0	0	0	0	0	0	2	0
Largemouth bass	9	4	0	0	17	65	0	0	0	0	0	0	26	69
Sunfish spp.	0	0	14	0	242	0	127	0	19	0	0	0	402	0
Crappie spp.	34	6	128	27	2	1	0	0	0	0	0	0	164	34
Yellow perch	35	4	0	5	0	1	1	1	0	0	0	0	36	11
Unidentified spp.	0	0	0	0	0	0	0	27	0	32	3	11	3	70
Total Individuals	523	560	993	1,383	454	1,190	977	150	54	744	10	20	3,011	4,047
Total Taxa	14	13	11	15	12	13	8	10	2	5	3	4	20	20
Sampling Effort														
Sets/Pulls	16	8	10	13	17	18	19	17	7	10	7	16		
Hours	173	119	118	197	—	—	—	—	—	—	25	79		

*Catch data from Desjardins and Markle (2000)

Six different gear types targeting a range of fish life stages and sizes were used by Oregon State University to sample J. C. Boyle reservoir during 1998 and 1999 (Desjardins and Markle, 2000). The overall dominant fish taxa collected (all gears combined) represent a mix of native and introduced species with warm or cool water temperature preferences that are either pollution tolerant or intolerant. Many of these same characteristics were noted for the fish community in Keno reservoir. Table E4.1-2 lists origin, status, thermal preference, and pollution tolerance values for fish species present in the Upper Klamath River and reservoirs.

Chub spp., which was the most abundant taxa collected in J. C. Boyle reservoir during 1998 and 1999, and tui chub, another dominant taxa, are native, pollution tolerant species with cool water temperature preferences. Two other dominant taxa, sucker spp. and Klamath speckled dace, also are native, cool water species, but are pollution intolerant (shortnose sucker are pollution sensitive). The other overall dominant taxa (fathead minnow, bullhead, pumpkinseed, sunfish spp.) are introduced, pollution tolerant species that exhibit a warm water temperature preference (pumpkinseed prefer cooler water). Bullhead, pumpkinseed, and sunfish spp. are game species while the rest of the dominant taxa are non-game species.

Among adult fish collected in J. C. Boyle reservoir during 1998 and 1999, native species accounted for approximately 55 percent of the total (Desjardins and Markle, 2000). Tui chub was the most abundant species and redband trout the fifth most abundant species of adult native fishes collected. Results of previous fisheries studies in J. C. Boyle reservoir generally indicate the fish community has not changed greatly over the past 15 years, except perhaps in the increased abundance of several popular warm water game species (largemouth bass and white crappie) that now support a popular recreational fishery (ODFW, 1997). Information on redband trout spawning and post-spawning movements through J. C. Boyle reservoir and their use of Spencer Creek and on juvenile migrations through the reservoir are discussed in Section E4.2.2.

The endangered shortnose and Lost River suckers accounted for about 1.5 percent of the native fish captured in J. C. Boyle reservoir during 1998 and 1999, and may represent individuals or their progeny that originated in Upper Klamath Lake (PacifiCorp, 2000). Shortnose sucker were much more abundant in the catch than Lost River sucker. J. C. Boyle reservoir was the only reservoir of the three reservoirs sampled by Oregon State University where all life stages of suckers (adults, juveniles, larvae) were collected during both 1998 and 1999 (Desjardins and Markl, 2000). This may reflect the effects of several factors, as described by Desjardins and Markle (2000). These include J. C. Boyle reservoir serving as a downstream sink for larvae and juvenile suckers dispersed from upstream spawning in Upper Klamath Lake. In addition, the presence of juveniles and younger adults suggests that there is sufficient habitat in the reservoir to support these life stages. Also, fewer numbers of introduced, dominant predators, such as yellow perch, crappie, and largemouth bass, in J. C. Boyle reservoir than in downstream reservoirs may contribute to sucker survival (Desjardins and Markle, 2000).

ODFW management policies for J. C. Boyle reservoir are the same as for the Klamath River as a whole. Policies include the natural production of redband trout directed at wild fish management, the natural production of warm water game fish directed at a basic yield fishery, the protection and management of the Lost River and shortnose suckers according to these species' recovery plan, and the management of other native non-game fish species exclusively for natural production within their native habitat (ODFW, 1997).

Copco Reservoir

Table E4.2-17 summarizes catch data and sampling information by gear type in Copco reservoir during 1998 and 1999. Scientific names of fish captured are provided in Table E4.1-2. As noted for J. C. Boyle reservoir, the taxonomic categories of multiple species listed in Table E4.2-17 reflect difficulties in distinguishing among species in small specimens.

Approximately 45,000 fish representing 22 taxonomic categories were collected in Copco reservoir (Desjardins and Markle, 2000) (see Table E4.2-17). Nearly 8,000 fish representing 18 taxa and more than 37,000 fish representing 19 taxa were collected in 1998 and 1999, respectively. The five most abundant taxa collected overall in 1998 were yellow perch (5,990 individuals), golden shiner (596), chub spp. (229), sucker spp. (213), and bullhead spp. (202). Largemouth bass (160) was the sixth most abundant species collected. These taxa collectively accounted for 94 percent of the total catch in 1998. Yellow perch alone accounted for 76 percent of the total catch (see Table E4.2-17).

The same five taxa that dominated the overall catch in Copco No l. reservoir in 1998 also were dominant in 1999 collections, although the order of abundance varied slightly for several species. Numbers of yellow perch collected in 1999 again exceeded the total number of all other species collected. The five most abundant taxa collected in 1999 included yellow perch (21,337), sucker spp. (8,519), golden shiner (6,143), bullhead spp. (399), and chub spp. (208). These taxa together made up nearly 99 percent of the total catch in the reservoir in 1999. Yellow perch accounted for 57 percent of the total catch (see Table E4.2-17).

The six different gear types that were used to sample a range of fish sizes and life stages in Copco reservoir provide information on the fish community in that water body. The overall dominant fish taxa collected was yellow perch, followed by considerably fewer numbers of sucker spp., golden shiner, bullhead spp., and chub spp. These species represent a mix of native (chubs, suckers) and introduced (yellow perch, golden shiner, bullheads) taxa, with warm water (golden shiner, bullheads) or cool water (yellow perch, chubs, suckers) temperature preferences that are pollution tolerant (chubs, golden shiner, bullheads) or intolerant (yellow perch, suckers).

This same mix of species origins, thermal preferences, and pollution tolerances was observed in fish collections upstream in J. C. Boyle reservoir during 1998 and 1999. However, a major difference between the two reservoirs is the greater relative abundance and apparently absolute abundance of game species, particularly yellow perch, in Copco reservoir. A striking example of this difference was the collection over a 2-year period of more than 27,000 yellow perch in Copco reservoir and only 47 yellow perch in J. C. Boyle reservoir. Thirty-two yellow perch were collected farther upstream in Keno reservoir during sampling in 2001 and 2002. Conversely, fathead minnow, an introduced species that is prey for game fish, dominated the total catch in Keno reservoir during 2001 and 2002 and was among the most abundant species collected in J. C. Boyle reservoir. However, fathead minnow was represented by only three individuals in the total catch in Copco reservoir.

In previous fisheries investigations, yellow perch was the dominant species collected in the Copco reservoir by CDFG during a 3-year study in the late 1980s, the same as in 1998 and 1999. Warm water fish species were far more abundant than cold water species, and non-native fish species were more abundant than native species. Catch data continue to indicate adult redband trout are very uncommon in the reservoir (Desjardins and Markle, 2000; City of Klamath Falls, 1986).

Table E4.2-17. Number of fish collected in Copco reservoir by gear type during 1998 and 1999.

*Targeted life stage in parentheses after gear type (A = adult, J = juvenile, L = larvae)**

Species	Trammel Net (A)		Trap Net (A, J)		Beach Seine (J)		Larval Trawl (J, L)		Dip Net (J, L)		Larval Drift Net (J, L)		Total	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Lamprey spp.	2	0	0	0	0	0	0	0	0	0	0	0	2	0
Tui chub	136	101	2	8	0	0	0	0	0	0	0	0	138	109
Blue chub	52	17	0	1	0	0	0	0	0	0	0	0	52	18
Chub spp.	0	0	0	0	0	4	140	53	89	146	0	5	229	208
Golden shiner	0	0	3	1	593	129	0	397	0	5,616	0	0	596	6,143
Fathead minnow	0	0	0	1	0	1	0	0	0	1	0	0	0	3
Klamath speckled dace	0	0	0	0	0	10	0	0	0	0	0	0	0	10
Klamath smallscale sucker	16	1	0	0	0	0	0	0	0	0	0	0	16	1
Klamath largescale sucker	2	0	0	0	0	0	0	0	0	0	0	0	2	0
Shortnose sucker	94	64	0	0	0	0	0	0	0	0	0	0	94	64
Lost River sucker	2	0	0	0	0	0	0	0	0	0	0	0	2	0
Sucker spp.	3	0	0	0	0	54	41	2,979	18	5,160	151	326	213	8,519
Bullhead spp.	182	221	15	178	5	0	0	0	0	0	0	0	202	399
Rainbow trout	3	0	0	0	0	0	0	0	0	0	0	1	3	1
Sculpin spp.	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Sacramento perch	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Pumpkinseed	8	3	30	31	0	5	0	8	0	1	0	0	38	48
Largemouth bass	12	6	2	0	128	8	18	1	0	2	0	0	160	17
Sunfish spp.	0	0	0	0	17	0	9	3	0	1	0	0	26	4
Crappie spp.	57	44	41	30	0	0	7	5	2	18	0	0	107	97
Yellow perch	480	75	92	1,504	16	16,301	5,000	3,274	400	183	2	0	5,990	21,337
Unidentified spp.	0	0	0	0	0	1	12	71	0	73	5	14	17	159
Total Individuals	1,049	532	185	1,755	759	16,516	5,227	6,791	509	11,201	158	346	7,887	37,141
Total Taxa	14	9	7	9	5	10	7	9	4	10	3	4	18	19
Sampling Effort														
Sets/Pulls	17	8	2	14	21	21	18	32	5	14	8	16		
Hours	204	123	35	219	—	—	—	—	—	—	30	73		

*Catch data from Desjardins and Markle (2000).

Approximately 13 percent of the adult fish collected in Copco reservoir during 1998 and 1999 were the endangered shortnose and Lost River suckers, and almost all of these were shortnose sucker (Desjardins and Markle, 2000). Older shortnose sucker and Lost River sucker expatriates from Upper Klamath Lake are reported to move downstream to waters such as Copco reservoir (Snedaker, 2002). Few juvenile suckers were collected in the reservoir, which suggests little sucker recruitment is occurring. This may reflect the presence of non-native predators, such as yellow perch, largemouth bass, and crappie, and the reservoir's lack of rearing habitat for larval and juvenile suckers (Desjardins and Markle, 2000).

Other aspects of Copco reservoir include its popularity as a sport fishery for primarily warm water species. It also is the site of several largemouth bass fishing tournaments during the summer.

In addition to the net sampling, hydroacoustic techniques were also used to assess the general characteristics of the deep-water fisheries in Copco and Iron Gate reservoirs. In addition, traditional netting methods were also used to help verify the hydroacoustic results and identify some of the fish species "targets" identified with the hydroacoustic equipment. Both impoundments were sampled in August and October 2003. Additional sampling is scheduled for April 2004. The interim analysis presented here summarizes the initial findings from August 2003. The final report will be available in summer 2004 and will include the October 2003 and April 2004 results. The interim hydroacoustic technical report (with sampling data results) is presented in the Fish Resources FTR as Appendix 3F.

In surveying the reservoirs, the paths of the hydroacoustic sampling consisted of transects 150 m apart to provide adequate spatial representation of the fish populations while also minimizing the incidence of multiple acquisition of targets. For each reservoir, a prescribed path was developed over the areas of the impoundments greater than 5 m deep. Two daytime surveys and one nighttime survey were conducted over each survey path during the investigation. Gas bubbles were abundant in the deeper areas of both impoundments during the August survey, but were generally easy to distinguish from the fish targets based on target strength.

The results from the August 2003 hydroacoustic indicate that the vast majority of fish were observed above the thermoclines in the impoundment. This is appears to be a valid conclusion as the hypolimnions were found to be anoxic. Fish abundance along the survey paths were similar between both day and night sampling runs. Fish netting conducted in the pelagic zone concurrently with the hydroacoustic activities showed that most of the fish targets were yellow perch.

Most of the fish targets observed in Copco reservoir were generally towards the middle and eastern end of the lake. There were relatively few differences in spatial distribution of the targets in Copco reservoir between the day and night run. Most of the fish in Copco reservoir were distributed at a depth between 3 and 11 m during the day, but the fish were typically deeper at night, with an average depth of 11 m.

The results for the fish netting show that all of the fish caught were yellow perch within the size range of 130 to 285 mm. The median size of fish netted in Copco reservoir was 193 mm (CV 9.2). The only non-perch fish caught were two black crappie.

Iron Gate Reservoir

Table E4.2-18 summarizes catch data and sampling information by gear type for Iron Gate reservoir during 1998 and 1999. Scientific names of fish captured are provided in Table E4.1-2. As noted for J. C. Boyle and Copco reservoirs, the taxonomic categories of multiple species listed in Table E4.2-18 reflect difficulties in distinguishing among species in small specimens.

Approximately 25,000 fish representing 21 taxonomic categories were collected in Iron Gate reservoir (Desjardins and Markle, 2000) (see Table E4.2-18). More than 5,000 fish representing 18 taxa and nearly 20,000 fish representing 21 taxa were collected in 1998 and 1999, respectively. The five most abundant taxa collected overall in 1998 were tui chub (3,128), chub spp. (1,314), largemouth bass (336), crappie spp. (168), and golden shiner and yellow perch (133 each). All but tui chub and chub spp. were introduced species.

A slightly different set of taxa dominated the overall catch in Iron Gate reservoir in 1999. Dominant taxa in 1999 included golden shiner (13,829), pumpkinseed (2,325), sucker spp. (1,138), yellow perch (1,108), and largemouth bass (419). All but sucker spp. were introduced species. The five most abundant taxa collected each year in Iron Gate reservoir constituted approximately 93 percent of the total catch in 1998 and 96 percent of the total catch in 1999. Other species of interest collected included 13 shortnose sucker and 33 rainbow trout. No Lost River sucker were collected in Iron Gate reservoir either year (see Table E4.2-18).

Gear types used by Oregon State University in 1998 and 1999 to sample adult, juvenile, and larval fish sizes and life stages in Iron Gate reservoir provide information on the fish community in that water body. Dominant taxa collected during the 2-year study period consisted primarily of introduced species, many of which are game fish (e.g., largemouth bass, yellow perch, crappie spp., and pumpkinseed). However, some of the most abundant taxa collected in Iron Gate reservoir, such as tui chub, chub spp., and sucker spp., are native species.

Dominant species collected in Iron Gate reservoir during 1998 and 1999 represented a mix of native and introduced, warm water and cool water, and pollution tolerant and pollution intolerant taxa, the same as noted for Copco and J. C. Boyle reservoirs. Yellow perch continued to be abundant in the catch, but less so than upstream in Copco reservoir. Several other game species, such as largemouth bass and pumpkinseed, appeared to be somewhat more abundant than in upstream reservoirs. Fathead minnow were very uncommon in the catch in Iron Gate reservoir (three individuals captured), the same as in Copco reservoir, and may indicate predation effects on this species by numerous game fishes.

In fisheries investigations in Iron Gate reservoir conducted some 10 years earlier by CDFG (CDFG file data), introduced species consisting primarily of warm water and cool water game fish accounted for 96 percent of the total catch. Yellow perch was the dominant species collected by CDFG in 1988, comprising 53 percent of the total catch. Studies indicate that non-native warm water game species comprise an increasingly greater proportion of the catch proceeding downstream among the Klamath River reservoirs. Non-native species accounted for 77 percent of the adult fish collected in Iron Gate reservoir during 1998 and 1999. Catch data indicate that rainbow trout are present but not commonly collected in Iron Gate reservoir (Desjardins and Markle, 2000).

Table E4.2-18. Number of fish collected in Iron Gate reservoir by gear type during 1998 and 1999

*Targeted life stage in parentheses after gear type (A = adult, J = juvenile, L = larvae)**

Species	Trammel Net (A)		Trap Net (A, J)		Beach Seine (J)		Larval Trawl (J, L)		Dip Net (J, L)		Larval Drift Net (J, L)		Total	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Lamprey spp.	0	0	0	4	0	0	0	0	0	0	1	0	1	4
Tui chub	102	40	0	0	0	0	59	0	2,967	7	0	0	3,128	47
Blue chub	50	48	0	0	0	0	0	0	0	0	8	0	58	48
Chub spp.	0	0	0	0	9	0	1,298	9	0	0	7	6	1,314	15
Golden shiner	0	0	0	8	73	32	60	221	0	13,566	0	2	133	13,829
Fathead minnow	0	0	0	0	0	1	0	0	0	2	0	0	0	3
Klamath speckled dace	0	0	0	9	0	0	0	0	0	5	0	0	0	14
Klamath smallscale sucker	11	10	1	0	0	0	0	0	0	0	0	0	12	10
Shortnose sucker	2	11	0	0	0	0	0	0	0	0	0	0	2	11
Sucker spp.	0	1	0	0	0	0	3	114	14	604	25	419	42	1,138
Bullhead spp.	87	83	25	273	1	0	0	0	0	0	0	0	113	356
Channel Catfish	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Rainbow trout	6	2	0	1	0	2	2	4	0	16	0	0	8	25
Sculpin spp.	0	0	0	0	0	0	0	0	0	0	52	24	52	24
Pumpkinseed	18	8	1	41	22	90	6	5	0	2,179	0	2	47	2,325
Green Sunfish	0	0	0	2	2	1	0	0	0	0	0	0	2	3
Largemouth bass	7	5	1	1	277	62	51	9	0	342	0	0	336	419
Sunfish spp.	0	0	0	0	33	0	11	0	0	1	0	0	44	1
Crappie spp.	22	41	12	24	48	0	72	3	14	0	0	3	168	71
Yellow perch	52	247	38	180	9	18	1	17	0	1	33	645	133	1,108
Unidentified spp.	0	0	0	0	0	0	0	4	0	17	7	217	7	238
Total Individuals	357	497	78	543	474	206	1,563	386	2,995	16,740	133	1,318	5,600	19,690
Total Taxa	10	12	6	10	9	7	10	9	3	11	7	8	18	21
Sampling Effort														
Sets/Pulls	19	10	3	12	13	13	17	27	6	25	12	20		
Hours	227	118	56	206	—	—	—	—	—	—	44	87		

*Catch data from Desjardins and Markle (2000).

The endangered shortnose and Lost River suckers made up only 1 percent of the total adult catch in Iron Gate reservoir during 1998 and 1999 (versus 13 percent in Copco reservoir), and all endangered suckers collected during the study were either adults or larvae. The lack of sucker juveniles in Iron Gate reservoir suggests little recruitment is occurring, the same as noted for Copco reservoir. This may reflect the presence of predators (for example, yellow perch, largemouth bass, and crappie) and the reservoir's lack of rearing habitat for larval and juvenile suckers (Desjardins and Markle, 2000).

The results from the August 2003 hydroacoustic survey indicate that the vast majority of fish were observed above the thermoclines in the impoundment. This is appears to be a valid conclusion as the hypolimnions were found to be anoxic. Fish abundance along the survey paths were similar between both day and night sampling runs. Fish netting conducted in the pelagic zone concurrently with the hydroacoustic activities showed that most of the fish targets were yellow perch.

The distribution of fish in Iron Gate reservoir showed few fish present in the open-water area. Most fish were observed adjacent to the shorelines, especially the eastern shore, and in the inlet arm. During the night run, a large number of fish were congregated in the thalweg, 2 km west of the inlet. The fish were generally observed at depths from 3 to 13 m, with a considerable aggregation near the bottom end of this range.

The results for the fish netting show that most of the fish caught were yellow perch within the size range of 130 to 285 mm. The median size of fish netted in Iron Gate reservoir was 200 mm (CV 10.3).

Other aspects of Iron Gate reservoir include its popularity as a recreational fishery for yellow perch. It also is the site of largemouth bass fishing tournaments during the summer.

E4.2.1.3 Fish Species of Special Importance

There are several species in the Project area that are listed under the ESA and are under the protection of the states of Oregon or California. This section presents a brief overview of those species that are offered official protection. These include:

- Lost River sucker
- Shortnose sucker
- Coho salmon

A full discussion of these protected species is included in the Fish Resources FTR, Section 1.1.4.

In addition, there are several other species in the Project that are of recreational and native fish community importance. These include:

- Redband/rainbow trout
- Lamprey (Pacific, Klamath, and Pitt-Klamath brook lamprey)
- Various native forage fish (tui chubs, blue chubs, and speckled dace)
- Klamath suckers (largescale and smallscale)

Trout are discussed (and the data that were collected on them during the field studies are thoroughly analyzed) in the Fish Resources FTR, Section 3. The Fish Resources FTR also includes a full discussion of the lamprey species, as these are an important species to the Tribal fisheries management within the Project. The other native suckers and forage fish are also covered in the Fish Resources FTR and the data collected on them are presented for each of the river and reservoir reaches.

Lost River Sucker

The Lost River sucker is an endemic species to the Upper Klamath River basin and has limited distribution. The Lost River sucker was first listed as a state endangered species in 1974 by the State of California, and also is included on California's Fully Protected Species list. In 1988, it was listed as a federally endangered species (53 FR 137). In 2002, a petition was presented to the USFWS to delist the Lost River sucker (67 FR 93). 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.

At the time of the federal listing of the Lost River sucker (and shortnose sucker), the recognized threats to the species were stated as (67 FR 93):

- 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

In addition to these, there is also the recognized issue of entrainment of suckers from Upper Klamath Lake into the USBR Klamath Irrigation Project's A-Canal where they were essentially lost to the system. Also there is a recognized concern over the entrainment of suckers from Upper Klamath Lake into the downstream river where habitat may or may not be suitable for a sustainable population, and entrainment into PacifiCorp's East Side and West Side hydroelectric facilities.

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 (Buettner pers. comm.), and the Upper Klamath River including Copco reservoir. Juvenile suckers are suspected to have been observed in the Wood River and Crooked Creek (Markle, OSU, pers. comm.).

Lost River suckers are a long-lived species, with the oldest individual recorded as 43 years old when taken from Upper Klamath Lake (Scoppettone, 1988). Lost River suckers are one of the largest sucker species and may obtain a length of up to 1 meter (Moyle, 1976). Sexual maturity for suckers sampled in Upper Klamath Lake occurs between the ages of 6 to 14 years, with most maturing at age 9 (Buettner and Scoppettone 1990).

Spawning for Lost River suckers has been observed by various researchers to occur between March and May (Moyle 1976). Observations of Lost River suckers spawning in the tributaries of Upper Klamath Lake found that most spawned at depths between 21 to 70 cm and in water velocities ranging from 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).

Shortnose Sucker

The shortnose sucker is an endemic species to the Upper Klamath River basin (including Upper Klamath Lake and some of its tributaries) and is limited in its distribution within the region. The shortnose sucker was first listed as a California state endangered species in 1974, the same year as the Lost River sucker. Like the Lost River sucker, the shortnose sucker also is included on California's Fully Protected Species list. In 1988, it was listed as a federally endangered species (53 FR 137). In 2002, a petition was presented to the USFWS to delist the shortnose sucker (67 FR 93). The USFWS concluded that there was not sufficient scientific or commercial information to warrant the delisting of the shortnose sucker from the federal list of endangered species. As stated above, the limiting factors that potentially affect the shortnose sucker are those that were stated for the Lost River sucker.

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 sucker 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 sucker have also been collected from Copco reservoir on the Upper Klamath River, but it presumed that they are not native to this area. The Copco reservoir population of shortnose sucker is presumed to have come from Upper Klamath Lake (Dennis Maria, CDFG, Yreka 1991).

As with Lost River sucker, shortnose sucker are a long-lived species. Scoppettone (1988) found that the oldest shortnose sucker he examined in the basin was 33 years old when taken from Copco reservoir. Sexual maturity for shortnose sucker appears to occur between the ages of 5 and 8 years with most maturing at the age of 6 or 7 years (Buettner and Scoppettone 1990). Buettner and Scoppettone (1990) found that for female shortnose sucker sampled from Upper Klamath Lake, most growth occurred in the first 6 to 8 years of life. After that, the growth rates decreased and it was felt that this was related to the fish reaching sexual maturity.

Moyle (1976) reports that researchers have observed shortnose sucker 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 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 21 to 60 cm and in a water velocities of 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). 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).

Coho Salmon

The coho salmon is a native anadromous salmonid fish to the Klamath River system. The specific coho salmon stock in the Klamath River system belongs to the southern Oregon/northern California (SONC) ESU as defined by NOAA Fisheries. The SONC coho salmon was listed as threatened species under the ESA in June 1997 (62 FR 24588). The coho salmon was designated as a candidate species under CESA in 2001. In 2002, the California Fish and Game Commission found that the coho salmon warranted designation as a threatened species under CESA, but declined to list the species. In November, 2003, the CDFG released its Draft Recovery Strategy for the Coho Salmon, including the Klamath River system.

Prior to the federal listing in 1997, and in subsequent documentation regarding the listing of this stock of coho, much was written regarding the life history and factors affecting the populations. The following description of general information, life history, and limiting factors of the SONC stock of coho salmon has been taken directly from the more recent USBR's Biological Opinion (NOAA Fisheries, 2002).

All SONC coho salmon populations within the ESU are depressed relative to their past abundance, based on the limited data available (July 25, 1995, 60 FR 19 38011; May 6, 1997, 62 FR 24588). 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 (May 6, 1997, 62 FR 24588). 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.

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 (May 6, 1997; 62 FR 24588). 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.

Coho salmon occur in the mainstem Klamath River year round, and coho also inhabit several Klamath River tributaries (Henriksen 1995; INSE 1999;Yurok Tribe 2001; CDFG 2002). 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 prior to 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 both tributaries and the mainstem Klamath River.

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 fresh water 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 fresh water 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 within 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. Following emergence, fry move into shallow areas near the stream banks. 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).

E4.2.1.4 Fish Passage at the Project Facilities

Management Purpose and Construction History of Fish Passage Facilities

Currently, there is no upstream or downstream fish passage provided over or around Iron Gate dam and Copco Nos. 1 and 2 dams. The Iron Gate fish hatchery was built as mitigation for the loss of spawning and rearing habitat in the Klamath River and its tributaries between the Iron Gate Development and the Copco Developments. The current FERC license stipulates specific production goals from the hatchery for fall Chinook, coho, and steelhead. This facility is funded largely by PacifiCorp and is operated by CDFG (see Section E4.3.2 regarding Iron Gate fish hatchery operations).

Description of Current Fish Passage Facilities

Upstream fish passage facilities on the Upper Klamath River currently consist of fish ladders at J.C. Boyle, Keno, and Link River dams. The purpose of these passage facilities is to allow the passage of resident fish to the Upper Klamath River (and Upper Klamath Lake) and also provide spawning access to certain tributaries. The fish species targeted for use of the facilities are redband trout. The J.C. Boyle facility is the only one with downstream passage facilities (screens and a bypass are located at the diversion intake). The original construction of the Copco No. 1 and No. 2 Developments did not include provisions for fish passage. The original construction of the Fall Creek Development did not include fish screens or fish ladders on either the Fall Creek or Spring Creek diversions.

J.C. Boyle Dam

The original construction of the J. C. Boyle Development included fish screens on the power intake tower and a fish ladder at the dam, but no tailrace barrier at the powerhouse. The initial design of the power intake for the J. C. Boyle Development included four Rex traveling band screens. PacifiCorp has maintained these screens in good working order. In 1988, a new building was added to the intake to protect the screens. The existing screens do not meet modern standards for fish screens. They are 11 feet 2 inches wide and 29 feet 6 inches high at a low forebay level of 3,788 feet. The gross approach area for each of the four screens is 329.4 square feet for a total gross area of 1,318 square feet. The resulting approach velocity with an intake flow of 3,000 cfs is 2.3 ft/s, which is almost six times the current criteria of 0.4 ft/s for fry.

The existing screen bypass system, although consistent with the design one normally would expect for traveling band screens, does not meet modern design standards. The flow rate for the existing bypass is estimated at 20 cfs.

The existing fish ladder at J. C. Boyle dam is a pool and weir type ladder, with an auxiliary water supply system (AWS). FishPro (1992) reported 57 pools in the ladder, but according to the drawings, there are 63 pools. The pools are generally 8 feet 6 inches long, including the 6-inch weirs. The width of the pools is a consistent 6 feet. The weirs are 3 feet 6 inches high, 6 inches thick, and 6 feet wide. Each weir has a 4-inch-square orifice flush with the floor and centered in the weir. Pools 60 through 63 and the exit pool are controlled by 6-foot-wide automated weir gates, which, at full pool elevation of 3,793 feet mean sea level (msl), provide a 1-foot drop from pool to pool. At the low forebay elevation of 3,788 feet msl, the weir gates are fully down.

With a forebay range from 3,793 to 3,788 feet msl, the fish ladder operates over a gross head range of 60.2 to 55.2 feet. At full pool, there would be about 1-foot drop across each weir. This approximate 1-foot drop would also exist at the low forebay level since the automated weirs are set up to admit a constant flow. This 1-foot drop does not compare favorably with the normal criteria for resident trout of 6- to 9-inch drops between pools.

Flow in the ladder is estimated to be 0.6 cfs through the 4-inch-square orifices and 20 cfs over the 6-foot-wide weirs. The slope of the ladder is 1V:8.5H, which is steeper than both the current criteria for trout at 1V:10H and the current criteria for suckers at 1V:22H. The pool volume of the existing ladder is 192 cubic feet (4-foot average depth, 6 feet by 8 feet in plan). With an approximate ladder flow of 21 cfs, the turbulence factor for the typical pool would be 6.8 ft-lb/s/ft^3, which is 1.7 times the modern recommended value of less than 4.0 ft-lb/s/ft^3.

Iron Gate Dam

The original construction of the Iron Gate Development included the Iron Gate fish hatchery as mitigation for fishery impacts. No fish ladder was built to allow for upstream fish passage over the dam. The two existing fish ladders, one at the adult collection and holding facility at the base of the dam and the other on the hatchery outfall, are used to collect brood stock for the hatchery. The powerhouse intake tower in the Iron Gate forebay has a trash rack, but no fish screens.

The fish ladder at the base of the dam begins with an entrance pool adjacent to the powerhouse and leads to the adult trapping and holding facilities for the hatchery. This is a pool and weir type ladder with flow provided from the hatchery water supply system. This supply is drawn from the forebay at a depth of 70 feet. This water supply is oxygenated and is the main source of water for the adult trapping and holding facility. Water from the AWS can be supplied to the entrance pool of the fish ladder by pumps on the tailrace deck of the powerhouse.

The ladder at the hatchery was designed and constructed by the CDFG because of recurrent false attraction at the hatchery outfall. It has worked so well that in recent years, it has attracted the majority of the returning adults. Adults trapped at this site are trucked to the adult holding facilities at the base of the dam. This ladder is a pool and weir type with flow provided by the hatchery effluent.

E4.2.2 Factors Affecting Fisheries Resources

This section describes the factors associated with the current Project facilities and operations that affect fish resources. For riverine areas, the factors affecting fish are categorized into 1) instream flows, 2) flow fluctuations, and 3) resident fish passage. For Project reservoirs, the factors are categorized into 1) reservoir level fluctuations and 2) resident fish entrainment and mortality. The physical areas are generally presented geographically from upstream to downstream.

In the course of study and in the interim between the draft license application and this final application, PacifiCorp made certain changes to the proposed Project. The newly proposed Project begins at the J.C. Boyle Development and continues downstream to the Iron Gate Development. The Spring Creek diversion is now included in the Fall Creek Development. The East Side and West Side developments on the Link River and Keno Development are no longer part of the proposed Project. PacifiCorp plans to decommission the East Side and West Side developments (as described in Exhibit A). Keno dam will remain in operation, but is not included in the proposed FERC Project because the development does not have generation facilities, and its operation does not substantially benefit generation at PacifiCorp's downstream hydroelectric developments. Fish resource study results presented in the final license application are generally limited to this new proposed Project. Study results and discussion of existing conditions for all areas, including Link River and Keno, are available in the Fish Resources FTR.

E4.2.2.1 River Fisheries

Instream Flows

This study has received much attention from PacifiCorp and the relicensing stakeholders. Many meetings have been conducted by the Aquatic Work Group and the Work Group's Instream Flow Subgroup. The subgroup was formed to work through technical issues and work towards agreed upon instream flow input, analysis, and recommendations. PacifiCorp recognizes, and requests that FERC also recognize, that additional collaboration, refinement of model input variables, and analysis are needed with stakeholders to meet PacifiCorp's commitment to complete the instream flow study needed to provide a good technical basis for instream flow recommendations. This includes such items as working collaboratively to develop and produce agreed upon modeling input and, consequently, modeling results and recommendations.

PacifiCorp constructed its own rainbow trout envelope curves that were used for the instream flow analysis. However, these curves have not been reviewed or approved by the Instream Flow subgroup. As such, stakeholders have technical uncertainty surrounding the instream flow analysis presented in this application. PacifiCorp and the stakeholders will continue to develop Klamath River habitat suitability criteria (HSC) curves.

In order to address the instream flow study tasks, PacifiCorp and relicensing stakeholders will continue to meet to work on the following:

- Approve rainbow trout and sucker HSC curves
- Develop a habitat time series
- Complete bioenergetics modeling efforts
- Conduct peaking analysis
- Discuss modeling results as they relate to fisheries and other interrelated studies (e.g., recreation, geomorphology, etc.)
- Develop river flow regime recommendations for aquatic resources

It is anticipated that the above tasks will be completed by the end of May 2004. At the conclusion of these tasks, a final instream flow report will be distributed to FERC and interested stakeholders by the end of June 2004. At that time, PacifiCorp will review this additional information and revise, as appropriate, the Project operations and protection, mitigation, and enhancement (PM&E) measures included in this License Application.

This section presents the preliminary results of the instream flow studies for the J.C. Boyle bypass and peaking reaches, the Copco No.2 bypass reach, and Fall Creek. These studies were conducted using standard instream flow incremental methodology (IFIM) field techniques and Physical Habitat Simulation (PHABSIM) modeling methods, which are described in-full in the Fish Resources FTR. Instream flow studies for the Link River and the Keno Reach are not included. PacifiCorp proposes to decommission the East Side and West Side developments on the Link River, and remove the Keno Development from the proposed FERC Project. Instream flow releases from Iron Gate dam are, and will continue to be, based on USBR Klamath Project Operations Plan. The schedule for these instream flow releases was developed by USBR in consultation with USFWS and NOAA Fisheries to be protective of ESA-listed species. The instream flow releases from Iron Gate dam were determined using information from detailed instream flow studies in the Klamath River below Iron Gate dam (Hardy and Addley, 2001).

PacifiCorp developed preliminary fish habitat-flow relationships, or weighted usable area curves (WUA), for redband trout and suckers using the following HSC considerations:

- For redband trout, PacifiCorp relied upon the use of broad-based envelope curves in all reaches, except Fall Creek. In addition, site-specific redband trout curves developed from data collected in the J.C Boyle bypass reach were applied to the J.C. Boyle bypass reach. Envelope curves were developed from a database of rainbow trout curves (Figures E4.2-1, E4.2-2, E4.2-3, and E4.2–4). The selection process for curves to include consisted of the following criteria:

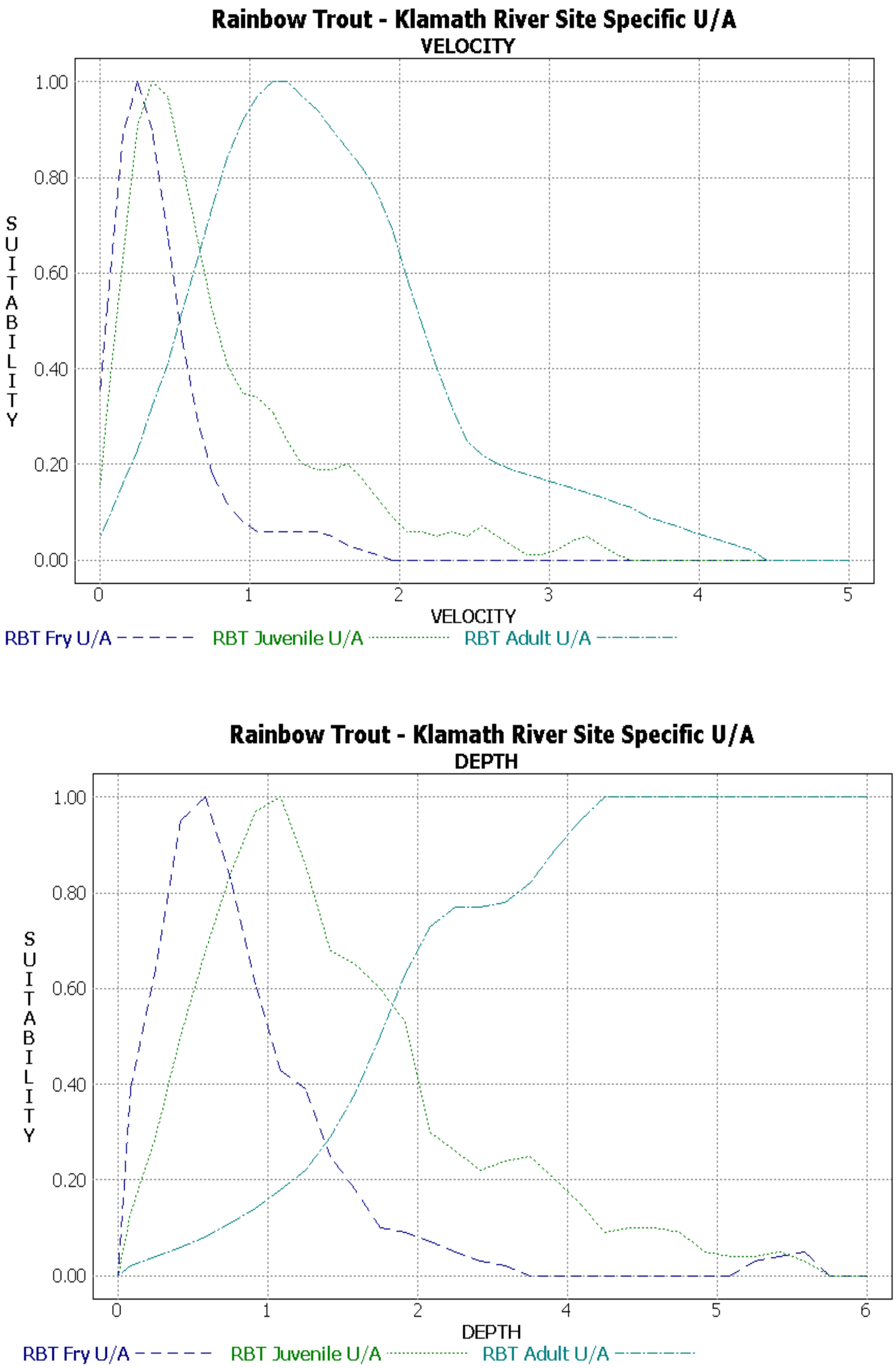
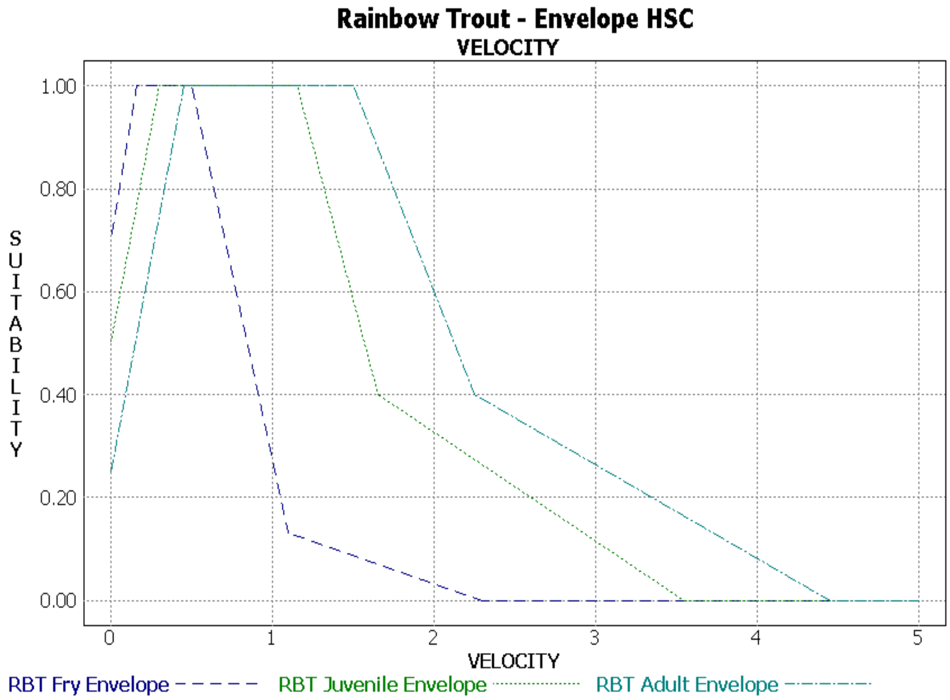


Figure E4.2-1. Rainbow trout fry, juvenile and adult site-specific use/availability HSC used in initial PHABSIM analysis for the Klamath River Project.



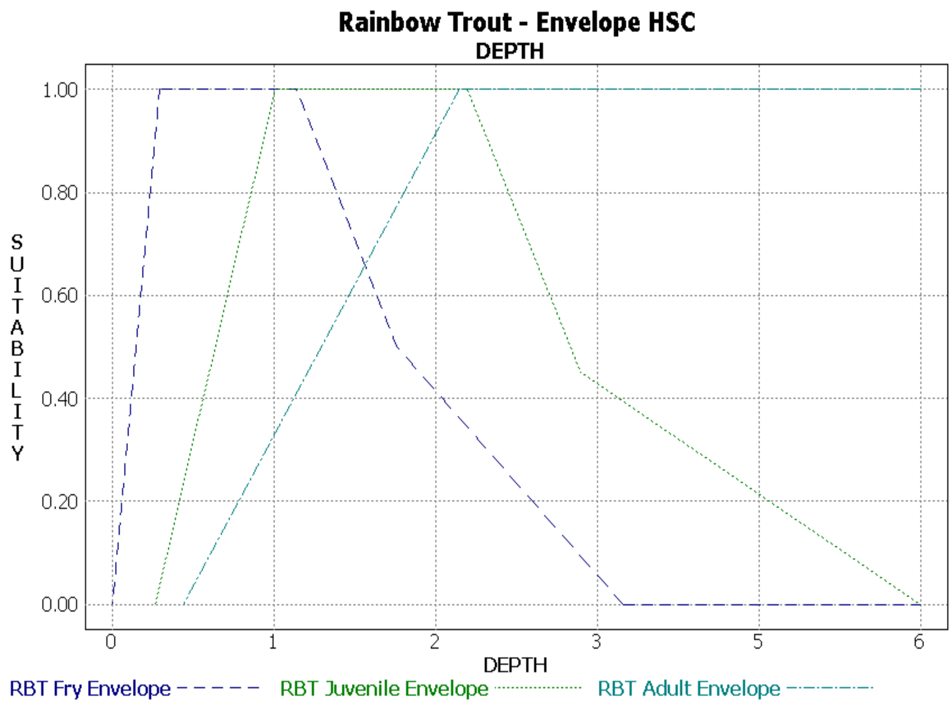
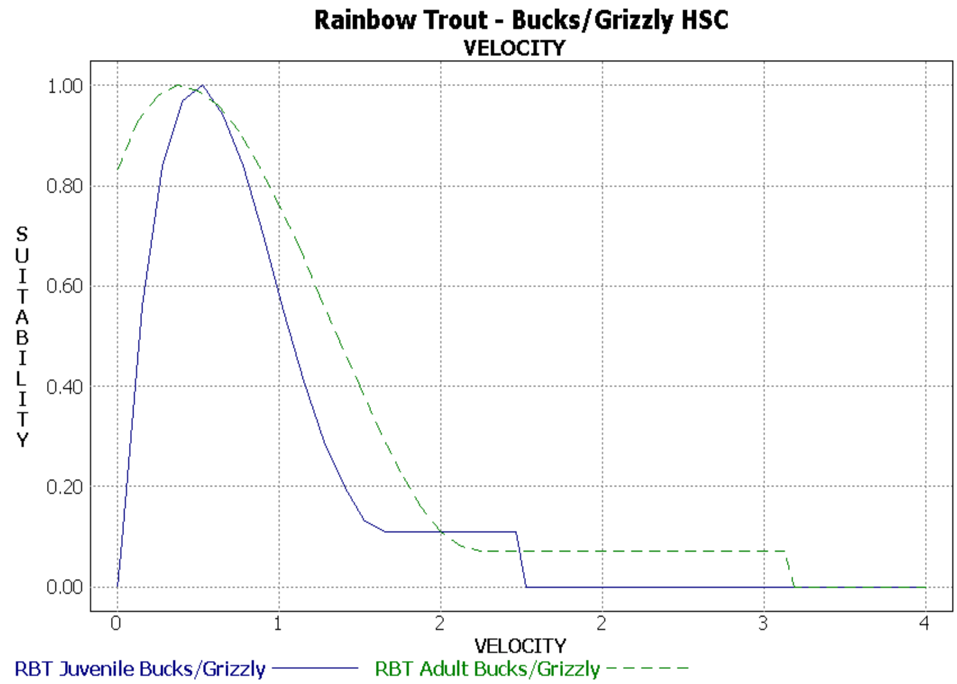


Figure E4.2-2. Rainbow trout fry, juvenile and adult envelope HSC used in initial PHABSIM analysis for the Klamath River Project.



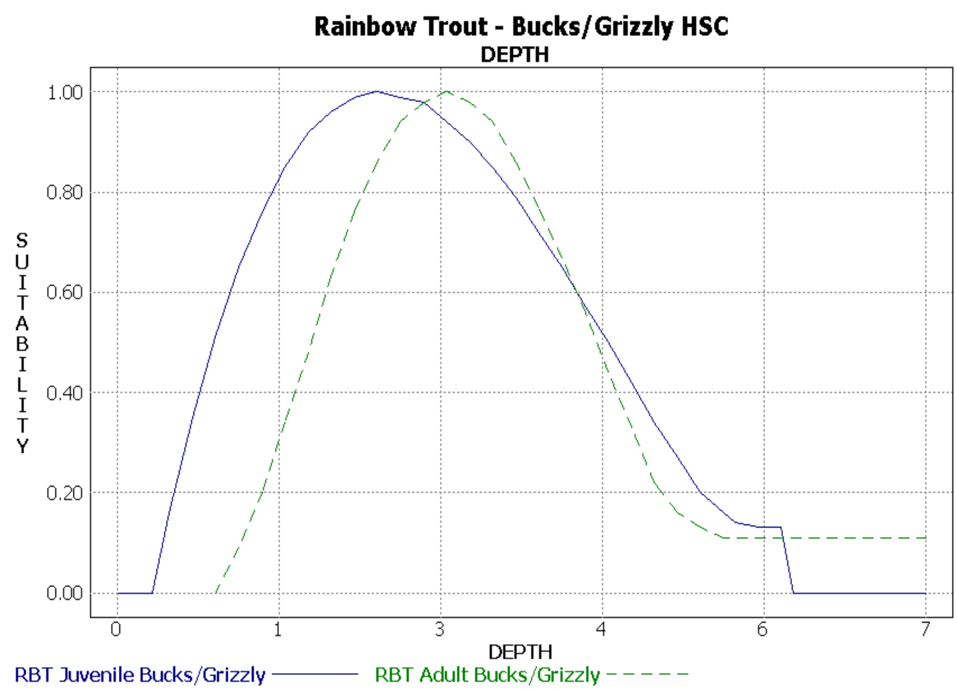
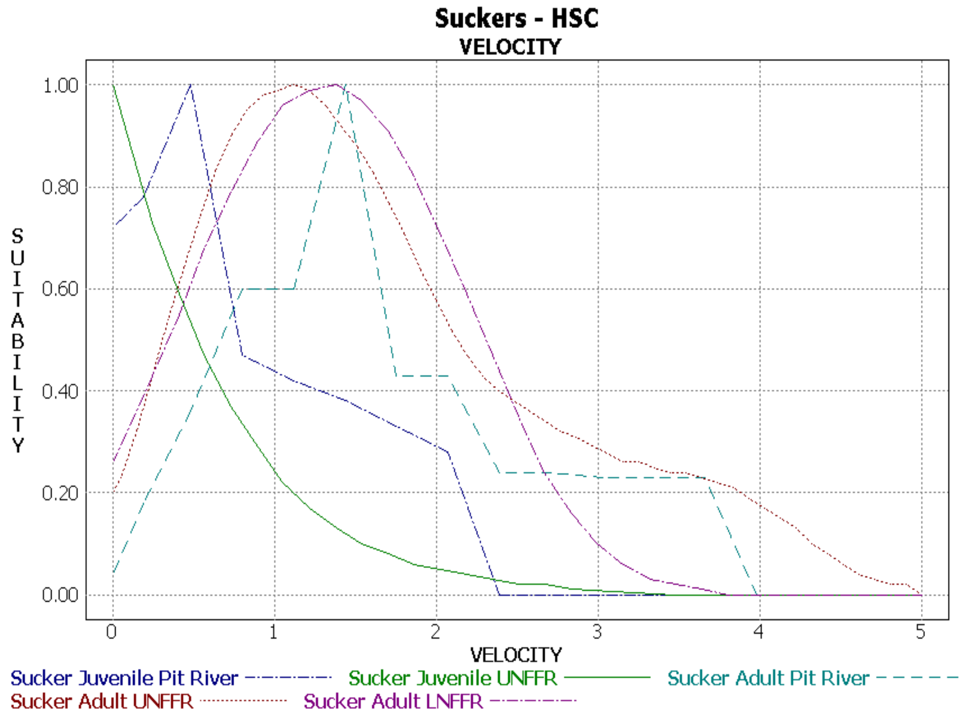


Figure E4.2-3. Rainbow trout juvenile and adult HSC used in initial PHABSIM analysis for Fall Creek, Klamath River Project (Source Bucks/Grizzly Creeks – TRPA 1991).



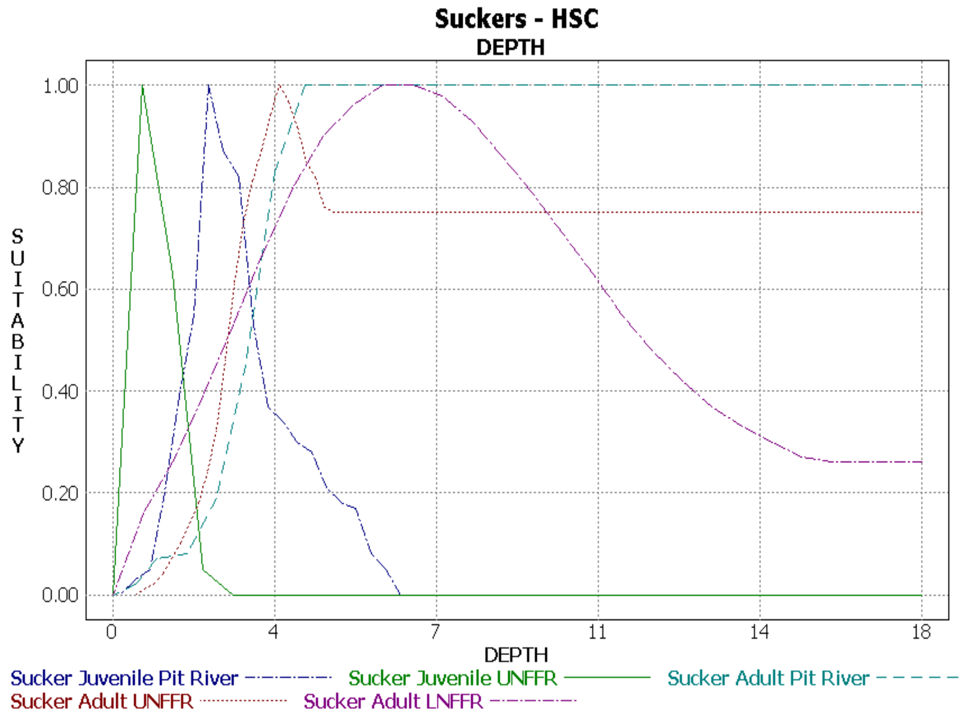


Figure E4.2-4. Sucker, juvenile and adult HSC used in initial PHABSIM analysis for the Klamath River Project. UNFFR and LNFFR – upper and lower North Fork Feather River.

  - HSC were developed under accepted sampling design accounting for habitat availability
  - sample size > 150; flows > 100 cfs to represent larger rivers (initial criteria of > 300 cfs did not include enough curves)
  - size of adults 30+ cm
  - source streams within natural range of redband trout.

  This process resulted in composite HSC based on five fry and juvenile curve sets and six adult curve sets (labeled Envelope in the figures). (See in Figures E4.2-1 through E4.2-4.)

- Because of the small size of Fall Creek, it was felt that the use of HSC developed in larger channels would not be appropriate. In addition, adult trout in Fall Creek are relatively small in size compared to adults found in the J.C. Boyle bypass and streams included in the envelope curves. HSC curves developed for Bucks Creek and Grizzly Creek in the northern Sierra (Thomas R. Payne & Associates, 1991) were used to construct envelope curves for the Fall Creek reach.
- Poor water visibility and low numbers of observations precluded developing site-specific information for suckers. Therefore, previously published curves from the Pit River (labeled Pit in the figures that follow) and North Fork Feather River (labeled UNFFR, LNFFR) were selected for initial habitat modeling.
- Cover and substrate information was collected for the site-specific rainbow trout curves and at each individual cell for all transects. However, the Instream Flow Subgroup has not yet agreed upon how this data will be applied to both the HSC and habitat modeling. Therefore, in the initial habitat modeling, cover was not included as a variable.

J.C. Boyle Bypass Reach
Release flows at the dam are augmented by approximately 225 to 250 cfs at the bottom of the reach as a result of accretion from springs. This estimate was determined through the instream flow analysis and is slightly greater than the previous estimate of spring flow of approximately 220 cfs. WUA output in the bypass reach was adjusted to account for this accretion through the following process:

1) The percentage of reach with a given flow was estimated based on the distance to known discharge sample points. The percentages used were 21.4 percent with no accretion, 13.6 percent with 100 cfs accretion, and 65.0 percent with 250 cfs accretion.

2) WUA values were calculated using all transects weighted for the entire reach.

3) For each release flow, the WUA at the corresponding accretion flow level was then weighted by the percent of the reach represented. For example, the WUA for a release flow of 200 cfs at the dam would equal WUA at 200 cfs × 0.214 + WUA at 300 cfs (100 cfs accretion) × 0.136 + WUA at 450 cfs (250 cfs accretion) × 0.65.

Habitat-flow relationships, or WUA curves, for redband trout fry, juvenile, and adult life stages in the J.C. Boyle bypass reach are presented in Figure E4.2-5. WUA curves based on envelope or site-specific HSC follow similar patterns, varying only in amplitude, a function of the range in depth and velocity suitability. Both fry and juvenile WUA decline over the range of flows simulated and flatten out at higher flows. The adult WUA curves increase slightly in the lower flow ranges before tapering off over the range of flows. The relatively flat WUA values with increasing flow are the result of suitability being maintained in margin areas, while the majority of the channel becomes unsuitable as a result of increasing velocities.

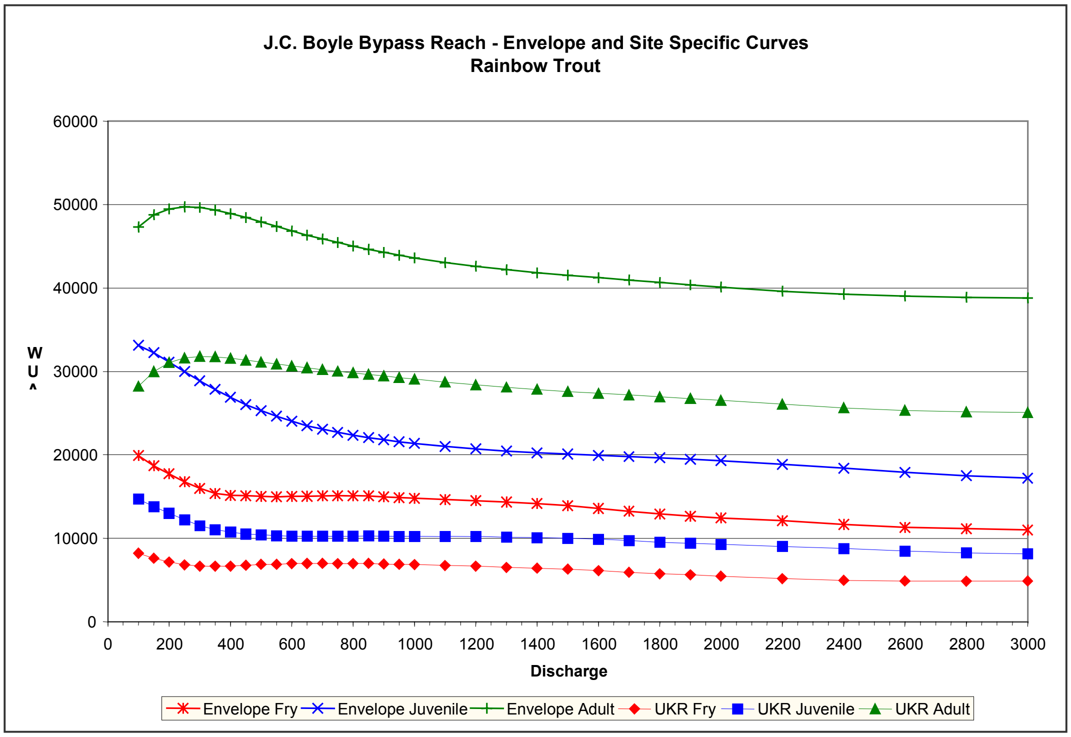


Figure E4.2-5. Habitat index simulation for redband trout fry, juvenile, and adult in the J.C. Boyle bypass reach using Upper Klamath River site-specific curves and envelope curves.

Sucker WUA curves in the J.C. Boyle bypass reach generally follow the same trends as redband trout (Figure E4.2-6). Juvenile suckers curves decline gradually before leveling off at higher flows. Both PIT and UNFFR adult sucker curves increase up to about 400 cfs then flatten out before declining slightly over the range of flows.

<u>J.C. Boyle Peaking Reach</u>

Only the envelope HSC curves for redband trout were used in the J.C. Boyle peaking reach. WUA curves for rainbow trout fry, juvenile, and adult life stages in the J.C. Boyle peaking reach are presented in Figure E4.2-7. WUA curves in the peaking reach respond similarly to those in the bypass reach. However, juvenile and adult curves show a steeper decline over the middle range of simulation flows. This is most likely a function of the larger channel size, resulting in more area in the main channel becoming unsuitable at higher flows as a result of high velocities.

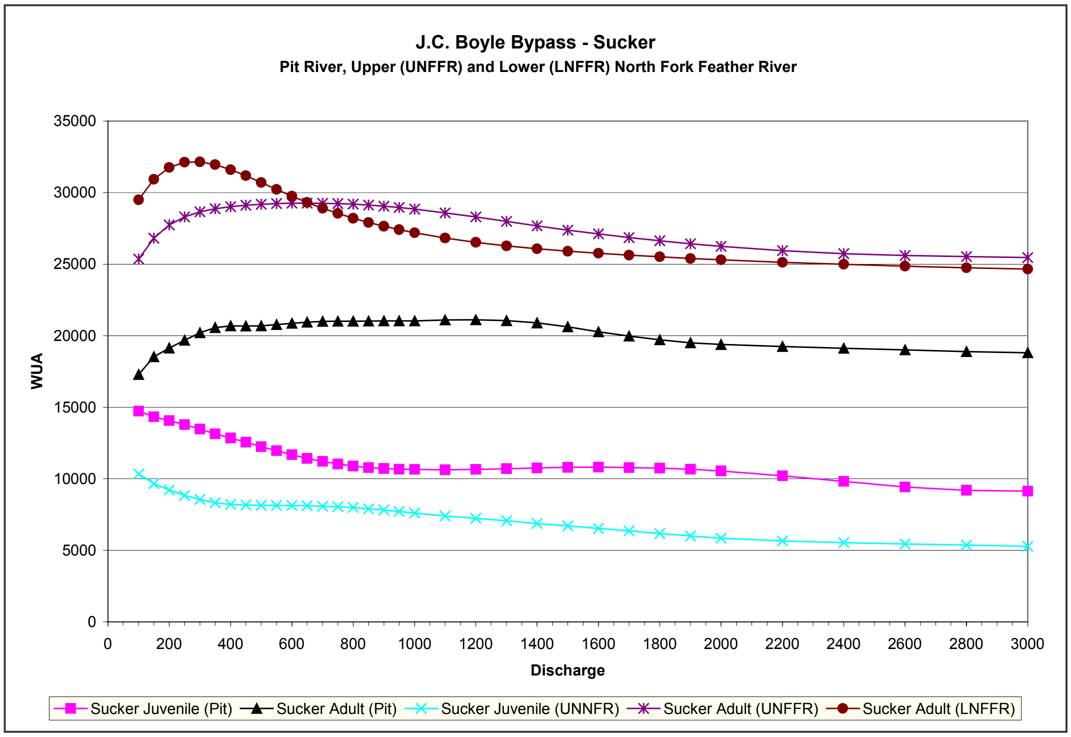


Figure E4.2-6. Habitat index simulation for juvenile and adult suckers in the J.C. Boyle bypass.

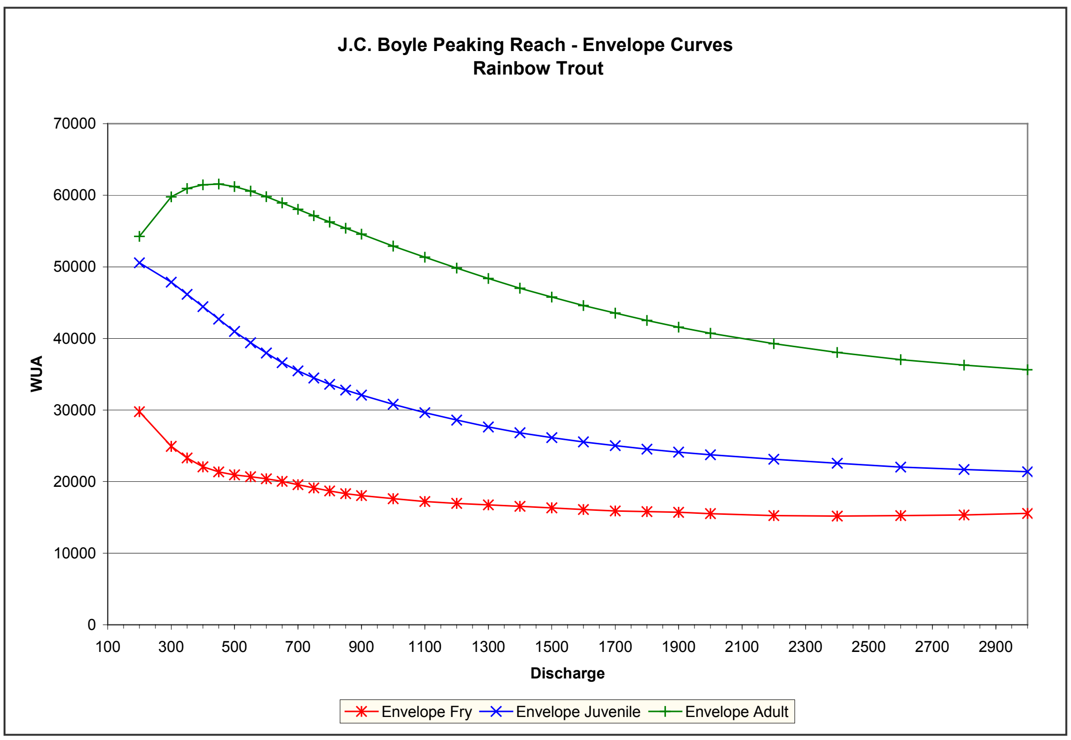


Figure E4.2-7. Habitat index simulation for redband trout fry, juvenile and adult in the J.C. Boyle peaking reach based on envelope HSC.

Juvenile sucker WUA curves in the J.C. Boyle peaking reach decline from low flow before flattening out over the higher simulation flow range (Figure E4.2-8). Adult sucker WUA curves based on PIT and UNFFR increase sharply, level off between 500 and 900 cfs, then decrease over the higher flow range. The adult sucker WUA curve based on LNFFR criteria shows a more abrupt increase, a narrow high arch, and steeper decline in WUA.

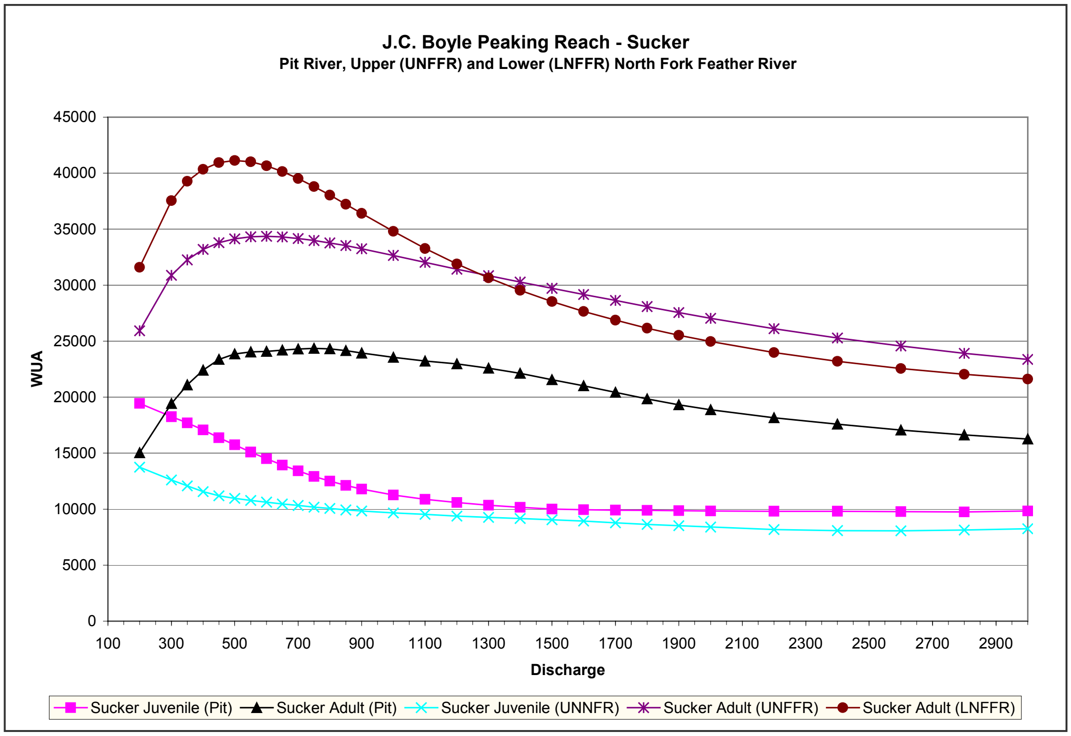


Figure E4.2-8. Habitat index simulation for juvenile and adult suckers in the J.C. Boyle peaking reach.

Copco No. 2 Bypass Reach

Only the envelope HSC curves for rainbow trout were used in the Copco No. 2 bypass reach. WUA curves for rainbow trout fry, juvenile, and adult life stages in the Copco No. 2 bypass reach are presented in Figure E4.2-9. WUA values are reflective of the channel shape in the reach. Because of riparian encroachment, the main channel has narrowed, leaving large, relatively flat cobble/boulder bars over portions of the reach. As water is added to the channel, velocities quickly become unsuitable for rainbow trout fry and juveniles up to 200 cfs. As flows continue to increase, water spills onto the large cobble/boulder bars producing the increase in WUA. Rainbow trout adults, on the other hand, show an increase in WUA as flows increase up to 200 cfs, in part because of their suitability for higher velocities and deeper water. Sucker WUA curves in the Copco bypass show similar patterns to rainbow trout (Figure E4.2-10). It should be noted that, although edge velocity data was collected for the hydraulic model at 600 cfs, the reliability of velocity simulations across large boulder bars may be suspect at higher simulation flows.

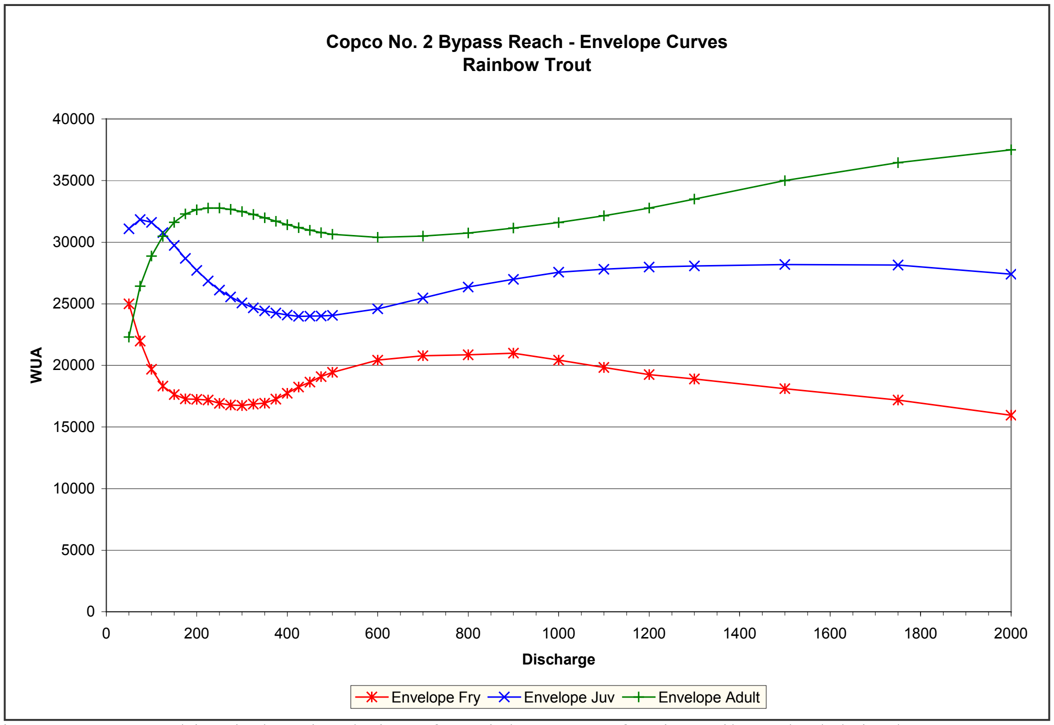


Figure E4.2-9. Habitat index simulations for rainbow trout fry, juvenile and adult in the Copco No. 2 bypass reach using envelope HSC curves.

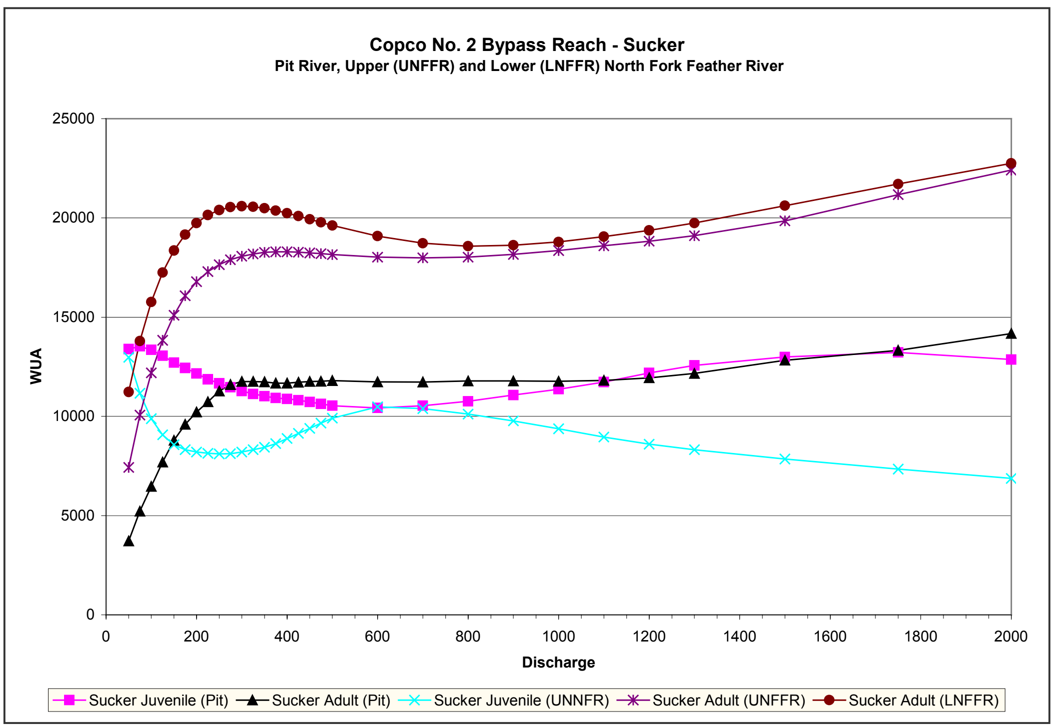


Figure E4.2-10. Habitat index simulation for juvenile and adult suckers in the Copco No. 2 bypass reach.

Fall Creek Bypass Reach

WUA curves for rainbow trout juvenile and adult life stages in the Fall Creek are presented in Figure E4.2-11. As stated previously, because of the relatively small size of the channel, it was decided to use small stream HSC (from Bucks Creek and Grizzly Creek in the northern Sierra) instead of the envelope curves developed for the Klamath River reaches. Juvenile WUA show an abrupt increase up to 5 cfs followed by a relatively flat curve. Adults WUA on the other hand show a gradual increase over the range of simulation flows.

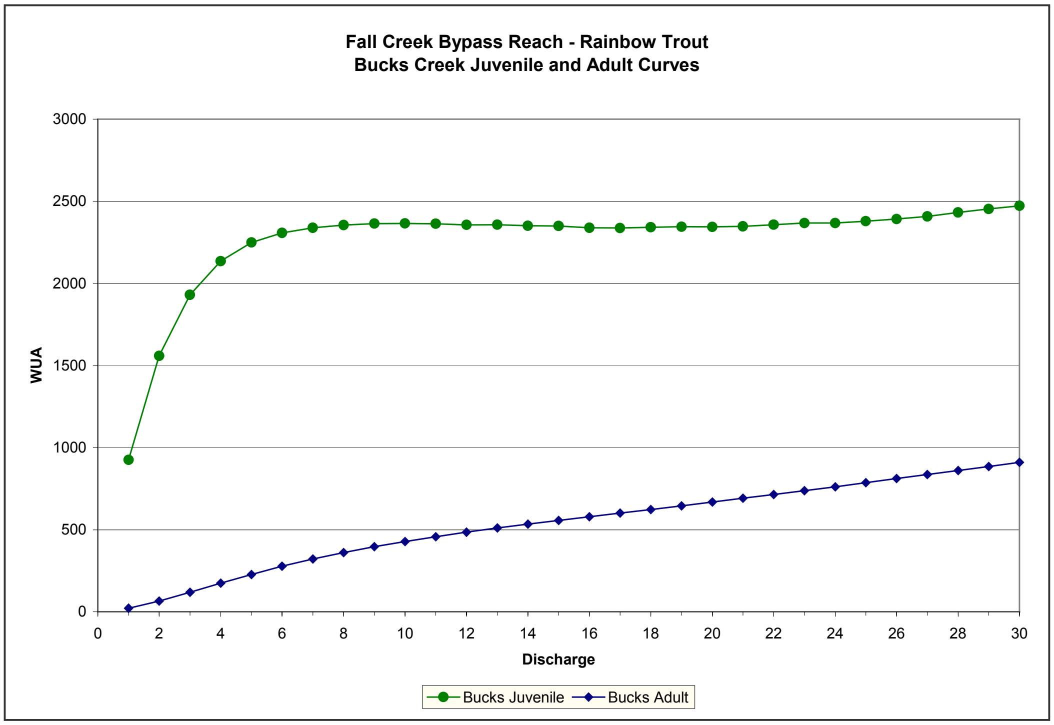


Figure E4.2-11. Habitat index simulation for rainbow trout juvenile and adult in the Fall Creek bypass. Juvenile and adult curves from Bucks Creek (Thomas R. Payne & Associates 1991).

Flow Fluctuations/Ramping

Hydroelectric facilities typically have the capability of increasing and decreasing flow levels downstream of the facilities. In general, the rate at which these changes occur is called the "ramp rate" or "ramping." From a fisheries perspective, ramping down the river flow has the potential to strand fish in areas of the channel that are relatively low-gradient, or where pockets or side channels exist in the river channel. Stranding is defined as the separation of fish from flowing water as a result of declining river stage from rapid decreases in flow (i.e., down-ramping). Smaller juvenile fish (less than about 50 mm long) are most vulnerable to potential stranding due to weak swimming ability and preference for shallower, near-shore habitats. River channel configuration, channel substrate type, time of day, and flow level before down-ramping (antecedent flow) are also key factors that determine stranding incidence. Up-ramping of flows typically is not an issue regarding fish stranding; however, the magnitude of flow change both upward and downward can affect fish behavior and habitat use as well as affect production of benthic macroinvertebrates, which are an important source of food for most riverine fish species.

In terms of fisheries/aquatic impacts, there is a major difference between a non-peaking project, such as Iron Gate, that occasionally changes flow (ramps) in response to natural hydrologic or minimum flow changes and a peaking project, such as J.C. Boyle, that typically ramps frequently and through a wide flow range. Peaking projects can create impacts on fish resources, directly and indirectly, as a result of the "rapidly varying flows" and creation of a "varial" zone on the streambed. Therefore, in reviewing the effects of streamflow fluctuations for the Project, it is important to distinguish among those developments that are 1) peaking facilities affecting riverine habitat, 2) peaking facilities that discharge directly to a reservoir thereby not affecting riverine habitat, and 3) non-peaking facilities, which at times need to alter flows.

The following sections describe current operations that affect flow fluctuations at each development that is part of the proposed Project and how those fluctuations (down-ramp and/or peaking flows) affect fish resources in the riverine reaches influenced by the Project. (The East Side and West Side developments are proposed for decommissioning. The Keno development is not included as PacifiCorp maintains the development is FERC non-jurisdictional. Therefore, these developments are not included.)

J.C. Boyle Bypass Reach

Current Down-Ramping

The J.C. Boyle Development consists of a reservoir, dam, diversion canal, and powerhouse. The powerhouse is located 4 miles downstream of the dam, and has a rated hydraulic capacity of 2,850 cfs. There is a minimum flow requirement of 100 cfs immediately downstream of the dam. Approximately 220–250 cfs of spring water enters the bypass, starting about 1 mile downstream of the dam. When inflow to J.C. Boyle reservoir exceeds 2,950 cfs and the reservoir is full, excess water is spilled into the 4-mile-long bypass reach.

The spillway at J.C. Boyle dam consists of three radial gates, each of which can pass approximately 10,000 cfs. Only one gate, however, is auto-remote controlled. Therefore, when river flows exceed approximately 13,000 cfs (assuming the powerhouse is operating), the control of ramping requires manual operation of the other two spill gates. Flows this high occur rarely.

Although ramp rates in the bypass are not a specific condition of the existing FERC license, PacifiCorp follows a ramp rate of approximately 0.6 ft/hr. This is based on incremental flow changes made at the dam of 135 cfs per 10 minutes (or 810 cfs/hr).

Down-ramping in the J.C. Boyle bypass reach does not occur for power production purposes. Therefore, down-ramping is done primarily when coming off of spill mode or a maintenance event. Although spill occurs about 10 percent of the time during the year (mostly winter and early spring), down-ramping occurs about 10 percent of the time of spill. Therefore, down-ramping in the bypass reach occurs only 1 percent of the total time in a year on average.

Effects

Because down-ramping at J.C. Boyle dam occurs rarely and mostly just during high flow events, the potential effects of down-ramping on fish resources in this reach has not been considered by PacifiCorp to be a major issue. Therefore, no specific ramping studies were performed in the reach except to describe current ramping rates and frequencies. However, it is possible that some stranding of small fish could occur at the current down-ramp rates under certain flow conditions and times of the year. When flows are dropping from about 1,000 cfs to the minimum of 350 cfs (lower reach segment) dewatering of streambed areas and a few side channels can pose a risk of stranding to small fish. Trout do spawn in this reach, and trout fry occur along the stream margins from early June through the summer. Although spill and the need to down-ramp rarely occur during this period, minimizing down-ramping rates during this period would be of benefit to reduce opportunity for fish stranding. The current practice is to down-ramp at a flow change rate that approximates 0.6 ft/hr.

J.C. Boyle Peaking Reach

Current Operations

Typically, the J.C. Boyle powerhouse is operated as a power peaking facility, especially when river flows reaching the dam are less than the rated turbine hydraulic capacity of 2,850 cfs. Power generation, and hence flow through the powerhouse, is shaped to coincide with peak customer electricity demand during the daytime. During the summer, peak demand typically occurs in the late afternoon and early evenings. Given the required up-ramp rate limit of 9 inches/hr below the powerhouse, generation must begin well in advance of peak electric load requirements so that the unit(s) are at full capacity for the peak demand period. Also, during the summer PacifiCorp attempts to bring river flows up in late morning to facilitate white water recreation.

The J.C. Boyle peaking reach between the powerhouse and Copco reservoir is 16 miles long. When ramping is initiated at the powerhouse it generally takes 5 to 6 hours for the flow change to arrive at Copco reservoir. Ramping can take place during any month of the year, but is most likely to occur in the drier summer and fall months. During times that spill is not occurring at the dam, discharges at the J.C. Boyle powerhouse are being down-ramped about 20 percent of the time. The rates of stage decline at the gauge location reflect the current practice of down-ramping (and up-ramping) at generally between 0.4 and 0.75 ft/hr.

Potential Peaking-Associated Effects on Fish

In an effort to identify effects of peaking on fish resources and potential mechanisms leading to these effects, several factors were explored. Specific studies and data analyses were performed to provide quantitative information, to the extent practical, on peaking-related factors potentially affecting or indicating effects on fish in the J.C. Boyle peaking reach. Some of the analysis compares fisheries information between the peaking reach and the Keno reach, which does not experience flow fluctuations associated with hydropower peaking. The factors evaluated include:

- Streambed Dewatering
- Fish Community Comparisons
- Trout Spawning Distribution
- Trout Fry Distribution and Movement
- Adult Trout Movement
- Juvenile Fish Stranding
- Trout Growth and Condition

Streambed Dewatering

To assess potential aquatic resource effects from flow fluctuations associated with peaking operations at J.C. Boyle, the amount of streambed that is alternately watered and dewatered in the peaking cycle was quantified for various flow ranges. This area is referred to as the varial zone. Aquatic productivity in terms of algae and macroinvertebrates is severely limited in this zone.

Quantification of the varial zone between different increments of flow was based on the stage-discharge relationships and cross sections surveyed as part of the instream flow study conducted in 2002. Data from 71 cross sections were available for analysis in the peaking reach. Standard output of the hydraulic model used in PHABSIM includes wetted perimeter as a function of flow at each cross section. These wetted perimeter versus discharge relationships were developed for individual habitat types (riffle, run, pool, and glide). Grouping of the “all habitat” and “riffle only” relationship curves is shown in Figures E4.2-12 and E4.2-13.

The streambed in the varial zone, by definition, is not continuously wetted, and consequently, has little “effective” value for production of benthic organisms, such as algae and macroinvertebrates. Therefore, in terms of assessing impacts among peaking flow alternatives, it is the differences in the amount of continuously wetted streambed during several weeks’ time that best relates to benthic productivity potential. This is especially true in riffles, which tend to produce greater densities of benthic organisms than other mesohabitats. The “continuously wetted” streambed is best represented by the estimated wetted perimeter at the base flow within the peaking (or non-peaking) cycle. The following are examples of an impact assessment for the J.C. Boyle peaking reach using wetted perimeter information:

- Current peaking cycle (350-cfs base flow) compared to typical summer ROR flow of 700 cfs
- Current peaking cycle (350 cfs base flow) compare to typical spring ROR flow of 1,400 cfs

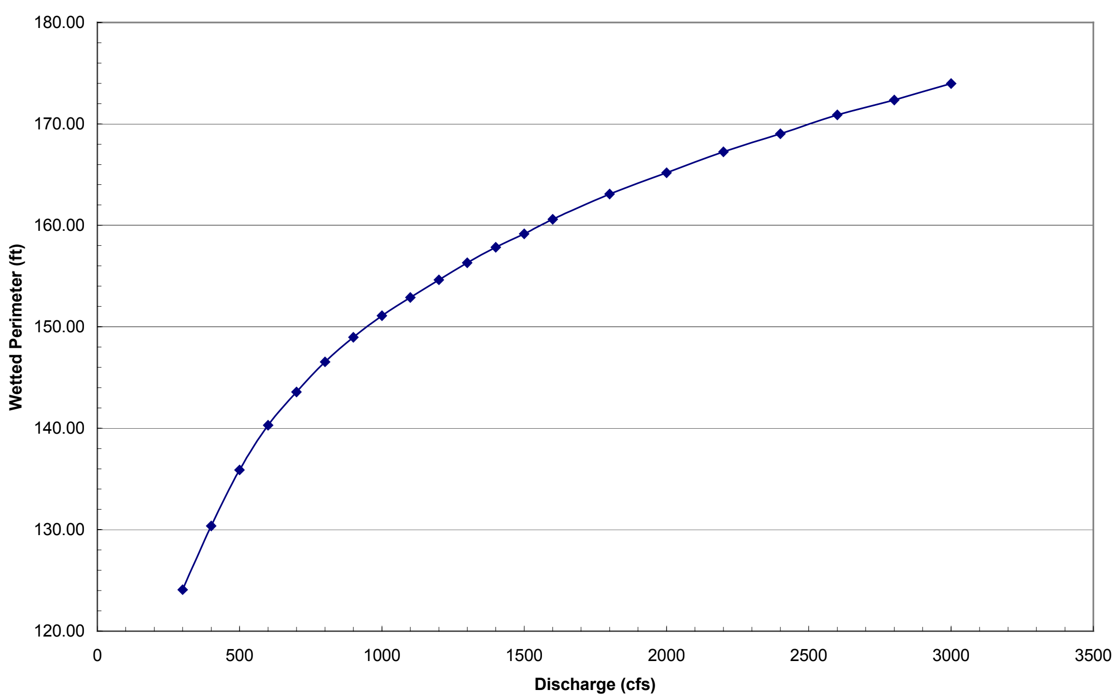


Figure E4.2-12. Wetted perimeter vs. discharge for all habitat types in the J.C. Boyle peaking reach.

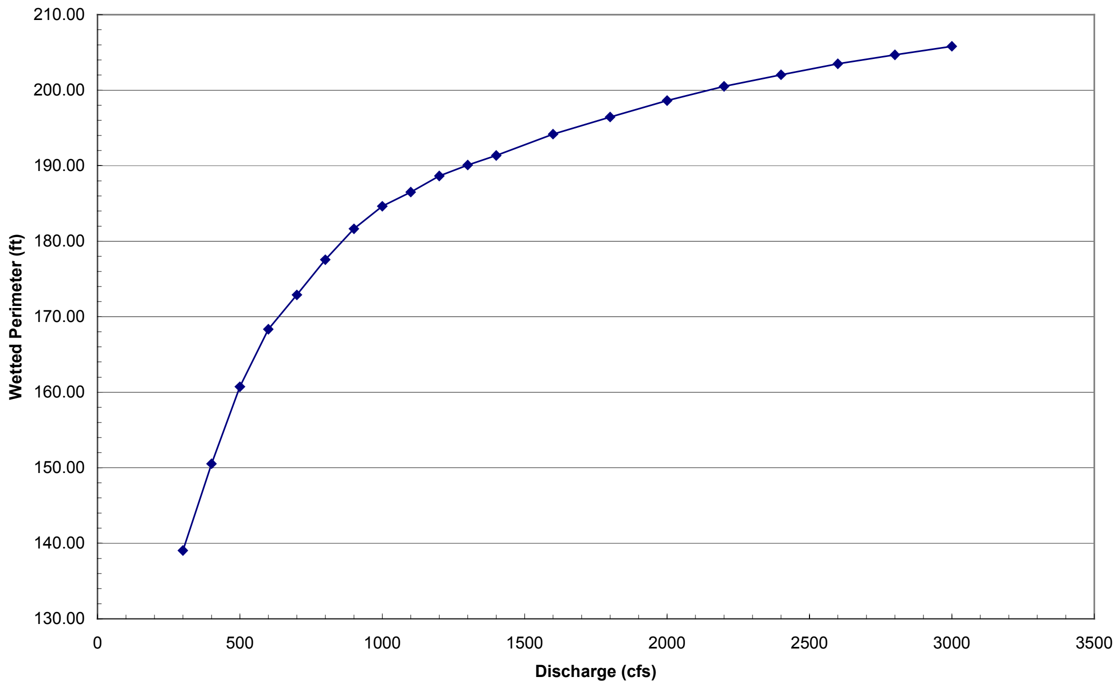


Figure E4.2-13. Wetted perimeter vs. discharge for riffle habitat in the J.C. Boyle peaking reach.

In the first example, applying the "all-habitat" wetted perimeter-flow curve, the average wetted perimeter at the 350-cfs base flow is 127.2 feet. At the assumed summer ROR flow of 700 cfs, the wetted perimeter is 143.6 feet. Therefore, the current peaking cycle provides 16.3 feet (11.4 percent) less wetted perimeter compared to ROR flow (Table E4.2-19). Applying only the riffle mesohabitat relationship between wetted perimeter and flow, the current peaking cycle provides 28.1 feet (16.3 percent) less wetted perimeter compared to ROR flow.

Table E4.2-19. Differences in streambed wetted perimeter (WP) for total habitats and riffle-only habitats between two run-of-river conditions and the current peaking-cycle base flow.

Run-of-River			**Peaking**			**Percent Differences**	
Base Flow (cfs)	WP total	WP riffle	Base Flow (cfs)	WP total	WP riffle	WP total	WP riffle
700	143.6	172.9	350	127.2	144.8	-11.4%	-16.3%
1400	157.8	191.4	350	127.2	144.8	-19.4%	-24.3%

In the second example, the average wetted perimeter for "all habitat" at the 350-cfs base flow is 127.2 feet. At the assumed spring ROR flow of 1,400 cfs, the wetted perimeter is 157.8 feet. Therefore, the current peaking cycle provides 30.6 feet (19.4 percent) less wetted perimeter compared to ROR flow in the spring (see Table E4.2-19). Applying only the riffle mesohabitat relationship between wetted perimeter and flow, the current peaking cycle provides 46.6 feet (24.3 percent) less wetted perimeter compared to ROR flow in this springtime example.

It is clear that peaking operations reduce the area of wetted streambed, which supports production of benthic organisms. Although the abundance and diversity of macroinvertebrates in the continuously-wetted areas of the J.C. Boyle peaking reach do not differ significantly from those in the non-peaking reaches in the Project area, the abundance and diversity in the varial zone of the peaking reach is significantly reduced compared to the adjacent continuously-wetted areas (see the Water Resources FTR, Sections 8 and 12). It is not known whether the reduced macroinvertebrate abundance in the peaking reach varial zone has, in turn, significantly affected the growth and condition of fish in the peaking reach. Information presented below on the growth and condition of trout in the peaking reach compared to trout in the non-peaking Keno reach provides some indication of possible effect.

Fish Community Comparisons

Electrofishing catch rates were used to compare fish communities in the Keno and J.C. Boyle peaking reaches. Based on the combined catches in all segments and seasons for each reach, relative catch rates indicate that fathead minnows and chubs (blue and tui) are more abundant in the Keno reach (Table E4.2-20). However, most of these species in the Keno reach were collected from a single location just downstream of Keno dam. The location consisted of quiet water pockets among large boulders interspersed with reed canary grass. It is likely that the calm water at this location was attractive to the large number of chubs and fathead minnows that move downstream out of Keno reservoir. These species prefer slack-water habitat, especially lakes and reservoirs. This location also contained many marbled sculpin.

Table E4.2-20. Keno and J.C. Boyle peaking reaches, fish catch per-hour by backpack electrofishing for all seasons and segments combined.

Common Name	Keno Reach	J.C. Boyle Peaking Reach
Redband trout	46.2	19.1
Blue chub	85.0	4.4
Tui chub	64.0	5.2
Speckled dace	190.6	286.3
Sculpin (marbled)	226.2	106.0
Lamprey	0.4	0
Lost River sucker	0.4	0
Unknown sucker spp.	0	30.2
Bluegill	0.4	0
Pumpkinseed	0.4	0
Fathead minnow	107.4	0
Unknown species*	42.0	0

*Most likely fathead minnows and/or chubs

To factor out the influence of this single location, catch rates in the lower half of the Keno reach were compared to those in the J.C. Boyle peaking reach. This comparison indicates that the difference in fish communities between reaches is not very apparent, especially for the native riverine species, speckled dace and marbled sculpin (Table E4.2-21). These two species were the most commonly observed in both reaches. Although much less abundant than in the upper Keno reach, the lower Keno reach still had a greater relative catch rate of fathead minnow and chubs compared to the J.C. Boyle peaking reach. These species are prolific in Upper Klamath Lake and Keno reservoir, both located upstream of the Keno reach. Annual movement of these species from Upper Klamath Lake to Keno reservoir was estimated to be more than 300,000 (New Earth/Cell Tech and PacifiCorp, 1999). It is unknown whether the greater relative abundance of fathead minnows and chubs in the Keno reach is the result of their recruitment from the upstream reservoir or whether flow fluctuations in the peaking reach create unfavorable conditions for them to reside there. However, the fact that few chubs and fathead minnows were observed in the non-peaking bypass reach below J.C. Boyle dam suggests that recruitment from upstream rather than flow fluctuations account for the difference. The peaking reach had a greater relative catch rate of suckers, which are native to the system, compared to the Keno reach.

Table E4.2-21. Keno reach segments and J.C. Boyle peaking reach, fish catch per-hour by backpack electrofishing.

Common Name	Keno Reach		J.C. Boyle Peaking Reach
	Upper Segment	Lower Segment	
Redband trout	3.0	69.7	19.1
Blue chub	222.3	10.4	4.4
Tui chub	142.5	21.4	5.2
Speckled dace	165.7	204.1	286.3
Sculpin (marbled)	469.8	93.8	106.0
Lamprey	0	0.5	0
Lost River sucker	1.0	0	0
Unknown sucker spp.	0	0	30.2
Bluegill	1.0	0	0
Pumpkinseed	0	0.5	0
Fathead minnow	231.4	40.1	0
Unknown species*	99.0	11.0	0

*Most likely fathead minnows and/or chubs

The backpack electrofishing catch rate of redband trout was substantially greater in the Keno reach (46.2 fish/hr) than that in the J.C. Boyle peaking reach (19.1 fish/hr) (see Table E4.2-20). However, most of the trout in the Keno reach were observed in the lowest 0.5 mile just above J.C. Boyle reservoir. The upper Keno segment produced a trout catch rate of only 3.0 fish/hr (Table E4.2-21). Recruitment of juvenile trout into the Keno reach is believed to be from Spencer Creek, which is a tributary of J.C. Boyle reservoir (ODFW, 1991). Therefore, the relatively high catch rates in the lowermost Keno reach may be merely indicative of their source from Spencer Creek. Perhaps similarly related to recruitment source, most of the electrofished trout from the peaking reach were collected in the California segment downstream of Shovel Creek, which is known to be the primary spawning location for trout in the lower peaking reach (Beyer, 1984).

Peaking operations at the J.C. Boyle powerhouse occur primarily from late spring through fall, although such operations may occur at any time of the year based on water inflow. Therefore, a comparison of catch rate trends through the seasons may indicate cumulative effects of peaking. For the two primary non-trout native riverine species, speckled dace and marbled sculpin, catch rates in the Keno reach declined steadily for both species for the May through October sampling season (Table E4.2-22). In the J.C. Boyle peaking reach, catch rates for these species increased substantially between spring and summer, followed by a moderate decline in the fall. These results do not suggest any cumulative effect associated with peaking for these two most common native species.

Table E4.2-22. Keno and J.C. Boyle peaking reaches seasonal fish catch per-hour by backpack electrofishing.

Common Name	Keno Reach			J.C. Boyle Peaking Reach		
	Spring	Summer	Fall	Spring[a]	Summer	Fall
Redband trout	72.0	25.0	42.3	0	63.2	2.9
Blue chub	83.4	0	132.9	10.3	0	0
Tui chub	7.6	41.7	110.7	24.1	0	0
Speckled dace	306.9	211.4	108.3	68.8	497.7	261.4
Sculpin (marbled)	552.0	166.9	60.7	31.0	144.8	116.2
Lamprey	1.3	0	0	0	0	0
Lost River sucker	1.3	0	0	0	0	0
Unknown sucker spp.	0	0	0	0	0	59.5
Bluegill	1.3	0	0	0	0	0
Pumpkinseed	0	0	0.8	0	0	0
Fathead minnow	21.5	65.4	182.9	0	0	0
Unknown species [b]	0	162.7	0.8	0	0	0

[a] California segment of peaking reach not sampled

[b] Most likely fathead minnows and/or chubs

The typical daily peaking operation involving one turbine at the J.C. Boyle powerhouse produces a streambed varial zone of about 30 feet and a river stage drop of about 20 inches during a period of 3 to 6 hours (depending on distance from powerhouse). It would seem likely that small fish species preferring to reside and feed in shallow nearshore areas would be adversely affected by these frequent flow fluctuations. This might be especially true for speckled dace, which prefer shallow areas close to the shoreline, and sculpin and suckers, which have strong fidelity to the bottom substrate. However, the electrofishing catch rate data do not indicate any major differences for these species between the non-peaking Keno reach and the J.C. Boyle peaking reach.

Trout Spawning Distribution

Spawning of redband trout has never been documented in the J.C. Boyle peaking reach. Trout spawning that contributes to recruitment of juveniles to the peaking reach is known to occur in Spencer Creek [requiring passage at the J.C. Boyle dam], the J.C. Boyle bypass reach, and

Shovel Creek [in California]. The following is brief documentation of known trout spawning areas that appear to support recruitment to the peaking reach.

In the first 4 years after construction of J. C. Boyle dam in late 1958, between 800 and 3,400 adult trout migrated upstream in the springtime through the fish ladder at the dam (see the Fish Resources FTR, Section 7). These fish were believed to be returning to their natal spawning areas in Spencer Creek or perhaps to the gravel depositional area at the creek's mouth (prior to inundation). The number of trout moving upstream through the ladder annually has declined to a few hundred fish in more recent years.

In the bypass reach, trout spawning was observed only anecdotally during the Salt Caves studies in the late 1980s. In 2003, PacifiCorp undertook concerted efforts to better survey the reach for trout spawning activity. During two spawning surveys, 66 trout redds were identified. Most redds were observed in the lower half of the reach where it is dominated by spring water and contains patches of gravel deposited mostly behind boulders. Pre-survey observations also noted concentrated spawning activity in other areas in the bypass reach, but redds could not be positively identified. In addition, results of a trout movement study, also conducted in 2003, observed some adult trout moving from the peaking reach into the bypass reach presumably to spawn (see the Fish Resources FTR, Section 5). Based on the results of these recent studies, it is clear that the bypass reach is an important spawning area for trout. Although spawning gravel is limited in the bypass reach, the clear spring water undoubtedly contributes to the suitability of this reach for spawning and subsequent egg incubation.

Shovel Creek is a well known spawning area for trout in the California segment of the J.C. Boyle peaking reach. The spawning run was studied extensively by Beyer (1984). PacifiCorp's trout movement study (see the Fish Resources FTR, Section 5) found that nearly all (11 of 14) of the adult trout radio-tagged in the California segment of the peaking reach entered and presumably spawned in Shovel Creek. Also, two of the 14 fish radio-tagged in the upper Oregon segment of the peaking reach dropped downstream and entered Shovel Creek.

Based on the above evidence, it appears that little or no trout spawning occurs in the mainstem J.C. Boyle peaking reach. This conclusion is consistent with previous assessments (National Park Service, 1994; City of Klamath Falls, 1986). The fact that several thousand trout moved upstream through the J.C. Boyle fish ladder during the first few years after completion of the dam in 1958 suggests that the primary spawning areas for trout from below the dam site historically were above the dam site. Therefore, the current peaking operations do not affect any known trout spawning areas or subsequent egg incubation and fry emergence in the peaking reach. The lack of suitable spawning substrate in the reach, the evidence of large pre-dam spawning migrations to areas upstream of the dam site, and the historical accounts of large trout spawning migrations into Shovel Creek all suggest that trout did not likely spawn historically in the mainstem peaking reach. While it can be concluded that the construction of J.C. Boyle dam has altered the distribution of trout spawning, so it is less dependent on Spencer Creek and more dependent on the bypass reach, there is no basis to conclude that the flow fluctuations from peaking operations have adversely affected trout spawning distribution or success.

Trout Fry Distribution and Movement

The possibility that flow fluctuations associated with peaking operations could encourage small fish to move downstream was evaluated. A review of the literature regarding movement of juvenile salmonids in response to flow fluctuations is presented in the Fish Resources FTR, Section 6. Most of the reviewed studies were conducted in experimental stream channels with uniform hydraulics (channel shape) and minimal refuge area. The results of these studies suggest that wide flow fluctuations can encourage greater rates of downstream movement compared to a non-fluctuating regime, but typically only for a short time following fry emergence from the gravel when the fry tend to disperse naturally. Once fry grow out of this stage, they become more territorial and are less apt to move downstream in response to flow changes. In cases where increased emigration of emergent fry has been observed, most movement occurred only when water velocities in the fry-occupied areas exceeded their upper preference limit of about 1 fps.

To assess the potential for peaking-induced trout fry movement in the J.C. Boyle peaking reach, PacifiCorp conducted a trout fry distribution and abundance study in 2003. The results of the complete study are presented in the Fish Resources FTR, Section 3. During the biweekly sampling between late May and early September, a total of 1,212 fry were captured by single-pass electrofishing at 26 index locations (six in the bypass and 10 each in the Oregon and California peaking reaches). Two approaches were used to determined downstream movement. One approach was to examine changes in fry densities over time at each of the index areas to determine whether fry were dispersing downstream from the areas of initial highest density near known spawning areas (J.C. Boyle bypass reach and Shovel Creek). The other approach was to mark (fin clip) and recapture fry following at least one peaking cycle to determine whether they tended to remain near the area of original capture or move to downstream sampling areas.

Results of the trout fry movement studies indicated very little downstream dispersal of fry. In the Oregon portion of the J.C. Boyle peaking reach, fry were captured in the upper five index areas closest to the bypass reach where they most likely originated, but almost no fry were observed in the downstream index areas near Frain Ranch (Figure E4.2-14). In the California portion of the J.C. Boyle peaking reach, all fry were observed in the river downstream of the mouth of Shovel Creek; none were observed at the three locations upstream of Shovel Creek in California. Repeat sampling through the summer at these locations showed only a minor decrease in fry densities at all reaches, and the highest densities remained near the known spawning areas. Results of the mark-recapture studies indicated that all of the recaptured fry in the peaking reach were collected at the same location they were originally captured and marked.

Adult Trout Movement

Movements of adult trout in response to peaking were assessed using observations of radio-tagged fish in the summer of 2003. Complete radio-telemetry study results are included in the Fish Resources FTR, Section 5. Results of the study found that of 12 observations made during a peaking cycle only four movements were noted. These movements were generally not extensive (10 to 210 feet) and usually occurred either upstream or downstream within the same habitat unit. These results are consistent with the findings of other studies of trout movement in response to flow fluctuations from power peaking. Both Niemela (1989) and Pert and Erman (1994) found that trout tend to stay in the immediate area, usually in the same habitat unit, when exposed to wide flow fluctuations, but the movement response of each fish can be variable. Some fish remain faithful to a single location while other fish tend to move to more energetically favorable sites for foraging or refuge. Studies by Pert and Erman (1994) and by Rincon and Lobon-Cervia (1993) observed that the trout that remained faithful to one location often lowered their position in the water column closer to the substrate in response to increased water velocities. The studies conducted in the J.C. Boyle peaking reach in 2003 were not designed to detect changes in vertical position.

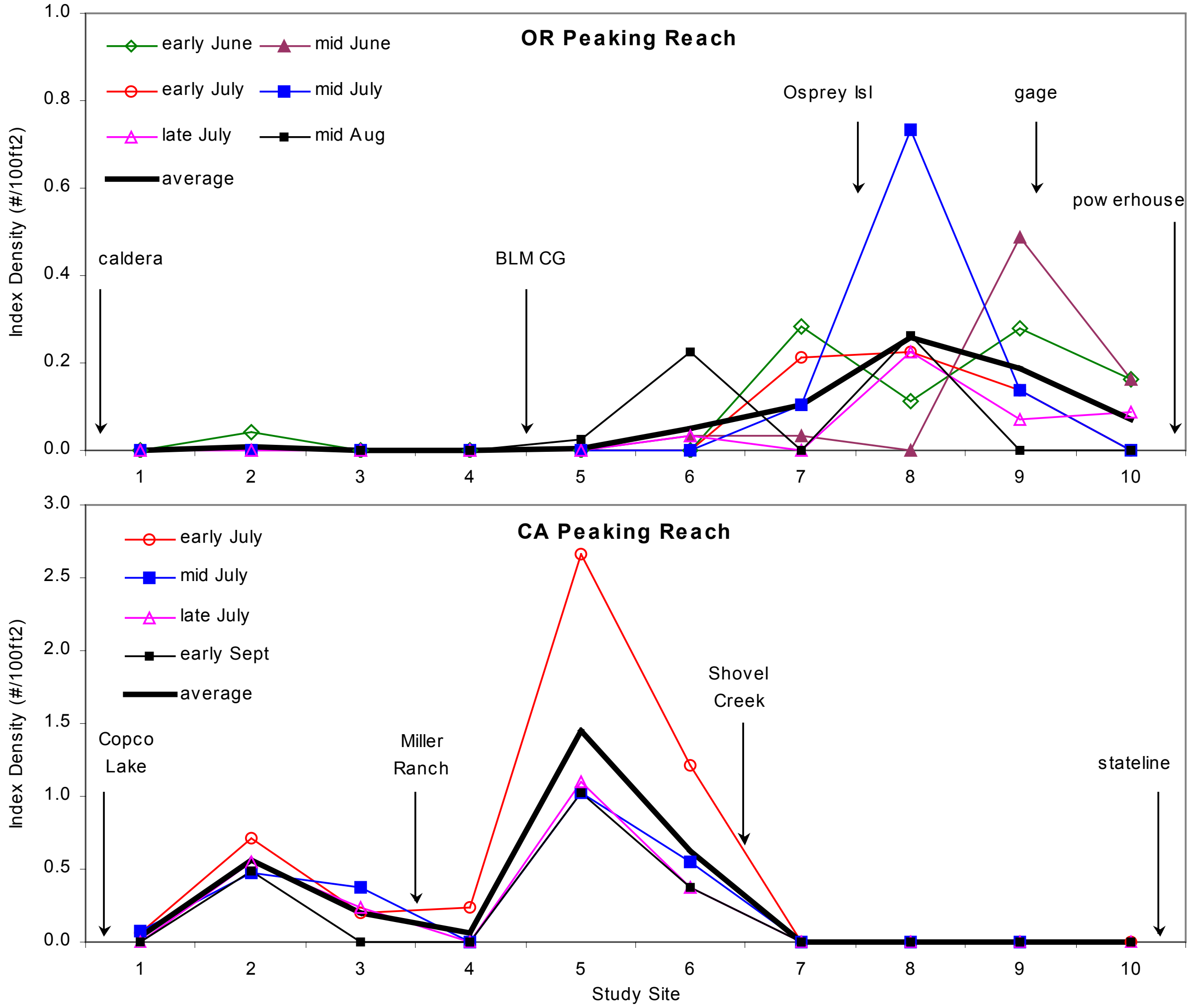


Figure E4.2-14. Index densities of rainbow trout fry (<50 mm FL) in the J.C. Boyle peaking reach according to location, index site, and sampling period. Approximate locations of landmarks are indicated.

Another objective of the radio-telemetry study was to determine whether migrating adult trout respond to the differences in water quality and flow at the confluence of the bypass reach and powerhouse tailrace when the powerhouse is discharging. Study results found no conclusive evidence of delay or deterrence of fish at this location. In fact, most fish appeared to move past the powerhouse tailrace and into the bypass reach on their first attempt without delay.

Juvenile Fish Stranding

Observations made for fish stranding in the J.C. Boyle peaking reach were conducted at two locations in Oregon at Frain Ranch (RM 214.3) and at three locations in California downstream of Shovel Creek (RM 206.3) (see the Fish Resources FTR, Section 6). These sites were selected for having high potential for fry stranding based on (1) large exposure area, (2) low beach gradient (less than 2 percent), (3) depressions and potholes, (4) presence of both aquatic vegetation and submerged grasses at the high-flow end of the ramping event, (5) top of islands, and (6) association with side channels. In total, the sites represent 75,500 square feet of area that becomes dewatered during a typical one-unit down-ramping cycle.

Observations were made on May 31, July 11, and August 8-9, 2002, and again on June 10-11, July 14, and August 19-20, 2003. These time periods were chosen to coincide with the period during which fry, especially trout fry, would most likely be present. Ramping on these dates (and throughout these periods) generally consisted of up-ramping in the morning (at the powerhouse) and down-ramping in late afternoon or evening through a flow range of approximately 1,500 (one turbine unit) to 350 cfs. The test conducted June 10-11, 2003, occurred following a down-ramp from 2,800 to 350 cfs (both turbine units). Ramping rates recorded at the USGS gauge just downstream of the powerhouse averaged about 0.7 ft/hr.

The results of the fish stranding/entrapment observations made in 2002 are shown in Table E4.2-23. During the three tests conducted in 2002, no fish of any species or size were observed stranded. However, eight to 10 live trout fry were observed trapped in a pothole at the Foam Eddy bar (California) on July 11, 2002. The particular pothole was near shore and shaded, and was not at risk of drying up before the next flow cycle. Trout fry were observed swimming along the margins of all California sites in 2002, but not at the Oregon sites. Numerous small dace, often several hundred, were observed swimming along the margins at most sites, but none were seen stranded.

In the three tests conducted in 2003, six fish were observed stranded (Table E4.2-24): four sculpin, one speckled dace, and one unidentified sucker. Five of the six fish were observed at the Frain Ranch sites in Oregon. None of the fish was of a fry size for their species. The sculpins ranged from 75 to 85 mm; the dace was 110 mm; and the sucker was 135 mm.

Results of the stranding observation tests, while demonstrating some limited stranding of non-trout species, provided no indication that trout fry were being stranded by the current down-ramping in the peaking reach. The failure to observe any stranded trout fry could be influenced by low numbers of fry present at the study sites. Results of trout fry distribution studies conducted in the summer of 2003 (see the Fish Resources FTR, Section 3) found trout fry at sites just downstream of the J.C. Boyle powerhouse, but almost none near Frain Ranch where the two Oregon stranding observation sites were located. However, trout fry were observed during the fry distribution study downstream of the mouth of Shovel Creek (a known spawning tributary) where all of the California stranding test sites were located. Also, trout fry were observed at base flow along the margins of all three stranding test sites in California following the down-ramp tests. Thus, while trout fry generally may not be abundant in the peaking reach, the stranding observation sites in California corresponded to where most fry seem to be distributed in the reach.

Table E4.2-23. Peaking reach fish stranding and entrapment observations, 2002.

	May 31, 2002				July 11, 2002				August 8-9, 2002			
Site	**ΔFlow**	**No. Strand.**	**No. Trap.**	**Notes**	**ΔFlow**	**No. Strand.**	**No. Trap.**	**Notes**	**ΔFlow**	**No. Strand.**	**No. Trap.**	**Notes**
Island Complex	1,500 – 350	0	0		1,500 – 350	0	0	Numerous dace along margins	1,500 - 350	0	0	Hundreds of 1" to 1.5" dace along margins Several trout fry along margin
Miller Bridge	1,500 – 350	0	0		1,500 – 350	0	0	Several trout fry in side channel Numerous dace at Shovel Creek mouth	1,500 - 350	0	0	Several trout fry in side channel
Foam Eddy	1,500 – 350	0	0		1,500 – 350	0	8-10 trout fry	Trapped fry in 10' x 3' pothole Several trout fry observed along river margin	1,500 - 350	0	0	
Caldera	1,500 – 350	0	0		1,500 – 350	0	0	100s of dace along river margin	1,500 - 350	0	0	
Point BAR	1,500 – 350	0	0		1,500 – 350	0	0	Numerous dace in river above Shovel Creek	1,500 - 350	0	0	

Table E4.2-24. Peaking reach fish stranding and entrapment observations, 2003.

	June 10-11, 2003				July 14, 2003				August 19-20, 2003			
Site	**Δflow**	**No. Strand.**	**No. Trap.**	**Notes**	**ΔFlow**	**No. Strand.**	**No. Trap.**	**Notes**	**ΔFlow**	**No. Strand.**	**No. Trap.**	**Notes**
Island Complex	2,800 – 350	0	0	3 trout fry observed in river above side channel	1,500 - 350	0	0	100s of 1" dace along margins Sculpin darting among rooks	1,700 - 350	0	0	Dark. Flashlights used.
Miller Bridge	2,800 – 350	0	0	Numerous dace	1,500 - 350	0	0	No trout fry observed in s.c.	1,700 – 350	1 Sculpin (80 mm)	0	Dark
Foam Eddy	2,800 – 350	0	0	1 trout fry observed in river margin	1,500 - 350	0	0	No trout fry observed along margin	1,700 - 350	0	0	Dark
Caldera	2,800 – 350	1 dace (110 mm)	0	Stranded dace ~50' from bank	1,500 - 350	0	0	100's of dace along margin before and as dropping 5 garter snakes on bar	1,700 - 350	1 sucker sp. (135 mm)	0	Dark
Point BAR	2,800 – 350	2 sculpin (75 mm each)	0	Both stranded sculpin near grass edge on sand/silt substrate	1,500 - 350	0	0	3 garter snakes on bar	1,700 - 350	1 sculpin (85 mm)	0	Dark. 2 garter snakes on bar

Another factor that may have influenced the results of the fish stranding observations is the attenuation of the down-ramping rate, measured by stage change per hour, as the water travels downstream of the powerhouse. The down-ramp attenuation (and lag time) was evaluated at lower Frain Ranch (5.4 miles below the powerhouse) and at the mouth of Shovel Creek (13.4 miles below the powerhouse). At Frain Ranch, the powerhouse down-ramp rate of approximately 9 inches/hr became attenuated to about 5 inches/hr (Figure E4.2-15). This equates to a 44 percent reduction in the down-ramp rate. At the Shovel Creek site, a powerhouse down-ramp rate of about 8 inches/hr was attenuated to about 3 inches/hr (Figure E4.2-16). This equates to a 62 percent reduction in down-ramp rate. At both sites, the rate of attenuation was accompanied by a corresponding increase in the duration of the down-ramp event. For example, the 3-hour-duration down-ramp event at the powerhouse lasted 6 hours at the mouth of Shovel Creek (see Figure E4.2-16).

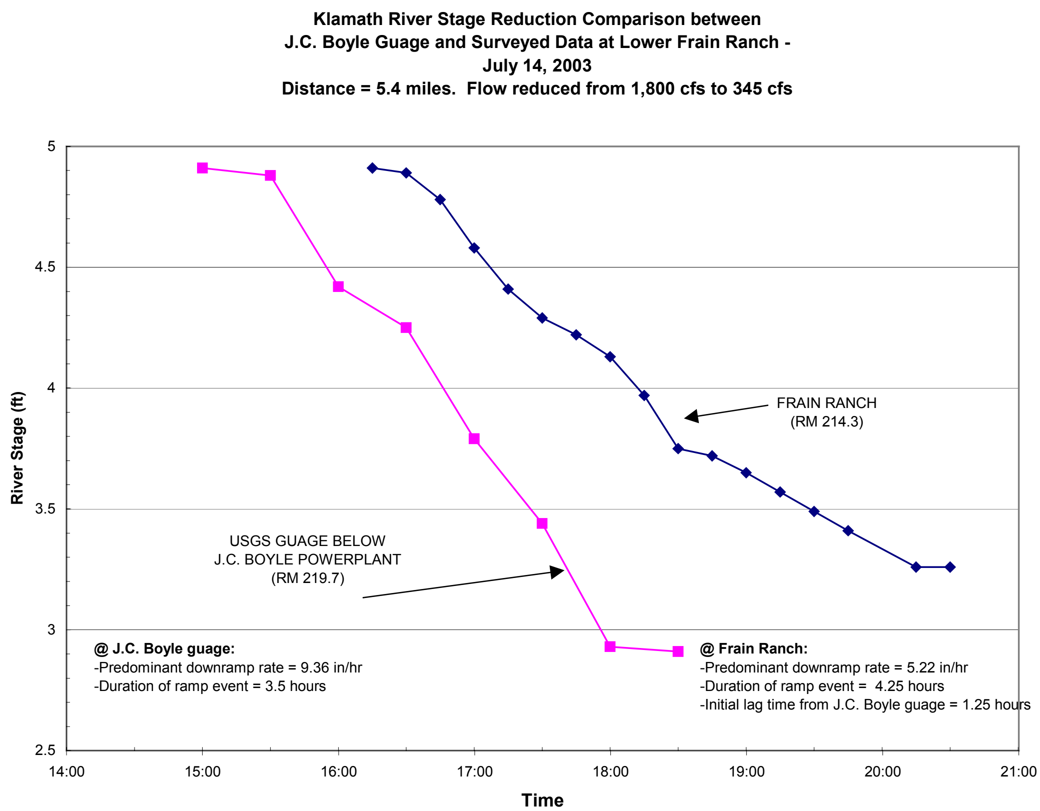


Figure E4.2-15. Klamath River stage reduction comparison between J.C. Boyle gauge and surveyed data at lower Frain Ranch, July 14, 2003.

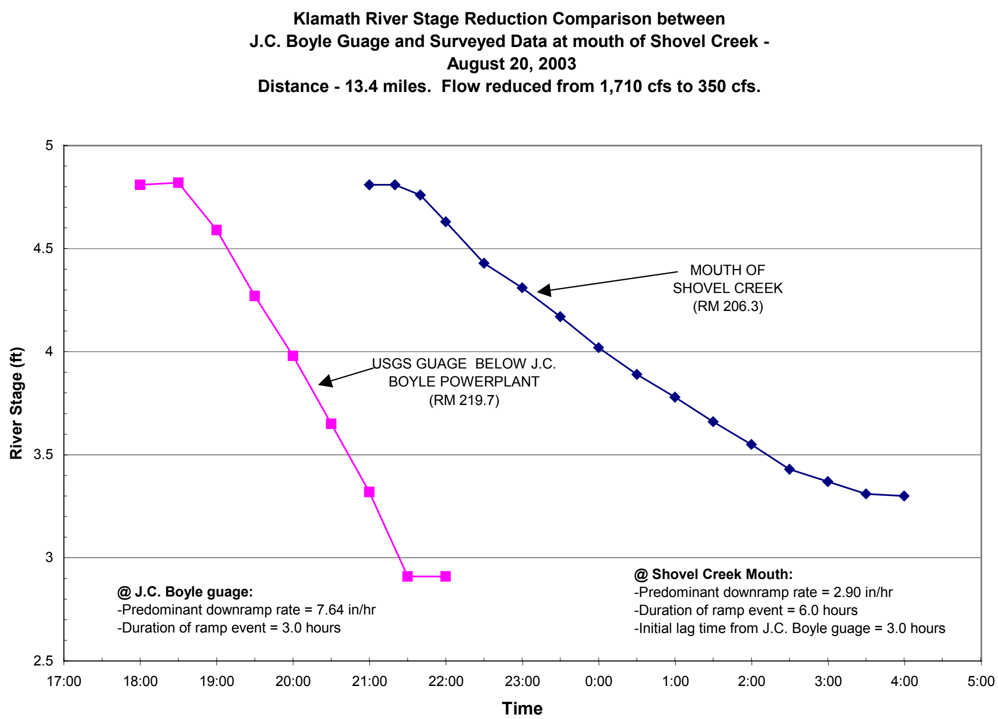


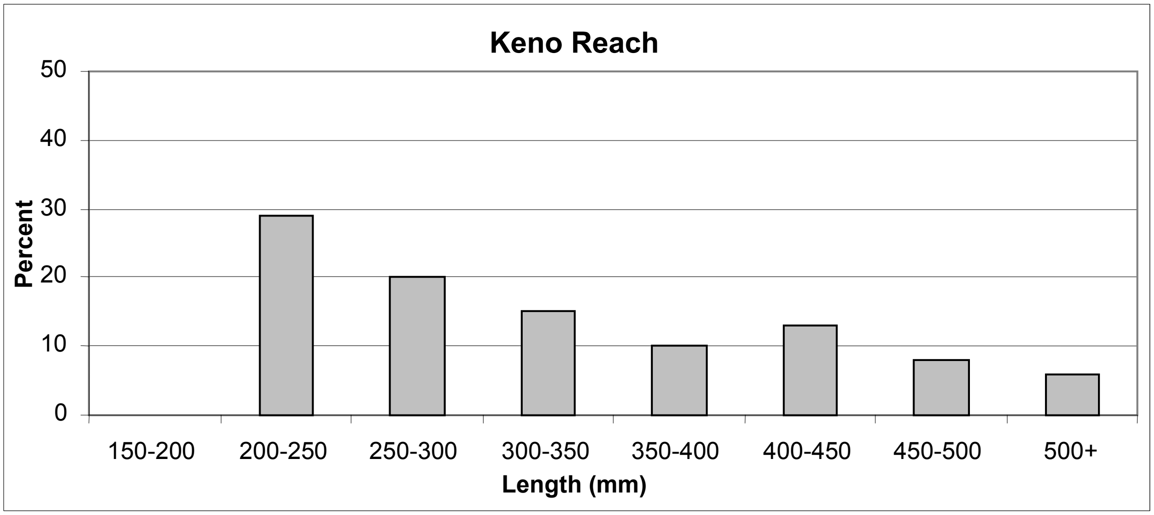
Figure E4.2-16. Klamath River stage reduction comparison between J.C. Boyle gauge and surveyed data at mouth of Shovel Creek, August 20, 2003.

Trout Growth and Condition

The J.C. Boyle peaking reach experiences much more frequent and extensive flow fluctuations compared to the Keno reach. Therefore, comparisons of the fisheries data for the Keno and peaking reaches were made to provide insight to potential effects of peaking operations at J.C. Boyle powerhouse. Parameters compared below include redband trout size, age and length information, and condition factors.

Size

ODFW conducted angler surveys in the Klamath River (to the Oregon/California state line) from 1979 through 1982. This period followed a change in trout management that included a cessation of planting of hatchery-reared trout. Therefore, all fish were assumed to be naturally produced. Trout captured in the Keno reach were considerably larger than those captured in the J.C. Boyle peaking reach (Figure E4.2-17). More than half of the Keno reach trout exceeded 300 mm, whereas about 24 percent of the peaking reach trout were larger than 300 mm.



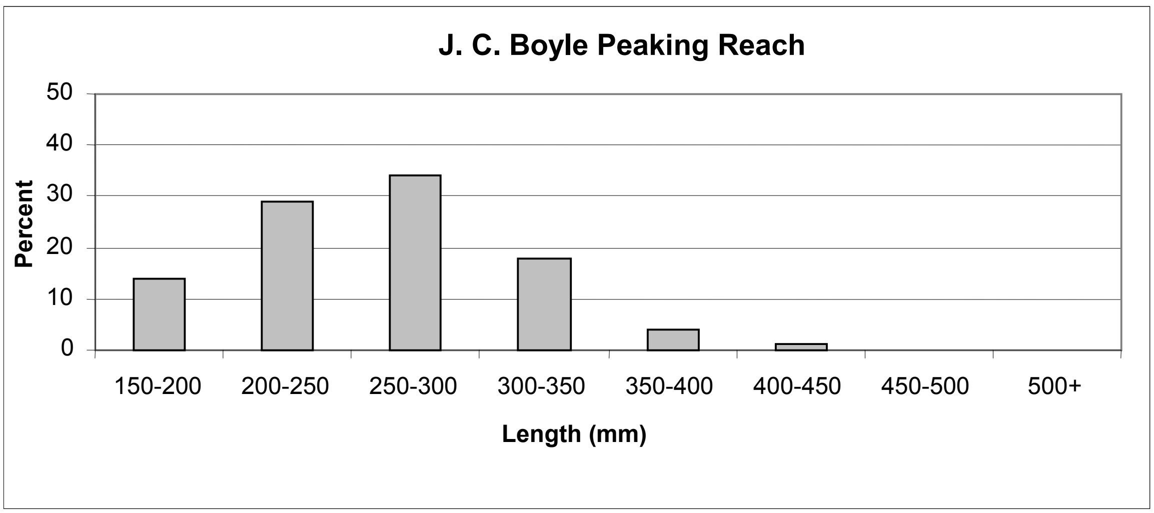


Figure E4.2-17. Redband trout length frequency from 1979 to 1982 ODFW angler surveys.

Results of sampling conducted by angling in 2002 (as part of PacifiCorp's fisheries investigation study) indicate the same general differences in trout length in the two reaches as was seen in the 1979-1982 data (Figure E4.2-18). Average lengths were 271 and 251 mm for the Keno and J.C. Boyle peaking reaches, respectively. The primary length mode was 250 to 300 mm in both reaches. However, trout in the Keno reach exhibited a much larger range in size with more fish in the larger size classes. In the Keno reach, 28 percent of the trout were more than 300 mm compared to 16 percent in the J.C. Boyle peaking reach.

Both the ODFW data and the 2002 sampling data for the Keno reach indicate a possible secondary peak in size at about 400 mm. This pattern suggests that there is some environmental condition associated with trout in the Keno reach may favor greater growth as the fish become larger. This pattern was not observed in the J.C. Boyle peaking reach.

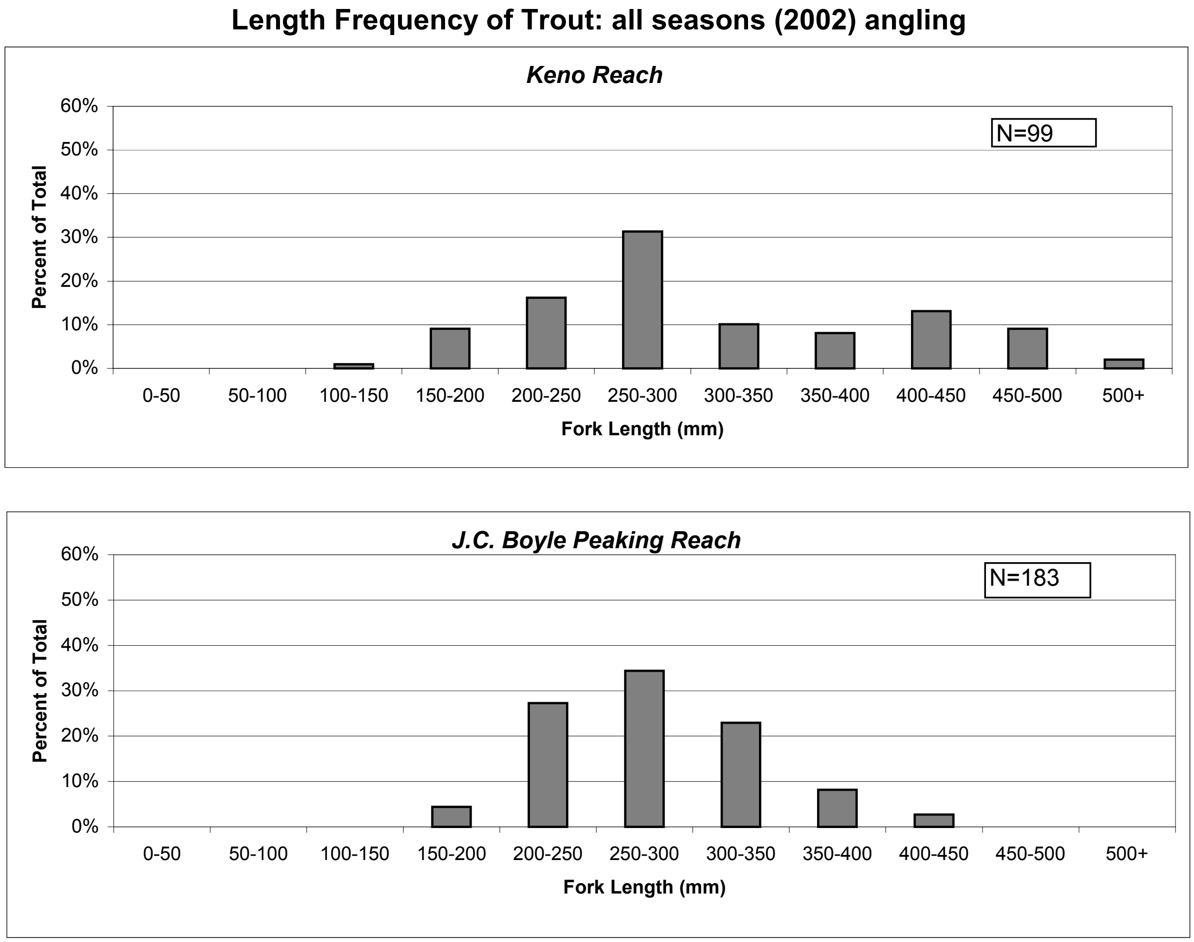


Figure E4.2-18. Length frequency of trout: all seasons (2002) angling.

Age Structure

The length frequency data for trout indicate a clear difference in size between the two river reaches. Specifically, the Keno reach contains a greater proportion of larger fish than the J.C. Boyle peaking reach. Differences in size can be attributable to differences in growth (see below) or age composition or a combination of both. To assess both of these factors, scales from 157 trout (approximately equal numbers per reach) were viewed under a microscope to determine age (and back calculated length-at-age). Because the scales were collected from trout captured primarily by angling, the younger (smaller) fish in the population were not represented in the sample. Also, age determination of older fish is difficult using scale reading, and the confidence in aging fish older than 5 years is poor. Therefore, trout age data are presented only for ages 1 through 5. While these data may not accurately represent the complete age structure of each population, they should reasonably represent the relative differences between the two river reaches for ages 1 through 5.

As shown in Figure E4.2-19, trout tend to be older in the Keno reach compared to those in the J.C. Boyle peaking reach. The percentage of trout age 3 and older was 52 percent in the Keno reach and 34 percent in the peaking reach. These results indicate that differences in trout age structure between the two reaches probably contribute to the observed differences in size composition.

Figure E4.2-19. Age distribution of redband trout by reach.

Trout Length-at-Age and Growth

A total of 157 trout scales, with approximately equal numbers representing each of the two river reaches, was examined for determination of age and back-calculation of fish length to each annulus. The average back-calculated length-at-age (to last annulus) for trout from the Keno and J.C. Boyle peaking reaches is shown in Figure E4.2-20**.** Trout at age 1 and age 2 from the Keno reach were smaller on average than those of the same age from the peaking reach. At age 3, however, Keno reach trout were of similar size to those in the peaking reach, and by age 4, Keno reach trout were larger than peaking reach fish. A statistical evaluation of these length-at-age patterns was conducted using a generalized linear model that looked at length as a function of age, reach location, and the differences in the age function in different reaches. The linear function of length-at age was significantly different ($p<0.001$) between the two reaches (see the Fish Resources FTR, Appendix 3D).

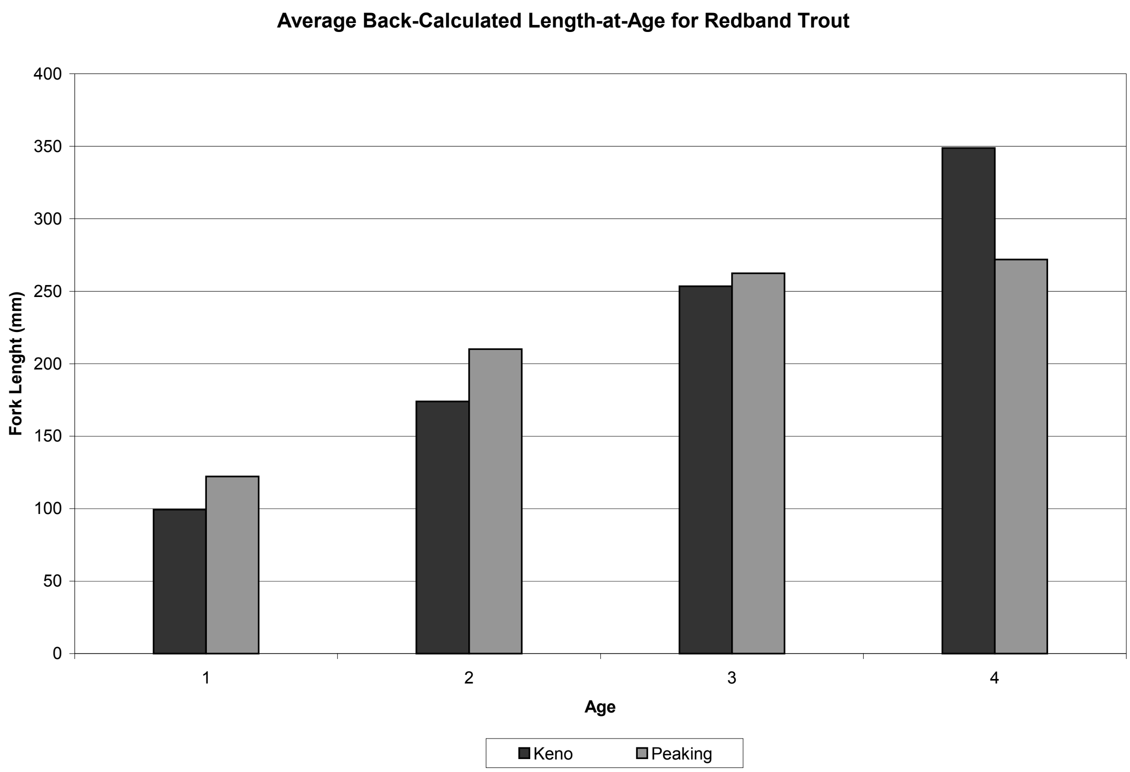


Figure E4.2-20. Average back-calculated length-at-age for redband trout.

Average annual growth rates of trout were determined by comparing the estimated length at last annulus to the previous-to-last annulus for each individual fish and then averaging the length differences. Results of the growth analysis (Figure E4.2-21) are consistent with the length-at-age analysis. Growth is greater in the J.C. Boyle peaking reach compared to the Keno reach for trout through age 2, but similar for the age increment between 2 and 3. After age 3, growth rates are greater for Keno reach fish compared to peaking reach fish.

Typically, growth rates of trout tend to decline with age (Carlander, 1969). This is the pattern observed for trout in the J.C. Boyle peaking reach. Keno reach trout, however, show an unusual pattern of relatively constant growth (length gain per year) between age 1 and 5. The relatively higher growth rates for Keno reach trout after age 3 could be indicative of a shift in diet to larger prey organisms, such as fish, or a shift in location to a more energetically favorable habitat, such as a lake. A limited stomach content analysis conducted in 2002 indicated that trout from the Keno reach, as well as those from the peaking reach, were eating predominantly insects. The analysis did not include a taxonomic or size determination of the ingested insects. Because the fish from which stomachs were obtained were captured in the river, the analysis would not have detected whether some of the fish had foraged in J.C. Boyle or Keno reservoirs.

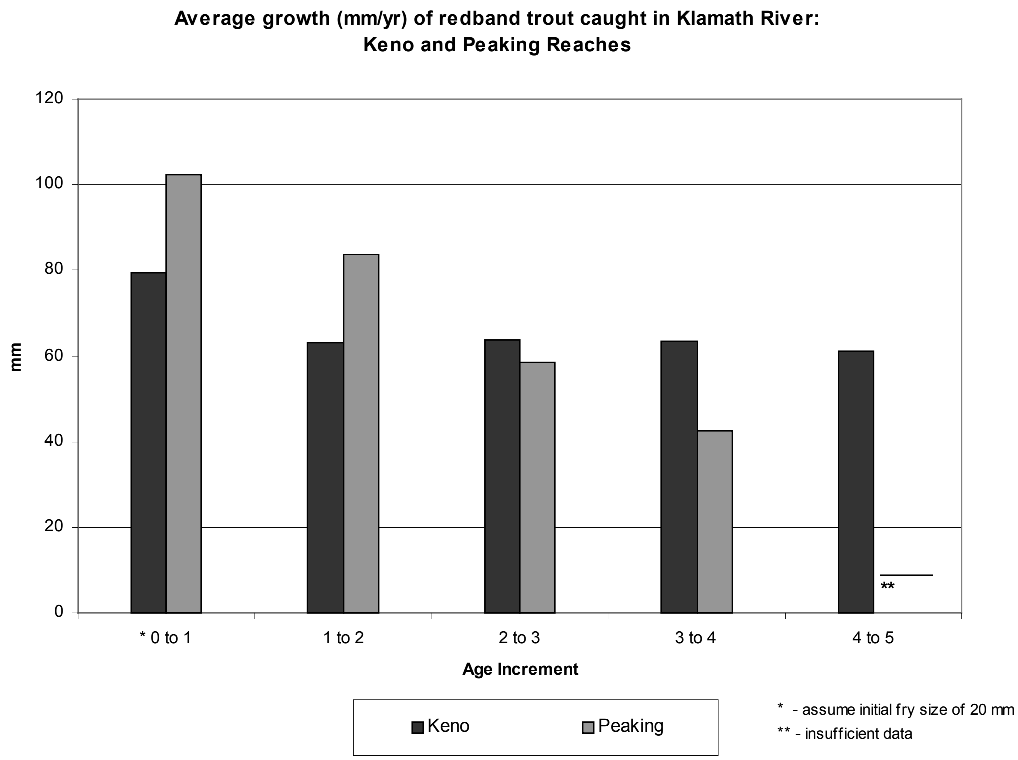


Figure E4.2-21. Average growth (mm/yr) of redband trout caught in Klamath River: Keno and J.C. Boyle peaking reaches.

Condition Factor

Condition factor (K) is the length-weight relationship used to express relative robustness of fish, and is assumed to be related to environmental conditions. Condition factors for rainbow trout greater than 1.0 are generally indicative of healthy fish (Carlander, 1969). Seasonal differences in condition factors often occur because of slow growth periods (e.g., winter) and spawning activity (e.g., post-spawn weight loss). Therefore, condition factors for trout captured in the Klamath River were computed by season and the total average represents the simple (unweighted) average of the three seasonal values.

Condition factors for trout in both reaches and seasons exceeded 1.0, indicating healthy fish (Table E4.2-25). Average condition factors for the Keno and J.C. Boyle peaking reaches were 1.18 and 1.20, respectively. No clear pattern of differences in condition factor was apparent by season.

Table E4.2-25. Condition factors (K) of redband trout caught in 2002.*

Season	Reach	
	Keno	J.C. Boyle Peaking
Spring	1.16	1.19
Summer	1.13	1.18
Fall	1.24	1.15
Average	**1.18**	**1.20**

* Only fish larger than 50 mm.

Summary of Peaking-Effects on Fish

- Streambed Dewatering. Compared to ROR conditions in the summer (assumed flow of 700 cfs), a typical one-unit peaking cycle (base flow of 350 cfs) reduces the wetted streambed area by 11.4 percent. In riffle areas, the reduction is 16.3 percent. Greater reductions occur when ROR flows are higher. These reductions in wetted streambed undoubtedly reduce the abundance of macroinvertebrates, which are the primary food source for fish.

- Fish Community. Electrofishing catch rate data do not indicate any major differences in fish communities between the non-peaking Keno reach and the J.C. Boyle peaking reach that cannot be attributed to other non-peaking factors (chub and minnow recruitment from Keno reservoir, and trout recruitment from tributaries). The similarities between reaches is especially apparent for the primary native riverine species, speckled dace and marbled sculpin.

- Trout Spawning. Spawning of redband trout is not known to occur in the J.C. Boyle peaking reach, most likely because of the lack of streambed areas containing suitable-sized spawning gravel. Trout spawning that contributes to recruitment of juveniles to the peaking reach is known to occur in Spencer Creek, the J.C. Boyle bypass reach, and Shovel Creek. None of these areas is affected by peaking flows in the mainstem Klamath River. Therefore, the current peaking operations do not affect any known trout spawning areas (or subsequent egg incubation and fry emergence) in the peaking reach.

- Fry Distribution and Movement. Results of studies of trout fry movement in the J.C. Boyle peaking reach indicated very little if any downstream dispersal of fry associated with flow fluctuations.

- Adult Trout Movement. Results of a radio-telemetry study of adult trout movement found that no movement occurred in 75 percent of the observations made during a peaking cycle. For those fish that did shift position during the peaking cycle, movements were generally not extensive (10 to 210 feet) and usually occurred either upstream or downstream within the same habitat unit. Migrating trout that encountered the J.C. Boyle powerhouse tailrace during peaking discharges were not delayed or deterred from passing through the area.

- Juvenile Fish Stranding. Results of stranding observation tests, while demonstrating some very limited stranding of non-trout species, provided no indication that trout fry were being stranded by the current down-ramping in the peaking reach.

- Trout Growth. Compared to trout in the non-peaking Keno reach upstream of J.C. Boyle reservoir, trout in the peaking reach grow significantly faster through age 2 (approximately 200 mm length), grow at a similar rate between ages 2 and 3 (approximately 250 mm length), and then grow slower after age 3. The exact mechanism for this difference in relative growth pattern is not known. PacifiCorp is conducting a bioenergetics study and the results will be filed with FERC in spring 2004. This study may provide some explanation for the differences in trout growth pattern observed in the Keno and J.C. Boyle peaking reaches.

- Trout Condition. The average condition factor (length-weight relationship) of trout larger that 50 mm in the peaking reach was 1.20. This is similar to trout in the Keno reach (1.18). Condition factors greater that 1.0 for trout are considered indicative of healthy fish.

Of the various lines of potential evidence examined to assess the effects of peaking on rainbow trout, the only one that is possibly revealing is the difference in growth patterns for trout in the peaking reach compared to those in the non-peaking Keno reach. This growth pattern difference is curious because peaking-reach trout grow faster than Keno-reach trout until they are about 200 mm. At larger sizes the Keno reach trout then grow faster. Such a result would not suggest a difference in overall prey abundance but rather a difference in prey size or prey species available to the two populations. A bioenergetics modeling study, which will be completed in early 2004, may provide more insight to this finding regarding growth patterns.

Copco No. 2 Bypass Reach

Current Down-Ramping

Copco No. 1 powerhouse has a maximum hydraulic generating capacity of 3,200 cfs. The powerhouse is a peaking facility, discharging directly into the Copco No. 2 forebay. Since discharges occur directly into the Copco No. 2 forebay, there is no riverine habitat directly affected by Copco No. 1 peaking operations.

Copco No. 2 powerhouse is a peaking facility that operates synchronously with Copco No. 1. The powerhouse, located about 1.5 miles downstream of the Copco No. 2 diversion dam, discharges into Iron Gate reservoir.

There are no current ramp rate restrictions for the 1.5-mile-long bypass reach between Copco No. 2 dam and Copco No. 2 powerhouse. However, in the event of an unscheduled powerhouse shutdown at the Copco No. 2 powerhouse, Copco No. 1 powerhouse is shut down in response so no spill is needed at Copco No. 2 dam. If the outage at Copco No. 2 powerhouse will be lengthy, PacifiCorp may elect to operate Copco No. 1 powerhouse and spill water at Copco No. 2 dam. Copco No. 1 rarely operates in a peaking mode under such circumstances.

Nearly all spill gates at Copco No. 1 and Copco No. 2 dams are manually operated. Therefore, the ability to control ramping, if needed, in the Copco No. 2 bypass would be limited if flows passing the Project exceed the hydraulic capacity of the powerhouses (both 3,200 cfs). There is no gauge in the Copco No. 2 bypass reach, therefore, data on the frequency and rate of current down-ramping are not available. Although not gauged, ramping at this facility is infrequent and occurs only when maintenance requires spill at the dam, during a forced outage, or when inflows are greater than the hydraulic capacity of the powerhouse.

Effects
There is no FERC minimum instream flow applied to the Copco No. 2 bypass reach. PacifiCorp provides an approximate 10 cfs of water via leakage of the spill gates and a sluice way on the left side of the dam. This provides some habitat for fish and other aquatic biota. Warm water temperatures in this reach during the summer limit fish use to a few warmwater species. Some trout, probably from Iron Gate reservoir, are known to use the lower portion of the bypass reach in the spring and fall when water temperatures are most favorable.

Although fish use of this reach is limited, the occasional down-ramping that occurs when Copco No. 1 is coming off spill, and during other maintenance events, has the potential to cause stranding of small fish.

Below Iron Gate
Current Down-Ramping
The Iron Gate Development consists of a reservoir, dam, and powerhouse. It is the most downstream hydroelectric facility of the Project. The powerhouse is located at the base of the dam resulting in no bypass reach. The Iron Gate powerhouse consists of a single 18-MW unit with a hydraulic capacity of 1,735 cfs. In the event of a turbine shutdown, a synchronized bypass valve diverts water around the turbine to maintain flows downstream of the dam.

Iron Gate dam and powerhouse are operated for base load generation to provide stable flows in the Klamath River downstream of the dam. The powerhouse is not operated as a peaking facility. At flows less than about 1,735 cfs, the Iron Gate turbine can be regulated closely to control ramping rates. At flows more than 1,735 cfs, Iron Gate dam spills and the ability to control downstream flow fluctuations becomes more difficult because the spillway is an ungated overflow type structure. The concrete spillway has no flow control gates; therefore, control of spill at Iron Gate, to the extent that it can, moves upstream to the Copco facilities. Flow control becomes complicated in this flow range (1,735 to 3,200 cfs) because of the influence of turbine discharges, reservoir retention time, reservoir-induced flow attenuation, and tributary inflow between Copco and Iron Gate reservoirs. At flows exceeding 3,200 cfs, flows at Copco No. 1 dam can be controlled only via 13 sets of spill gates, 11 of which are manually operated. The precision of flow control when operating these gates is hindered by their overall size, and, if Copco reservoir is full, control of spill is difficult.

The FERC ramp rate restriction in the current license at Iron Gate dam is a maximum change of 3 inches/hr (as measured at the USGS gauge downstream of the dam) or 250 cfs/hr, whichever is less, "provided that the licensee shall not be responsible for conditions beyond its control."

Currently, ramp rates at Iron Gate are prescribed by the 2002 Biological Opinion issued by NOAA Fisheries to USBR to protect coho salmon (NOAA Fisheries, 2002). The rates are as follows and supersede the prior FERC stipulated rates:

- 50 cfs per 2-hour period when not spilling (less than 1,750 cfs)
- 150 cfs per 4-hour period when spilling (more than 1,750 cfs)

The ramp rates stipulated in the 2002 Biological Opinion are five times more restrictive (slower) than the FERC ramp rate restrictions. The 2002 Biological Opinion ramp rates equate to about 0.4 inch/hr at the USGS gauge (No. 11516530), located about 0.5 mile below the dam, which is the current compliance point. Rate of stage decreases at non-pool cross sections below Iron Gate dam downstream of the Iron Gate gauge (based on 10 available cross sections between Iron Gate dam and Interstate 5 [Hardy and Addley, 2001]) average two-thirds the rate seen at the USGS gauge for the same cfs/hr change. Thus, the 0.4 inch/hr at the USGS gauge (2002 Biological Opinion ramp rate) equates to about 0.25 inch/hr in wider areas of the river where stranding potential would be greatest. Rates become further attenuated downstream.

In addition, the 2002 Biological Opinion specifies that flows cannot be reduced more than 150 cfs per 24 hours when not spilling, and no more than 300 cfs per 24 hours when spilling.

Because Iron Gate is not a peaking facility, ramping occurs on a limited number of occasions during the year. These occasions include (1) when spring runoff decreases to the extent that spill is no longer needed, (2) during annual maintenance when the turbine and bypass valve are shut down and downstream flow requirements are met via the spillway, and (3) when changing USBR's required ESA instream flows below the dam. As shown in Figure 4.2-22, Iron Gate down-ramps (more than 0.01 ft/hr) less than 3 percent of the time during the year when flows are less than 3,200 cfs. When ramp rates were limited to 3 inches/hr (pre-2001 Biological Opinion [NOAA Fisheries, 2001]), ramping generally occurred at much lower rates (less than 1 inch/hr). Since the 2001 Biological Opinion rates were imposed, the frequency of down-ramping has not changed, but the rates have been significantly reduced to mostly less than 0.05 ft/hr (see Figure 4.2-22).

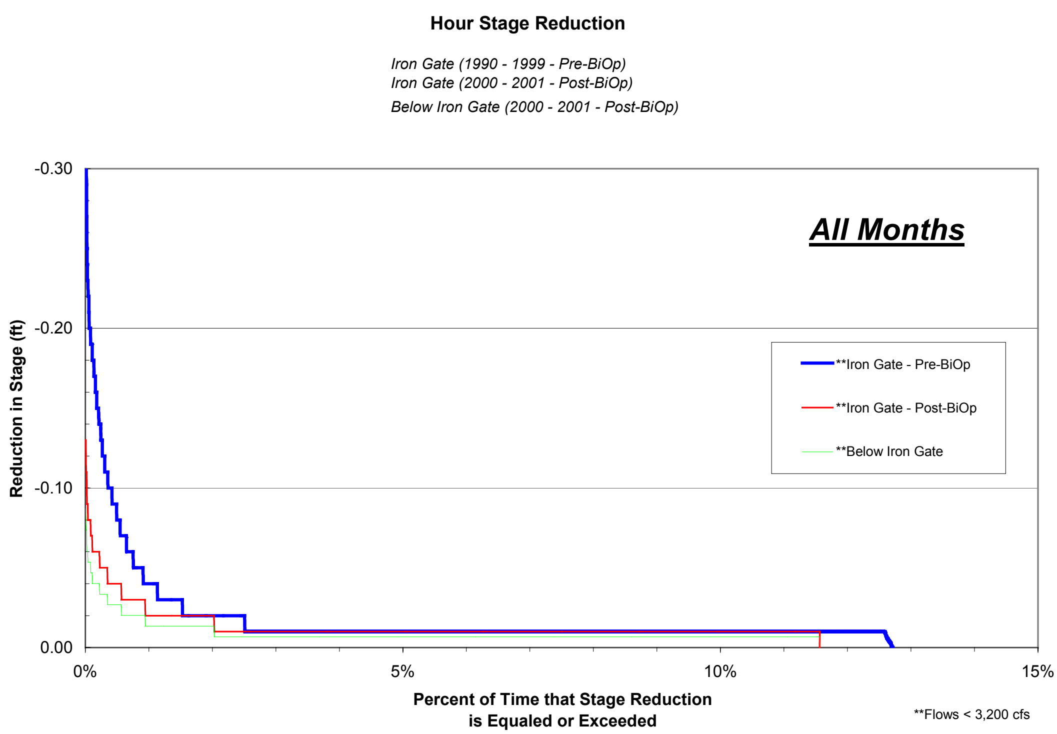


Figure E4.2-22. Hour by stage reduction (all months).

Down-ramping frequency and rate also were depicted for the January through June period, which corresponds to the time when salmonid fry would be most abundant (Figure E4.2-23). The ramping frequency and rates for this period are similar to those in the all-months period.

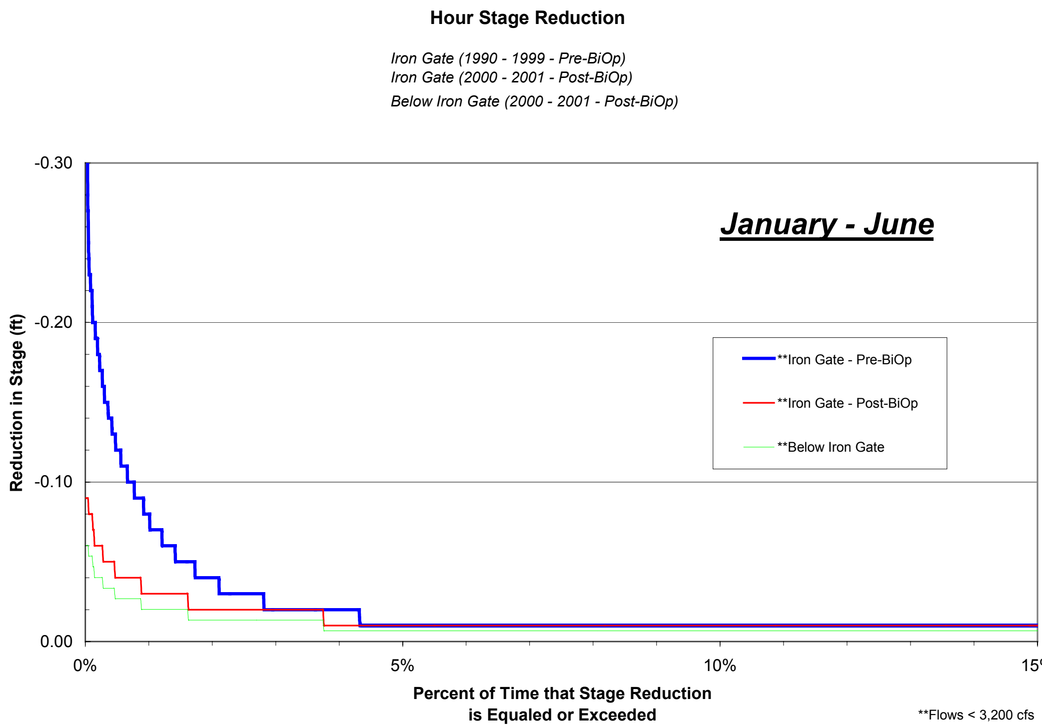


Figure E4.2-23. Hour by stage reduction, January-June.

Effects

As previously mentioned, the Iron Gate dam development is not operated for power peaking purposes. Therefore, the only potential effects on fish associated with changes in discharge are the stranding of small fish or entrapping fish in potholes or side channels when discharges are reduced. In terms of stranding potential from down-ramping, important considerations include: (1) the rate of river stage decline (down-ramp rate), (2) the frequency that down-ramping occurs if the rate is fast enough to strand fish, (3) the seasonal timing of the down-ramping if the rates are fast enough to strand fish, and (4) the amplitude of flow change in the case where side channels can become alternately watered and dewatered more frequently than would occur from natural hydrologic events. These are discussed below as they relate to current ramping at Iron Gate dam.

Down-Ramp Rate. Down-ramping rates, usually depicted as stage change per hour or flow change per hour, have been the focus of numerous studies of salmonid fry stranding. A review of these studies is provided in the Fish Resources FTR, Section 6. A down-ramp rate of 2 inches/hr (or alternately 0.2 ft/hr for compatibility to USGS gauges) is generally regarded as a conservative rate for the protection of salmon fry under most conditions (Hunter, 1992; Olson, 1990) and is often recommended for non-peaking hydroelectric projects. In the case of Iron Gate dam, the current FERC-licensed down-ramp rate limit is 3 inches/hr as measured at the USGS

Iron Gate gauge. At more typical cross sections just downstream of the gauge, the 3 inches/hr rate equates to about 2 inches/hr. Therefore, the FERC down-ramp rate limitation is similar to the generally accepted conservative rate applied for the protection of sensitive life stages of juvenile salmonids.

As noted above, PacifiCorp currently operates the Iron Gate facilities in accordance with the NOAA Fisheries 2002 Biological Opinion, which stipulates a down-ramp rate equivalent to only 0.4 inch/hr at the gauge. The ramp rates stipulated in the 2002 Biological Opinion are six to eight times more restrictive (slower) than those recommended in USBR's Biological Assessment. upon which the 2002 Biological Opinion was presumably based. No discussion of the rationale used for the development of these rates is provided in the 2002 Biological Opinion. Regardless of their basis, however, these down-ramp rates are very conservative compared not only to other systems, but also to unregulated streams supporting similar fish species.

Down-Ramping Frequency. Down-ramping frequency is primarily an issue with peaking facilities that fluctuate flows daily. At such facilities the down-ramp is followed by an up-ramp, and this flow cycling creates a varial zone on the streambed where the production of benthic organisms is reduced. This potential impact is not relevant to reaches downstream of Iron Gate dam.

Down-ramping frequency also can be relevant in situations where rapid down-ramping rates are known to cause stranding on gravel bars. In such cases, more frequent down-ramping would cause greater cumulative losses of fry from stranding over time. This would not be expected to be a problem at Iron Gate assuming that the conservative rates stipulated in the 2002 Biological Opinion are followed. Down-ramping has and continues to occur very infrequently (see Figures E4.2-22 and E4.2-23), especially when viewed in context with natural unregulated stream.

Seasonal Timing. The seasonal timing of down-ramping can be an important consideration when taking into account the early life stages of the fish of concern in the affected river reach. The seasonal factor is most likely associated with fish size. The many controlled stranding studies on salmonids (see the Fish Resources FTR, Section 6) have demonstrated that small, newly emerged fry are at greatest risk of stranding when exposed to rapid down damping. For the Klamath River downstream of Iron Gate dam, Chinook salmon fry begin emerging as early as January followed by coho salmon, and then steelhead trout in late spring. For these species, the greatest risk of stranding occurs between January and early July.

Other native fish species in the Klamath River such as lamprey, suckers, sculpins, speckled dace, and chubs also are predominately spring spawners; thus, their fry would be present and most susceptible to stranding in the spring and early summer. The susceptibility of these non-salmonid species to stranding on stream banks has not been studied under controlled experimental conditions. However, they have been observed incidentally during salmonid stranding studies, and they have been observed trapped in side channels along with salmonids when side channels become disconnected from the main river flow following flow recedence. Such an occurrence was documented on the Klamath River in April 1998 (see discussion below) where, in addition to 746 salmonid fry, approximately 500 individuals of eight non-salmonid species were found trapped in pools of a side channel that had become disconnected from the main river during a seasonal decline from high flows.

While non-salmonids have not been subject to controlled-rate stranding studies, down-ramping rates that have been determined to be safe for salmon fry are also believed to be protective of other native species co-existing in the stream (Hunter, 1992). At Iron Gate dam, the current very conservative down-ramp rates result in a slower stage reduction than would be expected under unregulated conditions. This rate would not be expected to cause stranding of non-salmonids in the river downstream of the dam.

Amplitude of Flow Change. The amplitude of flow change, the overall change in flow quantity, during down-ramping is a concern primarily at peaking facilities where habitat conditions (depth, velocity) can become unsuitable for small fish at the flow extremes in the cycle. Also, side channels and associated potholes can become entrapment areas where daily peaking flows alternately flood and then dewater these channels.

In natural unregulated streams, large declines in flow, over short time periods or even long seasonal periods, often dewater side channels and isolate fish. A prime example of a natural side channel entrapment is a documented case in the Klamath River that occurred in 1998 at a site about 20-miles downstream of Iron Gate dam (Hardin-Davis, Inc., 2002). In late April 1998, an artificial spawning channel became isolated from the main river entrapping several hundred salmonid fry, mostly Chinook salmon, in three pools. The channel became isolated as main river flows declined from 4,363 cfs to 1,987 cfs following a high flow event. The total drop in stage in the main river near the spawning channel site exceeded 3 feet. The flows during the event exceeded the turbine capacity at Iron Gate, and the rates of flow change were beyond what could be controlled by the hydroelectric project. The average rate of flow decline during the 3-day period was 33 cfs/hr, which equates to a 0.4-inch/hr stage drop at the Iron Gate gauge. This 1998 fry entrapment event, although occurring in an artificially modified channel, demonstrates that fish entrapment is independent of the rate of stage drop and rather is a function of the channel becoming disconnected from the main river as flows drop below a certain level. In this case, Iron Gate dam was able to attenuate the rate of flow decline, but the amplitude of the flow decline that dewatered the side channel was a hydrologic event beyond the control of Iron Gate dam.

The amplitudes of flow changes at Iron Gate dam are dictated by natural hydrologic events when flows exceed about 3,000 cfs inflow. Between 3,000 cfs and 1,750 cfs (powerhouse capacity of Copco and Iron Gate, respectively), flow changes are controlled by what enters the reservoir from the combination of natural events and the USBR's controlled releases from Upper Klamath Lake and return water from the Klamath Irrigation Project. When inflows to the reservoir are less the 1,750 cfs, the amplitude of flow changes are dictated by the USBR's instream flow schedule per the NOAA Fisheries 2002 Biological Opinion, which may vary from year-to-year based on the water year type. The schedule calls for flow changes at monthly or semi-monthly intervals.

A comparison of the minimum flow requirements at the semi-monthly intervals shows that the amplitude of monthly flow change in most cases is less than 300 cfs but can be as much as 738 cfs during the spring runoff season of wet years (Table E4.2-26). It is likely that some side channel habitat can become isolated during such flow changes. However, the monthly instream flow schedule is designed to mimic the shape of the natural hydrograph on the respective water-year types. Therefore, the amplitude of flow changes dictated by the USBR instream flow schedule would not be expected to differ significantly from what would occur naturally. Regardless, PacifiCorp's role in these instream flow changes is only to make the flow adjustments gradually (150 cfs/day at flows less that 1,750 cfs and 300 cfs/day at flows greater than 1,750 cfs) per the NOAA Fisheries 2002 Biological Opinion.

Table E4.2-26. Instream flows below Iron Gate dam.

Time Period	FERC Instream Flow Requirements	2002 Biological Opinion Flows			
		Above Average	Below Average	Dry	Critical Dry
October	1300	1345	1345	879	920
November	1300	1337	1324	873	912
December	1300	1387	1621	889	929
January	1300	1300	1334	888	1101
February	1300	1300	1804	747	637
March 1-15	1300	1953	2190	849	607
March 16-30	1300	2553	1896	993	547
April 1-15	1300	1863	1742	969	874
April 16-30	1300	2791	1347	922	773
May 1-15	1000	2204	1021	761	633
May 16-31	1000	1466	1043	979	608
June 1-15	710	827	959	741	591
June 16-30	710	934	746	612	619
July 1-15	710	710	736	547	501
July 16-31	710	710	724	542	501
August	1000	1039	1000	647	517
September	1300	1300	1300	749	722

Fall Creek Bypass Reach

Current Down-Ramping

Fall Creek, originating from headwater spring sources, has an extremely stable flow regime. Even large storm events have little influence on the stream at the point of its diversion to the Fall Creek powerhouse. Therefore, water diversion into the power canal runs nearly continuously and at a constant flow rate. Depending on the type of powerhouse maintenance being conducted, flow is either diverted into the canal and routed around the powerhouse through bypass valves or released at the dam to meet downstream needs. CDFG operates a salmon rearing facility at Fall Creek downstream of the powerhouse that requires continuous flow. Although there is no prescribed down-ramp rate for the diversion dam, the need to reduce flows in the bypass is rare, only occurring when canal maintenance is required.

As previously mentioned, the Fall Creek powerhouse units each have a synchronous bypass valve that diverts flow instantaneously around the units into the tailrace in the event of a unit trip. This is designed to maintain continuous flow during these events and alleviate the need for powerhouse down-ramping. Although rare, there may be occasions when the operators need to curtail all flows through the powerhouse including those through the bypass valves.

Effects
Flows routed to the Fall Creek powerhouse run almost continuously, passing either through the turbines or the flow-continuation valve. Therefore, flow changes in the bypass reach occur rarely only during the times that the diversion canal is being shut down for maintenance and subsequently brought back on line. The rate at which flow is returned to the canal affects the rate at which flows decrease in the Fall Creek bypass reach. Fish stranding has not been documented in Fall Creek during these maintenance activities.

Resident Fish Passage

The following section reviews fish passage at the developments to be included in the proposed Project. For information on Link and Keno dams, please see the Fish Resources FTR.

J.C. Boyle Dam
Upstream Fish Passage
Construction of J. C. Boyle dam on the Klamath River was completed in October 1958. An upstream fish passage facility (ladder) designed primarily for redband trout was built as part of the Project. To verify that the ladder performed as intended, ODFW monitored fish use of the ladder in 1959 starting in mid-May. At the end of the year, it was projected, based on once-per-week monitoring, that 5,529 redband trout had moved upstream through the ladder. This estimate did not include January through mid-May when many more fish may have moved upstream during the spring spawning run. In general, the large number of fish using the ladder in 1959 indicated that the ladder performed well.

Counts of fish movement through the ladder in 1960 were made only for the March through May period corresponding to the spring spawning migration. The passage for the 3 months was 800 trout (Toman, 1983). Monitoring throughout most of 1961 and 1962 (only limited monitoring in July-September) provided estimates of 3,882 and 2,295 trout per year, respectively, with most of the movement occurring in the spring. No fish ladder monitoring was conducted again until 26 years later, beginning in 1988 and continuing through the end of 1991. The numbers of fish passing through the ladder each of these 4 years was 507, 588, 412, and 70, respectively. It is important to note that the number of fish using the ladder in 1959 through 1962 is based on extrapolations, while the data on fish using the ladder from 1988 to 1991 are the actual numbers of fish sampled. Consequently, direct comparisons of data should be viewed with caution.

The number of fish observed using the ladder annually in the 1988-1991 period was considerably less than what was estimated in the 1959-1962 period. Because of the decline in use of the ladder, ODFW recommended that PacifiCorp conduct a review of possible factors contributing to the decline in ladder use. It was also recommended that PacifiCorp conduct a radio-tracking study to assess the movement of trout as they approach the J.C. Boyle bypass reach, dam, and fishway entrance in an effort to determine if fish are passing through ladder effectively. The results of the initial fish ladder review are provided in the Fish Resources FTR, Section 7, and are briefly summarized below. Results of the trout movement study are included in the Fish Resources FTR, Section 5, and are briefly summarized below.

Possible reasons for declining use of the ladder that were evaluated included:

- Water releases at the spillway of the dam may be providing a false attraction to the migrating fish such that many fish may be unable to find the entrance to the ladder
- Differences in water temperature between the 4-mile-long bypass reach (consisting mostly of spring water) and the full-flow reach below the powerhouse may discourage fish from moving into the bypass reach and hence to the ladder
- The relatively high number of fish estimated to have used the ladder in 1959-1962 may have been due to the large numbers of hatchery trout planted in those years
- The ladder itself may not be performing efficiently

A brief summary of findings for these potential factors is presented below.

Spillway Flows

To determine whether false attraction of fish to the spillway could explain the drop in fish passage estimates between two periods, actual flow conditions at the dam were reviewed for the years when fish counts were made. The records reveal that substantial spill did not occur during either the 1959-1962 period nor in 3 years (1988, 1990, and 1991) of the 1988-1991 period. Therefore, spillway flows could not have accounted for the drop in fish use of the ladder.

In 1989, spill occurred for a short period of about 6 weeks. The spill coincided with the peak of the spring spawning migration in late March and April. Even with spill exceeding 3,000 cfs during most of April 1989, fish counts were still highest in that month, consistent with other non-spill years. These data suggest that this spill did not dissuade the movement of fish through the ladder.

Water Temperatures

ODFW monitored water temperatures in the J.C. Boyle ladder coincident with the trout movement studies between 1959 and 1962 (Toman 1983). The vast majority of the fish moved up the ladder when water temperatures were between 45 and 60°F. This period corresponded to the spring spawning migration, primarily in March and April, and the fall migration in late September and October. Although the bypass reach downstream of the dam is heavily influenced by spring water, water temperatures in the bypass are similar to those of water being discharged at the powerhouse at the times of year that the trout are moving upstream (see the Water Resources FTR, Section 4). Therefore, it does not appear that water temperature differential could be causing a decreased use of the J.C. Boyle ladder because there is little differential at the times of year when the fish normally migrate.

An objective of the trout movement study conducted by PacifiCorp in 2003 was to determine whether migrating adult trout respond to the differences in water quality, water temperature, and flow at the confluence of the bypass reach and powerhouse tailrace when the powerhouse is discharging. Study results found no conclusive evidence of delay or deterrence of fish at this location. In fact, most fish appeared to move past the powerhouse tailrace and into the bypass reach on their first attempt without delay.

Hatchery Fish

ODFW planted 15,000 to 32,000 catchable-sized (≥ 8 inches) rainbow trout annually from below Keno dam to below J.C. Boyle dam in the 1959-1962 period (ODFW file data summarized in

Toman, 1983). These hatchery fish may have contributed to the number of trout observed passing through the J.C. Boyle ladder during this period. ODFW continued to plant hatchery trout in the Klamath River until 1978, at which time the river was reclassified for wild trout management. The fact that estimates of trout using the J.C. Boyle ladder dropped from approximately 2,000 to 4,000 per year in the early 1960s to about 500 per year by the late 1980s could be explained, in part, by the elimination of stocking of hatchery trout.

Ladder Design

The upstream fishway at J.C. Boyle dam is a pool and weir type ladder with submerged orifices and an AWS to help attract fish to the ladder's entrance. It was designed and constructed in 1958 in accordance with criteria prescribed by the state of Oregon at that time. The primary criteria included 12-inch drops between pools and a vertical-to-horizontal slope of 1:8.5. Contemporary criteria for resident trout fishways are 6- to 9-inch drops between pools and a 1:10 slope.

It is doubtful that reconstructing the fish ladder in accordance with contemporary design criteria would noticeably improve fish passage efficiency. The tagging studies indicate that few fish even approach the facilities, and those that do appear to move through the ladder quickly once they enter the facility. It is unlikely that the non-contemporary design of the existing ladder could explain the decline in its use over the years. To argue such would require the illogical assumption that the ladder efficiency became progressively worse through the years, yet the ladder has remained unchanged.

As part of its relicensing responsibility, PacifiCorp reviewed the ladder configuration in relationship to current design criteria (see the Fish Resources FTR, Section 7). Some modifications and improvements to the facility are being proposed by PacifiCorp to potentially enhance the function of the ladder and facilitate its continued maintenance and operation.

Tagging Studies

In 1990, 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. The Spencer Creek trap collected 926 adult rainbow trout from March 4 through May 8. The results revealed that only 8 of the 300 tagged fish from the ladder entered Spencer Creek. 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.

During fall 1988, Beak Consultants tagged a total of 453 rainbow trout over 200 mm fork length from the Klamath River downstream of the J.C. Boyle powerhouse (City of Klamath Falls, 1989). ODFW monitored fish passage at the J.C. Boyle fish ladder in late 1988 and throughout 1989. None of the tagged fish were observed in the fish ladder.

In late winter 2003, PacifiCorp captured and radio-tagged 42 adult trout from downstream of J.C. Boyle dam, and subsequently monitored the fish ladder at the dam for evidence of movement at and through the ladder. Only 1 of the 42 fish attempted and passed the ladder. The rapid and successful passage of this fish through the ladder indicates that it was not delayed or deterred by the fishway or entrance conditions. The fish was later observed in Spencer Creek where it presumably spawned.

The results of these tagging studies provide concurring evidence that only a small fraction of the trout originating from downstream of the dam actually use the upstream fish passage facilities at J.C. Boyle dam, and that most trout from below the dam presumably spawn below the dam.

Conclusions

The fact that the estimated number of trout passing J.C. Boyle dam in the 1959-1962 period was higher than the actual number of fish observed in the more recent years of 1988-1991 may be due, in part, to the elimination of planting of hatchery trout starting in 1978. The decline in use of the ladder also may indicate that there has been a change in the way redband trout are using the area near the dam. However, the evidence summarized above does not indicate that the current fish passage facilities or Project operations have contributed to the declining use of the ladder. A more plausible explanation for the reduced trout use of the ladder is that the trout population has modified its movement behavior over the years in an adaptive response to new conditions with the dam in place. The construction of J.C. Boyle dam undoubtedly inundated riverine habitat, which could have included potential spawning areas. The fish observed moving upstream over the dam in the first few years after dam construction would have been following their homing behavior to natal spawning or over-wintering areas, which may have been inundated by construction of the dam. It is known that Spencer Creek, which enters the reservoir, is a good spawning stream and still supports spawners from the upstream Keno reach. However, it is also likely that there was good spawning habitat at the mouth of Spencer Creek in this section of the Klamath River that is now inundated. This reach of the Klamath River was relatively low gradient (15 ft/mi), and thus likely was a depositional area for spawning gravel originating from Spencer Creek and the upstream Keno reach.

Surveys conducted by PacifiCorp in 2003 indicate that considerable trout spawning takes place in the lower portion of the J.C. Boyle bypass reach (see the Fish Resources FTR, Section 3). Flow in this reach consists primarily of spring water, which is known to be favorable to spawning and egg incubation success. Prior to construction of J.C. Boyle dam, springtime flows were typically greater the 2,000 cfs. Given these relatively high flows of compromised water quality passing through this high-gradient reach (> 100 ft/mi), it is doubtful that successful spawning occurred here historically. Despite this apparent shift in spawning location to below the dam, some trout continue to pass upstream of the dam to spawn, and the maintenance of this connectivity to the upstream trout population is important for the long-term health of both populations. Therefore, maintaining the fish passage facilities at J.C. Boyle dam in good operating condition is advisable. Also, because the bypass reach is a spawning area for trout below the dam, efforts to protect the water quality and spawning substrate in the reach should be given high priority.

Downstream Fish Passage

The existing fish screens and ladder at the J.C. Boyle Development met existing design criteria when constructed in 1957. Both facilities appear to be in good condition and have been maintained to meet the original design criteria. However, neither of these facilities meets current fish passage criteria for the state and federal fisheries resource agencies in relation to resident and anadromous fish.

<u>Copco No. 1 and Copco No. 2 Dams</u>
Neither Copco No.1 or No. 2 dams were constructed with upstream fish passage facilities; therefore, upstream migration of resident fish species is not possible. However, most of the species, except for possibly a few rainbow trout, tend not to be migratory and would not benefit from upstream fish passage facilities. In addition, neither intake facilities are screened to prevent fish from being entrained into the powerhouses. Entrainment is discussed in the next section (E4.2.2.2 Reservoir Fisheries).

<u>Iron Gate Dam</u>
Iron Gate dam was not constructed with upstream fish passage facilities; therefore, upstream migration of resident fish species is not possible. However, most of the resident species, except for possibly a few rainbow trout, tend not to be migratory and would not benefit from upstream fish passage facilities. Anadromous fish in the Klamath River, however, are blocked by Iron Gate dam. Section E4.3, Anadromous Fisheries, presents a detailed discussion on the fish passage issues relative to anadromous fish in the Project.

The intake facilities to the Iron Gate powerhouse are not screened. Therefore, it is probable some fish are entrained into the turbines. Entrainment and turbine mortality is discussed in the following section.

<u>Fall Creek Diversion Dam</u>
The fish species of primary concern at this site is resident trout. The original construction of the Fall Creek Development did not include fish screens on either the Fall Creek or Spring Creek diversions. Fish ladders were not included over either dam. PacifiCorp is proposing upgrades at the Fall Creek Diversion dam (see Section 4.7, Proposed Enhancement Measures) that would facilitate upstream passage as well as screening the power canal intake.

E4.2.2.2 Reservoir Fisheries

There are two main issues related to the operation of the Project with respect to reservoir fisheries that have the potential to adversely affect the reservoir fish populations. These are 1) fluctuating reservoir levels that may adversely affect the use of littoral zone habitat by fish, or directly affect the fish themselves, such as in stranding, and 2) the potential for reservoir fish to be entrained into hydroelectric facilities, which can result in turbine-induced mortality. The following presents an assessment of these two issues.

<u>Reservoir Level Fluctuations</u>

Project reservoir fluctuations consist of short-term level fluctuations in J.C. Boyle, Copco, and Iron Gate reservoirs.

The biological consequence of water level fluctuations can be both beneficial and detrimental, depending on the existing fish community, the lake’s bathymetry, the lake’s production status, and management priorities. In other reservoir and lake systems, intentional drawdown is commonly used as a management tool to control overabundant macrophytes, to encourage or discourage the reproduction of targeted fish species, and to affect predator-prey interaction to the benefit of management priority species. Depending on timing and magnitude, water level fluctuations in reservoirs can have detrimental effects on the reproduction of desired species that spawn or rear in shallow water.

Because of the complexity of mechanisms, both physical and biological, that can play a role in determining the consequences to fisheries of reservoir fluctuations, it is important to rely as much as is practical on empirical site-specific information. Oregon State University recently conducted such studies at J.C. Boyle, Copco, and Iron Gate reservoirs (Desjardins and Markle, 2000). Although these studies focused on endangered suckers, the results provide important insight into the effects of current reservoir operation on the total fish communities.

J.C. Boyle Reservoir

J.C. Boyle reservoir is a 420-acre, 7.5-mile-long impoundment behind J.C. Boyle dam. It has a maximum depth of 53 feet, but much of the area has depths of only 10 to 20 feet. Compared to the other major reservoirs in the system, Copco and Iron Gate, J.C. Boyle reservoir has proportionately large littoral area.

Load-factoring operations at the J.C. Boyle powerhouse cause water level fluctuations in the reservoir—typically about 2 ft/day.

The issue of the potential effect of reservoir fluctuations on Lost River and shortnose suckers was addressed in the USFWS Biological Opinion (USFWS 1996). In that document, the USFWS concluded that there would be only low levels of impact in the Klamath River and reservoirs because of changes in reservoir elevations. As a condition of its 1996 Incidental Take Statement, however, PacifiCorp was required to document the distribution and abundance, age class structure, recruitment success, and habitat use by different life stages of shortnose and Lost River suckers in J.C. Boyle, Copco, and Iron Gate reservoirs. Oregon State University, contracted by PacifiCorp, subsequently conducted a 2-year study (Desjardins and Markle, 2000). The authors presumed, based on extrapolation from the literature, that water level fluctuations in J.C. Boyle reservoir would have a negative effect on larval and juvenile suckers, compared to Copco and Iron Gate reservoirs, which experience much less fluctuation. However, the results of the study revealed that J.C. Boyle had the greatest number of juvenile suckers and that there appeared to be sufficient habitat to support these early life stages (Desjardins and Markle, 2000).

The study also found that J.C. Boyle reservoir contained fewer non-native fish species than the other reservoirs. Predation by non-native fish has been identified as an important factor limiting the recovery of other sucker populations. Populations of yellow perch and catfish, two potential predators of suckers, were less common in J.C. Boyle reservoir. These study results suggest that water level fluctuations in J.C. Boyle reservoir are not adversely affecting the Lost River and shortnose sucker populations in the reservoir.

Angling groups have raised concerns that reservoir fluctuations could interfere with bass spawning success. In most years, reservoir fluctuations resulting from load-factoring operations do not occur during the bass spawning period (April and early May) because of high inflows. However, in drier years when inflow is low, PacifiCorp has on occasion drawn the reservoir down to a lower level (approximately 2 feet) and maintained a stable or slightly increasing level until bass spawning has been completed. The reservoir is then brought back up so that daily fluctuations do not drop below spawning depth. This has helped to ensure that bass eggs do not become desiccated.

Copco Reservoir
Copco reservoir has a surface area of approximately 1,000 acres and a maximum depth of about 90 feet. Copco is maintained at near maximum pool elevations during the summer, but it is often drawn down several feet in the autumn. Power generation causes daily water level fluctuations of only about 0.5 feet. Because of local sportsmen's concerns, PacifiCorp may attempt to minimize weekly reservoir fluctuations in the spring during the bass spawning period.

Iron Gate Reservoir
Iron Gate reservoir has a surface area of 944 acres and a maximum depth of about 160 feet. Much of the reservoir is deeper than 35 feet, with steeply sloped banks. Iron Gate acts as a re-regulation reservoir for variable inflow from the Copco powerhouse. Reservoir elevations can vary daily by about 1 foot, as a result of load-factoring inflow from Copco. This degree of fluctuation is not believed to be significant enough to adversely affect fish resources in such a large reservoir.

Fish Entrainment and Turbine-Induced Mortality

PacifiCorp has addressed the issue of entrainment and turbine mortality at their facilities by reviewing existing fisheries information for the Project reservoirs and tailwaters, coupled with other entrainment and mortality studies at projects with similar fisheries and environments. The purpose of the evaluation was to characterize the potential for entrainment and to estimate turbine-induced mortality of the fish most likely to be entrained. This information was used in conjunction with other fisheries information for the Project area to determine whether entrainment potentially could be adversely affecting fish populations in Project reservoirs.

PacifiCorp's evaluation of fish entrainment and turbine-induced mortality is presented in-full in the Fish Resource FTR, Section 7.0. The following is a summary of the approach used to assess the issue and the major findings and conclusions reached regarding entrainment and mortality at each of the Project's hydroelectric facilities.

Assessment Approach
The general study approach for assessing fish entrainment was to apply existing study trends and data from similar projects and interpret this information in conjunction with known fisheries data for the Project reservoirs and dam tailwaters. In the past 20 years, there have been many entrainment studies conducted at dams in coolwater and warmwater environments similar to the conditions in Project reservoirs. Although highly variable, common trends and correlations with a number of biological, environmental, and physical site conditions have been noted (FERC, 1995). Potential physical factors affecting entrainment that were addressed in the assessment included reservoir size, dam height, forebay configuration, depth of intake, and water flow through the reservoir or powerhouse. Biological factors included fish species present and those most likely to be entrained, fish size, seasonal and diurnal movements, and density dependent influences on fish movement.

In addition to assessing the potential for fish entrainment, a considerable amount of literature was available regarding the causes of injury and mortality to fish as they pass through hydroelectric turbines. Factors affecting mortality relate to the probability of physical contact with moving turbine blades, pressure changes and cavitation, and shear forces and turbulence. Information that will be used to estimate mortality rates of entrained fish at each powerhouse will include: turbine design, number of turbine runner blades, project head, peripheral runner velocity, intake depth, operating efficiency, and size of fish entrained.

The literature-based estimates for the probable numbers of fish being entrained at Project reservoirs were coupled with probable turbine-induced mortality rates for each of the Project facilities based on their specific physical characteristics. The following section summarizes the findings and conclusions reached by PacifiCorp regarding these two issues along with how site-specific information (e.g., reservoir species composition, etc.) most likely influences the potential magnitude of the effects of fish entrainment and turbine mortality on reservoir fish populations.

Findings and Conclusions

A common understanding is that fish residing in hydroelectric reservoirs can become entrained through powerhouses and that a portion of those fish are killed as they pass through the turbines. The median number of fish entrained annually at the 26 FERC-reviewed projects reviewed by PacifiCorp was approximately 83,000 fish (see the Fish Resources FTR, Section 3). Using reservoir size to characterize potential entrainment at Project facilities, the database indicates a median annual entrainment of 75,655 fish for reservoirs the size of J.C. Boyle and 115,979 fish for reservoirs the size of Copco and Iron Gate. Using hydraulic capacity as an estimator of entrainment provides a median estimate of 85,848 fish entrained annually at each development.

It is likely that the J.C. Boyle and Copco powerhouse intakes entrain fewer fish than observed at the other reviewed projects because of the frequent shut down of these powerhouses at night (for power peaking) when most native species appear to move downstream. This conclusion is based on the results of an entrainment study conducted at the power canal intakes at Link River, where 75 percent of the entrainment was estimated to occur at night (New Earth/Cell Tech and PacifiCorp, 1999).

The preliminary results of hydroacoustic sampling in Copco and Iron Gate reservoirs in August 2003 also indicate that entrainment at these dams/powerhouses may be relatively low (see the Fish Resources FTR, Section 3). Most fish targets in Copco reservoir were observed generally toward the middle and eastern end of the lake farthest away from the deeper water near the dam. Similarly, the distribution of fish in Iron Gate reservoir showed few fish present in the deeper open-water areas and most fish adjacent to the shorelines, especially along the eastern shore and in the inlet arm.

The fish species composition in Project reservoirs provides an initial indication of which species are most likely to become entrained (Table E4.2-27). Based on this information, most of the entrainment at the Project developments likely consists of non-native fish species, including yellow perch (Copco and Iron Gate), pumpkinseed, bluegill, crappie, other sunfish, and bullheads. The likely predominance of yellow perch entrainment is further supported by the results of vertical gill netting in Copco and Iron Gate reservoirs in August 2003, which was done in conjunction with the hydroacoustic surveys. Only yellow perch were captured in the open water areas of Iron Gate reservoir; perch accounted for 95 percent of the catch in Copco reservoir, with black crappie being the remaining 5 percent.

Table E4.2-27. Species composition of J.C. Boyle, Copco, and Iron Gate reservoirs by family group as found by trammel net, trap net, trawl, and seine sampling in 1998 and 1999 by PacifiCorp and Oregon State University.

Family	J.C. Boyle	Copco	Iron Gate
Cyprinidae *(chubs, minnows, shiners)*	53.1%	5.0%	49.2%
Percidae *(yellow perch)*	0.8%	81.5%	13.7%
Centrarchidae *(bass, sunfish)*	23.7%	1.5%	21.3%
Ictaluridae *(bullheads, catfish)*	12.4%	1.8%	11.5%
Catostomidae *(suckers)*	8.1%	9.5%	3.4%
Salmonidae *(trout)*	1.0%	0.0%	0.4%
Cottidae *(sculpins)*	0.6%	0.0%	0.0%
Petromyzontidae *(lamprey)*	0.1%	0.0%	0.1%

The most abundant native species found in the Klamath reservoirs are chubs (tui and blue), and they would undoubtedly make up a significant proportion of the entrainment. However, they are generally bottom dwellers and, thus, may not be as prone to entrainment as their relative abundance in the reservoirs might suggest. Similarly, bullheads and suckers are bottom dwellers, and they too may be less prone to entrainment especially at Copco and Iron Gate reservoirs, which have shallow intakes at the deep-water dam faces. Even considering these possible minimizing factors, it is likely that annual entrainment still is several tens of thousands of fish at each of the Projects with yellow perch, sunfishes, and chubs being the most commonly entrained species.

Even though fewer fish may be entrained at the Klamath Project dams than observed at other sites, the rate of mortality associated with turbine passage is probably greater because of the dams' relatively higher head (and thus greater turbine runner velocity). Estimates of turbine-induced fish mortality were developed using a known relationship with turbine runner velocity and accounting for fish size, which also is known to be an important consideration (see Table E4.2-28). Turbine mortality at the Copco and Iron Gate powerhouses would be expected to be about 10 percent for the most likely size of fish (75 mm) to be entrained and about 20 percent for fish in the size range of 100 mm to 200 mm. Nearly all fish entrained at Copco No. 1 powerhouse would be expected to pass through the Copco No. 2 powerhouse, thus exposing those surviving fish to potential cumulative mortality at the second powerhouse. Potential mortality of fish passing through the high-head J.C. Boyle powerhouse would be 20 to 40 percent.

Table E4.2-28. Estimated percent turbine-induced fish mortality by fish size class at Klamath Project powerhouses.

Powerhouse	150mm	100mm	75mm	50mm
J.C. Boyle	36.6	24.4	18.3	12.2
Copco No. 1	17.9	11.9	8.9	6.0
Copco No. 2	20.0	13.3	10.0	6.7

Table E4.2-28. Estimated percent turbine-induced fish mortality by fish size class at Klamath Project powerhouses.

Powerhouse	150mm	100mm	75mm	50mm
Iron Gate	21.5	14.4	10.8	7.2

The question as to whether entrainment mortality is causing a biologically significant impact to resident fish populations and whether this impact is great enough to require costly mitigation (typically in the form of fish exclusion/screen facilities) has been a significant challenge for resource agencies and hydropower licensees alike (FERC, 1995). While the need for downstream protection facilities for anadromous fish is rarely disputed, the need to install facilities for resident fish is often debatable.

The response of resource agencies to the entrainment mortality issue has varied by state. In the most conservative cases, resource agencies have stated that “biological significant impacts” to fish populations are not relevant, rather that individual fish are being killed and that protection measures are needed to mitigate the losses (FERC, 1996a, 1996b). States that have taken this approach have nearly always recommended fish protection measures regardless of the results of site-specific entrainment mortality studies. FERC, in conducting their environmental analyses, generally has considered it important to review and interpret available information on potential impacts on fish populations because this could have a significant bearing on its balancing of developmental and nondevelopmental resources (FERC, 1996a, 1996b).

In the assessment of environmental effects of turbine entrainment mortality, the following factors were considered:

- **Native vs. non-native fish.** Entrainment at most of the midwestern and eastern projects consisted primarily of native fish species(FERC, 1995). However, reservoirs in the western United States, including those on the Klamath River, often are dominated by non-native species. Many of these non-native species, such as bass, catfish, perch, and sunfish, support popular sport fisheries. Resource agencies in the West are often confronted with management conflicts between protecting native species on the one hand and supporting anglers’ desires for game fish on the other hand.

  The Project reservoirs contain large populations of non-native species. Copco reservoir, in particular, contains over 80-percent yellow perch. This species, as well as the sunfish and catfish/bullhead species, would likely make up a majority of the fish entrained. Chub, both blue and tui, would be the most likely entrained native species.

- **Downstream habitat.** Entrainment mortality removes fish that would otherwise contribute to recruitment to waters downstream of the dam. Therefore, it is important to consider the type of downstream habitat available to these fish and whether recruitment from upstream is important to the downstream populations. At J. C. Boyle dam, fish that pass the dam enter a 20-mile-long high-gradient stream reach. Nearly all of the species found in J.C. Boyle reservoir prefer slackwater lake habitat. The fact that few of these species are found in the river downstream of the powerhouse may attest to their strong lake preference and inability to persist in riverine habitat. Those that do pass the dam (via screen/bypass system) probably reside in the river pools just downstream of the dam before the cool spring water inputs or move quickly downstream and enter Copco reservoir.

Fish that become entrained at Copco No. 1 enter the short (0.3-mile) Copco No. 2 headwater pond, which is essentially riverine in nature. These fish likely enter the Copco No. 2 powerhouse intake. Those that survive turbine passage at the Copco No. 2 powerhouse enter directly into Iron Gate reservoir, which provides habitat similar to Copco reservoir.

Nearly all of the fish in Iron Gate reservoir are species that prefer lake habitat. Because there are no reservoirs downstream of Iron Gate, it is reasonable to assume that those fish that are entrained and survive the turbines will eventually perish in the downstream riverine habitat.

- **Compensatory mortality.** Because the vast majority of fish entrained at hydroelectric projects consists of small YOY individuals, the principle of compensatory mortality has been applied to the interpretation of biological impacts associated with entrainment mortality on fish populations. Compensatory mortality refers to the fact that when the density of a fish population is reduced, the competition for resources, such as food or space, is also reduced, which then leads to higher survival rates of the remaining fish. Density-dependent compensation is important to fisheries management because its purpose is to offset the losses of individuals. It is the reality of this compensatory process on which management of commercial and recreational fisheries is based (Ricker, 1975). When assessing impacts of entrainment mortality, it has been argued that compensation tends to regulate the population toward a long-term average supported by habitat availability, and, therefore, higher mortality at the YOY stage has little or no impact on the population as a whole, especially when there appears to be an abundance of YOY fish as indicated by high entrainment rates.

- **Density dependent dispersal.** Most small fish that leave a reservoir may be “excess” fish from a habitat standpoint; i.e., as the rearing capacity of the upstream habitat becomes filled, the excess fish disperse downstream. High entrainment rates may just be indicative of a healthy up-stream population, which by definition would have surplus reproductive capacity.

Some stakeholders believe that this review (see the Fish Resources FTR, Section 3) does not provide sufficient information to support future PM&E options for protection of resident fish that can be entrained through Project powerhouses. However, site-specific studies to estimate fish entrainment and survival rates are very costly and often subject to considerable uncertainty (Eicher and Associates, 1992; FERC, 1995). PacifiCorp maintains that the results of the literature-based review coupled with site-specific fisheries data provide sufficient information to conclude that fish entrainment and associated turbine mortality are not likely to be causing significant adverse affects on resident fish populations in Project reservoirs.

E4.3 ANADROMOUS FISHERIES

E4.3.1 Anadromous Fish Passage

A major fisheries issue identified by the fisheries resource agencies, affected Native American tribes, and nongovernment organizations (NGOs) (stakeholders) during the relicensing process was the lack of fish passage facilities at several Project structures. PacifiCorp, working with stakeholders, formed the Fish Passage Work Group (FPWG) to address this issue (see Section E4.3.1.2).

The issue of anadromous fish run sustainability is important. Given the potential costs of constructing fish passage facilities, impacts on other resource areas, and risks to existing native fish populations, it must be demonstrated that the reintroduction effort will produce healthy, sustainable anadromous fish populations. Otherwise, the reintroduction program becomes a long-term supplementation effort requiring large and continuing releases of hatchery fish into the Upper Klamath River basin, providing little benefit to the species of interest. If the runs would not be sustainable without hatchery supplementation, continuing the Iron Gate hatchery program would return more adult fish to the basin than would a hatchery-supplemented reintroduction program.

Concerns for a successful reintroduction effort are based on a host of factors, all presented in great detail in three previous agency reviews of this issue (Fortune et al. 1966; KRBFTF, 1992; ODFW, 1997). All of these reviews advised against introducing salmon and steelhead trout to the upper basin because of multiple factors (such as poor water quality; disease; predation; mortality through fish passage facilities, lakes, and reservoirs; and nonsuitable stock genetics) that in combination would make sustainable recovery infeasible and would pose unacceptable risks to native resident fish. A summary of findings from these three reports is presented below in Section E4.3.1.1.

Studies conducted during relicensing have shown that all of the issues identified as part of the three previous reviews of anadromous fish reintroduction continue to exist in the basin today. For example, The Klamath River is listed by the Oregon Department of Environmental Quality (ODEQ) as water quality-limited for pH, ammonia, temperature, dissolved oxygen and Chlorophyll a. Stream flow and temperature issues became even more obvious in 2002 with the loss of over 30,000 fall Chinook salmon in the lower Klamath River below Iron Gate dam as a result of disease problems exacerbated by poor water quality (USFWS, 2003)[4].

Given the findings of previous fish reintroduction reviews, current basin environmental conditions, impacts to important resource areas such as river rafting, resident fish sport fishing and power generation, PacifiCorp is proposing to alter Project operations and facilities in a manner that emphasizes the protection of these tangible benefits instead of the highly uncertain benefits that may accrue to the public from the reintroduction of anadromous fish to stream reaches above Iron Gate dam at this time (see Section E4.7). However, this does not mean that anadromous fish passage and reintroduction has been abandoned.

E4.3.1.1 Previous Reviews of Anadromous Fish Reintroduction to the Upper Klamath Basin

The feasibility of reintroducing salmon and steelhead trout to the Upper Klamath basin above Iron Gate dam has been evaluated on three previous occasions. A summary of these reviews is presented below.

Fortune et al. 1966. The first study, completed in 1966, was directed by an inter-agency committee consisting of representatives from the U.S. Bureau of Sport Fisheries and Wildlife, U.S. Bureau of Commercial Fisheries, CDFG, Fish Commission of Oregon, and Oregon State

[4] Klamath River Fish Die-Off September 2002. Causative factors of Mortality.

Game Commission. In addition, an attorney from the City of Klamath Falls and a representative from Pacific Power and Light Company were members of the Steering Committee. This is the most comprehensive of the reviews, and the later reviews rely heavily upon the information presented in the Fortune et al. report. The evaluation included a useful historical account of fish occurrence in the Upper Klamath River basin based on published accounts, newspaper articles, and personal interviews with longtime local residents. The investigators also surveyed and documented habitat conditions in the Klamath River basin upstream of Iron Gate dam as they existed in 1965.

After evaluating the information contained in the Fortune et al. report, the Steering Committee advised against pursuing a program to re-establish anadromous fish runs to the Upper Klamath River basin. That conclusion was based on the following considerations as quoted from the committee's report:

1. Problems related to downstream passage of fry and juvenile fish at impoundments and lakes are serious. In the judgment of the Committee, losses due to residualism, predation, diversions and failure of downstream migrants to negotiate the impoundments would prevent the establishment and maintenance of adequate runs.

2. Losses of upstream-migrating adults at fishways and in forebays or lakes would also be inevitable.

3. The re-establishment of anadromous fish would depend on obtaining stocks of fish whose migrating, spawning, and incubation requirements fit within the very narrow limits afforded by conditions in the Upper Klamath River basin. There are insufficient stocks of fish in the Klamath to implement an effective transplant and no assurance that present Klamath stocks would adapt to the narrow requirements of the Upper Klamath River basin. Experience elsewhere has demonstrated it is very unlikely that suitable stocks outside the basin could be found.

4. While perhaps no single factor in itself precludes the possibility of establishing anadromous fish in the Upper Klamath River basin, the interaction of all factors would prevent establishment of self-sustaining runs capable of perpetuating themselves at a useful level.

Klamath River Basin Fisheries Task Force, 1992. The Klamath River Basin Conservation Area Restoration Program was authorized by Congress in 1986 to formulate a 20-year program to restore anadromous fish populations in the Klamath River basin, including the Trinity River. The KRBFTF, established by the Act, completed the "Upper Klamath River Basin Amendment to the Long Range Plan" in 1992. This amendment contained an evaluation of the feasibility of restoring anadromous fish to the Upper Klamath River basin. The three recommendations of the Task Force were:

1. The Task Force should not support attempts to restore anadromous fish above Iron Gate dam at this time.

2. Only native Klamath River broodstock should ever be employed in reintroduction efforts.

3. Continue efforts to conserve gene resources in the lower basin to preserve diverse life history strategies that might someday help to restore upper basin runs.

The reasons given for not supporting reintroduction included:

1. Disease Introduction. No viral diseases are known to infect native fish of the Upper Klamath River basin. If salmonids were brought in from other basins, or even allowed to pass upstream from Iron Gate dam, there is a strong possibility of introducing Infectious Hematopoietic Necrosis (IHN) to the Upper Klamath River basin, where native fish populations, including redband trout, have no natural resistance.

2. Genetic Risks. If out-of-basin stocks are used for reintroduction into the Upper Klamath River basin, they could stray and spawn with lower river stocks. Such interbreeding could lower the fitness of the locally adapted downriver stocks.

3. Suitable Stocks. Because the stocks that were genetically adapted to the Upper Klamath River basin have been extirpated, it is uncertain whether the genotypes present in stocks downstream of Iron Gate dam would be suited to the Upper Klamath River basin.

4. Habitat Quality. Water quality in the Upper Klamath Lake may have deteriorated since Fortune et al. (1966) assessed potential migratory problems for anadromous fish. High water temperatures and pH and low dissolved oxygen would be lethal to salmonids attempting to migrate through the lake after June 1. Water quality problems originating in the lake could continue to pose problems for outmigrating smolts downstream of the lake.[5]

5. Passage Conditions. Even with provisions for downstream passage facilities at the dams, the added stress of passing the dams and through the reservoirs, combined with passage problems through Upper Klamath Lake, could limit the success of attempts to reintroduce anadromous salmonids to the Upper Klamath River basin.

The Task Force evaluation concludes with the following statement:

> "While the dream of restoring salmon and steelhead remains alluring, consideration of reintroduction of these fish above Iron Gate dam should be left to the future."

ODFW, Klamath River Basin Fish Management Plan, 1997. ODFW addressed the topic of salmon and steelhead reintroduction in their 1997 Klamath River Basin Fish Management Plan. The report restates the four problems associated with reintroduction noted by the 1966 inter-agency committee (see above) and identifies two additional factors:

1. Introduction of Klamath River salmon and steelhead from California, the logical choices, would risk importation of viral diseases that could cause harm to existing native trout.

2. Successful reintroduction of salmon and steelhead would present direct competition for food and habitat with existing native fish fauna.

The Oregon management plan also summarizes the results of an experimental program (1970 to 1974) whereby surplus adult steelhead trout from the Iron Gate hatchery were trapped and released into the Oregon reaches of the Klamath River. An evaluation of the program (Hanel and

[5] Results of DEQ water quality and water quality studies conducted during relicensing confirm that water quality remains a limiting factor to anadromous fish production in the basin (see ODEQ website: http://www.deq.state.or.us).

Stout, 1974) concluded that few anglers were attracted to the potential sport fishery, many of the fish moved downstream into California waters, and the steelhead spawned at the same time and in the same areas as resident trout, many of which were larger than the steelhead. Due to negligible angler use and, in particular, the potential for interbreeding with the native redband trout, the program was discontinued.

The ODFW review concludes with the following statement:

> "Because of existing habitat problems, loss of native stocks, risk of disease introduction and potential competition with remaining native redband trout, it does not appear feasible, or prudent, to attempt re-establishment of anadromous salmon or steelhead to the Upper Klamath River basin in Oregon, now or in the future."

In general, the three reviews all agreed that successful restoration of anadromous fish populations depends on a number of factors, which individually or singly, can determine the sustainability of a fish population. These factors include:

1. Availability of stocks that are genetically adapted well enough to the local environmental conditions to meet survival levels necessary for sustainability
2. Sufficient physical habitat to meet spawning, egg incubation, rearing, and migration needs
3. Water temperature regimes that are consistent with the life history requirements for the stocks being considered for introduction
4. Suitable water quality conditions (in addition to temperature)
5. Ability of fish to freely migrate upstream and downstream past man-made structures with minimal mortality and delay
6. Sufficient marine survival (including harvest)
7. Sufficient in-river adult survival (including harvest)
8. Disease/pathogen resistance
9. Minimal competition (native and exotics)
10. Minimal predation (native and exotics)

It is important to recognize that all of these above factors are primarily independent variables as they pertain to the probability of establishing self-sustaining runs. As such, any one factor could trump the others and prevent successful reintroduction. Cumulatively, the probability of success for population sustainability is the product of the individual factors. It is therefore important to understand the concept of how the probabilities associated with multiple variables cumulatively interact in determining overall feasibility. These interactions among environmental attributes affecting fish survival and production are currently being addressed and evaluated by means of two different models, discussed below, which are being developed collaboratively in a modeling subgroup of the FPWG.

E4.3.1.2 Fish Passage Work Group

The FPWG was established to evaluate fish passage, habitat, and hatchery issues. The FPWG is composed of agency, tribal, NGO, and other interested parties. This work group is to assist in developing and assessing information on resident and anadromous fish passage issues and identifying, from a biological and technical perspective, preferred fish passage options for consideration. As part of the FPWG, three subgroups were set up to address specific topics associated with the fish passage evaluation and planning work. These include:

- Habitat Modeling Subgroup. This subgroup is responsible for determining fish passage effectiveness of proposed individual upstream and downstream facilities, different fish passage systems (e.g., trap-and-haul versus volitional passage), and probable outcomes in regards to the number of fish produced and their likely sustainability over time.

- Hatchery Subgroup. Members of this subgroup were tasked with evaluating current hatchery facilities to meet both current mitigation obligations and possible use in a reintroduction program. Several technical memos have been completed to date and distributed to the FPWG. These memos also are included in the Fish Resource FTR, Section 7.

- Engineering Subgroup. This subgroup was tasked with developing preliminary designs and costs for upstream and downstream fish passage facilities at all Project structures. The work of this subgroup has been completed and is documented in a series of technical memos for each development (see the Fish Resources FTR, Section7).

A description of the work and preliminary findings of the Habitat Modeling Subgroup are discussed in the following section.

E4.3.1.3 Habitat Modeling

The Habitat Modeling Subgroup continues to meet on a monthly basis to evaluate the anadromous fish reintroduction and fish passage issue. The group is using two separate modeling approaches to address information needs regarding the effectiveness of fish passage systems (KlamRAS) and anadromous fish habitat potential in key areas of the basin (EDT). A discussion of each model's purpose and modeling progress to date is presented below.

KlamRAS

KlamRAS is being used to focus on dam/reservoir passage efficiencies so that passage options (operations, facilities) can be assessed. The KlamRAS model incorporates both habitat data and fish passage survival through Project structures to estimate fish production in user-identified reaches or areas of the basin. The model allows the user to vary a wide-range of input variables to explore how different assumptions affect model results. Thus, this model is being used primarily as a tool to assess the effects various fish passage options have on fish production.

The Habitat Modeling Subgroup is in the process of parameterizing the KlamRAS Model. They are using a combination of data collected in other basins and the opinion of both fish passage engineers and biologists to set modeling values (and ranges) for fish screen collection efficiency, percent screen, bypass, reservoir and turbine survival, as well as juvenile and adult survival rates through various fish ladder and trap-and-haul scenarios.

After completing the parameterization process, the Habitat Modeling Subgroup will be examining five different project configurations to estimate impacts on anadromous fish production and survival. The scenarios include dam removal, volitional passage through fish ladders and screens, and trap-and-haul systems located at various locations in the Project area.

The outputs of these model runs will also be used to identify those critical uncertainties that drive model results. If possible, data collection efforts will be implemented to reduce the uncertainty around these input values to the extent possible.

One major uncertainty that has already been identified by the Habitat Modeling Subgroup and stakeholders is juvenile survival through Project reservoirs. To address this issue, PacifiCorp will be conducting a reservoir survival study for salmon smolts in 2004. The study will be conducted at Copco and Iron Gate reservoirs. These reservoirs are located in the California portion of the Project area. Studies will not be undertaken in Oregon waters until permits can be obtained from ODFW. ODFW is not allowing smolt studies to be conducted in Oregon waters because of concerns about disease and impacts on resident fish populations (letter from Amy Stuart, ODFW, November 19, 2003,).

Although not possible in 2004, the testing of juvenile survival through Keno reservoir and Upper Klamath Lake is a critical uncertainty that must be addressed, as it may have the greatest effect on fish production potential upstream of Iron Gate dam. Of the new areas being modeled for anadromous fish reintroduction, the majority of this habitat is located in the Upper Klamath River basin above Upper Klamath Lake. Results of previous reviews of anadromous reintroduction have all expressed concern that because of such physical constraints as lake length, depth, flow patterns and poor water quality, juvenile survival through the two lakes may be quite low. Additional difficulties include the absence of native anadromous fish stocks adapted to the specific environmental conditions for a reintroduction effort.

PacifiCorp estimates that KlamRAS modeling will continue through the completion of the reservoir survival study in summer 2004. The data from this study will be incorporated into the KlamRAS alternatives modeling exercise, at which time the results will be summarized and sent to the stakeholders for review and comment.

<u>Ecosystem Diagnosis and Treatment (EDT)</u>

The second model being used to explore the anadromous fish reintroduction issue is EDT. This model provides a tool to incorporate habitat features and biological productivity into the analysis of fish passage options. It provides a comprehensive habitat-based tool to address the success of restoring anadromous fish runs to the Upper Klamath River basin above Iron Gate dam. This model is being used to assess existing and potential habitat capacity and productivity in the Upper Klamath River basin by reach and tributary that may be considered for the reintroduction of anadromous fish. The habitat quantity and quality outputs from EDT are being used as inputs into KlamRAS. A detailed description of the EDT Model and analysis methodology can be found in the Fish Resource FTR, Section 7.

The habitat inputs used in EDT modeling are being developed from various sources, including:

1. Results of water quality, geomorphology, and Project operations studies conducted as part of relicensing

2. Studies conducted by other parties in the Upper and Lower Klamath River basins, including information on juvenile emigration timing, migration speed and survival in the Lower Klamath River, effects of disease on native fish populations, run-size estimates, estuary conditions, and mainstem habitat quality and quantity

3. Historical fisheries literature developed both within and outside the Klamath River basin

4. Expert opinion of Habitat Modeling Subgroup members familiar with Klamath River habitat and fish reintroduction efforts in other basins

For the most part, the EDT model has been fully parameterized (draft) for the river reaches extending from Iron Gate dam to Spencer Creek. Efforts to fill in the habitat data needed to evaluate the 236 miles[6] of stream reaches above Keno dam are ongoing and are expected to be completed by mid-2004.

Data entered into the EDT model to date tend to confirm that the habitat/environmental problems identified in the previous reviews of anadromous reintroduction still exist in the basin today. Two of the more important and highly related problems include water temperature and disease.

Water Temperature. Water temperature data collected in juvenile traps in the lower Klamath River downstream of Iron Gate dam show that stream temperatures after July 1 often exceed 24 degrees Celsius (°C) (Klamath River Fisheries Assessment Program, Juvenile Salmonid Monitoring on the Trinity and Klamath Rivers, 1994). Sustained stream temperatures above 21°C may cause severe stress and mortality to anadromous salmonid species.

Disease. Diseases such as *ceratomyxosis* may cause substantial mortality to juvenile Klamath River Chinook salmon when sustained temperatures exceed 16°C. Studies conducted on juvenile Chinook salmon by the USFWS in the Upper Klamath River basin showed that after 3 days of exposure, 100 percent of the test specimens were infected with *Ceratomyxa shasta* and 83 percent died within 17 days (USFWS, 2003). As stream temperatures in the Klamath River regularly exceed 16°C during the peak migration period for Chinook salmon (May-July), impacts from this disease on fish survival may be severe. In contrast, steelhead exposed to the same conditions showed virtually no mortality. The results of an investigation of *Ceratomyxa shasta* in the Klamath River, prepared by PacifiCorp in 2003, are included in the Fish Resources FTR, Section 8.

Initial, very preliminary EDT model runs show that even when passage survival through reservoirs and dams is assumed high, self-sustaining runs of fall Chinook salmon could not be achieved in the Project area. EDT estimates of adult fall Chinook salmon returns to the spawning grounds under three scenarios were as follows:

1. 487 adult returns to the spawning grounds with 100-percent dam survival—model predicted reservoir survival and current ocean and freshwater harvest rates.

2. 1,356 adult returns to the spawning grounds with 100-percent dam survival—model predicted reservoir survival and no harvest.

[6] Preliminary estimate of habitat in the Upper basin above Keno dam

3. 4,500 adult returns to the spawning grounds with 100-percent dam and reservoir survival, and no harvest.

In addition to the Project-related assumptions presented for each scenario (i.e., dam/reservoir survival), other factors responsible for the preliminary model results include; the quality of the free-flowing habitat available in the Project area, high water temperatures, disease, predation from introduced fish species, and harvest. These results point out the importance of including habitat in the Upper Klamath River basin in future model runs to determine if an increase in habitat quality and quantity can increase fall Chinook salmon production to sustainable levels, based on modeling.

Klamath River fall Chinook salmon are harvested in the ocean and freshwater at approximately 15 percent and 30 percent, respectively (Ocean Abundance Projections and Prospective Harvest Levels for Klamath River Fall Chinook Salmon, 2003 Season, Klamath River Advisory Team, March 9, 2003). These data indicate that re-establishing self-sustaining Chinook salmon runs upstream of Iron Gate dam may require the implementation of selective fisheries for hatchery fish in freshwater fisheries. This would not only require a change in harvest policy but also that all hatchery fish be marked prior to release into the basin.

The adult fall Chinook salmon run size of natural spawners to the mainstem Klamath River has averaged approximately 4,500 adults since 1990, with the vast majority of these fish returning in the last 2 years (CDFG, 2003) (Figure E4.3-1). On average, the mainstem Klamath River produces about 23.5 fish per mile of stream. Although the majority of the spawning currently occurs in key locations downstream of Iron Gate dam, one could roughly estimate, using the above spawner-per-mile value, that the 26 miles of additional free-flowing mainstem river in the Project area above Iron Gate dam might produce approximately 600 adults per year, if fish passage survival was the same through the Project area as it is in the free-flowing lower river. Some additional Chinook salmon might be produced in the 16 miles of small tributaries in the Project area as well. Although initial EDT model runs for the current Project configuration support this assumption, i.e., low production from the Project area with dams in place, model results are highly preliminary and are likely to change as data for the Project area are reviewed by the Habitat Modeling Subgroup and data for the Upper Klamath River basin are entered into the model.

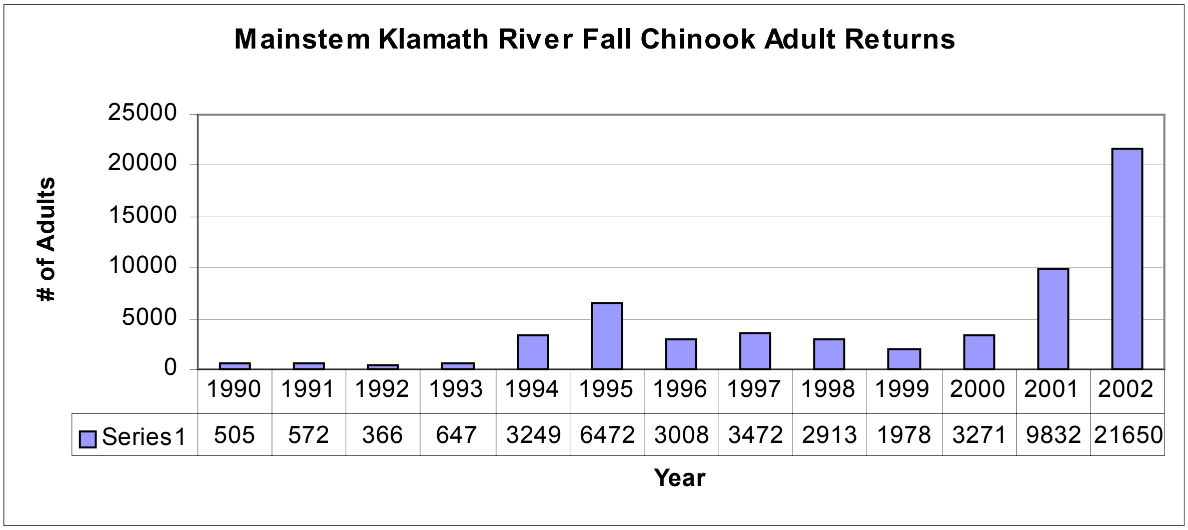


Figure E4.3-1. Fall Chinook adult returns to the mainstem Klamath River below Iron Gate dam. Includes natural spawners only. Source: CDFG (2003).

The Habitat Modeling Subgroup will continue working in 2004 to evaluate approaches for reintroducing anadromous salmonids to the upper basin. The tasks to be completed in 2004 deal with both modeling issues and finding solutions to the problems identified in previous reviews regarding reintroduction. A description of the tasks and a time frame for completing each is presented below:

- Conduct a parameter-by-parameter review of the habitat and fish passage inputs used in modeling stream habitat in both the Project area and the Upper Klamath River basin (above Keno dam). As can be seen from the preliminary EDT results presented above, the accuracy of key assumptions regarding harvest, dam and reservoir survival has tremendous influence on resulting estimates of production. The parameter review is expected to be complete by April 2004.

- Identify and model other anadromous species that could be candidates for reintroduction to the upper basin. The task is expected to be complete by June 2004.

- Develop criteria for modeling a "restored condition" for habitat in the upper basin. Based on these criteria, develop a suite of actions that would meet habitat objectives and goals. Different actions and approaches would be combined and modeled as separate scenarios to determine the best reintroduction strategy. Information on expected benefits, when these benefits are likely to be achieved, and how they may effect the implementation of different fish passage facilities and their location would be described. This task would start in June 2004 and continue until completed.

- Identify reintroduction strategies including broodstock source, stocking strategy, numbers of fish released, their location, and the facilities needed. Also, identify the parties that will need to be contacted to assist in this effort (start in May 2004). To assist in evaluating broodstock options, PacifiCorp completed an investigation of salmonid genetics in the Klamath River basin in 2003. The report is included in the Fish Resources FTR, Section 9.

- Identify those issues that parties outside of the Habitat Modeling Subgroup will need to address before reintroduction can take place. For example, parties outside the Subgroup will need to provide input (both policy and technical) on issues such as anadromous fish impacts on disease prevalence and competition with resident trout populations. (May 2004)

- Identify critical data gaps and uncertainties that will need to be addressed through data collection or other methods (modeling, etc.). Priority would be given to those data gaps that are needed for decision-making. This task would be on going throughout the process.

PacifiCorp will be submitting the results of Habitat Modeling Subgroup efforts to the stakeholders for review and comment as they are completed.

E4.3.1.4 Effects of Proposed Fish Passage Facilities on Anadromous Reintroduction

Although habitat modeling is ongoing, PacifiCorp has enough information in hand to propose a set of fish passage improvements that will not only benefit resident fish populations in the Project area, but will also benefit any reintroduction efforts implemented by others in stream reaches upstream of Keno dam. Again, although there are an estimated 41.5 miles of possible anadromous habitat in the Project area, the Upper Klamath River basin may have upwards of 236 miles.

PacifiCorp is proposing the following fish passage actions in its license application:

<u>Decommissioning of East Side and West Side Projects</u>

The decommissioning of these two facilities will eliminate juvenile and adult fish entrainment through Project structures providing protection to resident fish and ESA-listed sucker populations. Improvements here would also increase fish passage survival for any anadromous fish species re-established in stream reaches upstream of Klamath Lake.

<u>Improved Juvenile Collection Facilities at J.C. Boyle Dam</u>

PacifiCorp is proposing to construct a new juvenile collection system (gulper) in the J.C. Boyle reservoir. This facility will be used to reduce entrainment of juvenile and adult resident and anadromous fish, if they are reintroduced, through Project spillways and turbines.

If anadromous fish reintroduction efforts were implemented in stream reaches above the J.C. Boyle Development, PacifiCorp would consider working collaboratively with the agencies to collect and transport juvenile and adult anadromous fish captured in the gulper for release below Iron Gate dam. As noted in the three previous reviews of the anadromous reintroduction issue, because of the physical characteristics of Upper Klamath Lake and Keno reservoir, poor water quality conditions, and lack of a suitable stock for reintroduction, it appears quite unlikely that juvenile survival through the two lakes would be sufficient to maintain a sustainable population. However, if large numbers of juveniles did survive passage through the two lakes, it is believed that their overall survival rate through the Project would be higher in a trap-and-haul system in comparison to a system that allows them to migrate through two more reservoirs and dams. This assumption will be tested through the modeling effort and juvenile survival studies to be conducted in 2004.

E4.3.2 Iron Gate Fish Hatchery

Iron Gate dam was built in 1961 by Pacific Power and Light Company (now PacifiCorp). To mitigate for loss of anadromous fish habitat up stream of the dam, PacifiCorp was required to build and fund the Iron Gate salmon and steelhead hatchery. The adult salmon ladder, trap and spawning facility was built at the base of the dam and was put into operation in February 1962. The hatchery complex, including egg incubation, rearing, maintenance, and administration facilities, as well as staff residences, was constructed about 400 yards downstream of the dam with a completion date of March 1966. The largest feature of the hatchery complex comprises the 32 rearing ponds, each measuring 10 by 100 feet. The facilities have operated every year since construction with little modification.

Iron Gate fish hatchery is operated by CDFG. The program is funded both by CDFG and PacifiCorp. By agreement, PacifiCorp funds 80 percent of the total operating costs of the hatchery to satisfy its annual mitigation goals for fall Chinook fingerlings, coho yearlings, and steelhead yearlings. Beginning in 1979, portions of the fall Chinook fingerling production have been reared to the yearling stage for release in November. This extra cost has been funded by CDFG.

E4.3.2.1 Production Goals

The current production goals for the Iron Gate fish hatchery are shown in Table E4.3-1 for the PacifiCorp mitigation and CDFG enhancement programs. The original mitigation goals were set in the Order Issuing License for Iron Gate dam (Federal Power Commission, 1961). However, in 1979, CDFG and PacifiCorp agreed to modify the program to shift some of the Chinook production to yearling releases. These fish would be reared either at Iron Gate fish hatchery, Fall Creek ponds (a satellite facility to Iron Gate fish hatchery), or at both. The original order to release 6 million fall Chinook fingerlings (smolts) was changed to a production goal of 4.6 million then 4.92 million. Coupled with that change was a transfer of 180,000 smolts to the Fall Creek ponds for yearling production, and the retention of 900,000 smolts at the Iron Gate fish hatchery for yearling releases. Another more major change is the altered strategy in fall Chinook size at release. Originally, 6 million Chinook were released at 300 per pound plus an additional 5.5 million swim-up fry. CDFG has determined that releases at 90 per pound for smolts and 8 per pound for yearlings are more effective.

Table E4.3-1. Iron Gate fish hatchery production goals and constraints.

Species	Egg Allotment	Stocking Goals and Constraints			
		Type	Number	Minimum Release Size	Target Release Dates[1]
Fall Chinook	10,000,000	Smolt	4,920,000[2]	90/lb.	June 1 - 15
		Yearling	1,080,000[3]		October 15 - November 15
Coho	500,000[4]	Yearling	75,000	10-20/lb.	March 15 - May 1
Steelhead	1,000,000	Yearling	200,000	6 inches[5]	March 15 - May 1

[1] If unusual circumstances dictate, releases may deviate from the target release dates on approval from the Regional Manager.
[2] In years when yearlings are not reared at the Fall Creek ponds, the smolt production will be 5,100,000
[3] Approximately 900,000 shall be reared at Iron Gate fish hatchery and 180,000 shall be reared at the Fall Creek ponds and released from Iron Gate fish hatchery. If the Fall Creek ponds are not operated, the production goal shall be 900,000 yearlings.
[4] A large number of coho eggs must be taken to meet the hatchery production goal because of reduced egg survival caused by soft-shell disease.
[5] By September 1, steelhead numbers in the hatchery shall be reduced as necessary to meet but not exceed the production goal.

The current goals for steelhead trout also differ form the original goals in that the target size has been changed from 10 inches per pound to 6 inches. Production numbers have stayed the same at 200,000. Production goals for coho salmon are 75,000 smolts at a size of 10 to 20 inches per pound.

Egg take goals are greater than necessary to achieve the established production goals. This is done to address uncertainties from year to year in the hatchery and to allow culling of production lots as desired. The original egg take goal for Chinook was 12.8 million. This was increased to 18 million by CDFG following some high-return years to allow for excess eggs to be used for production elsewhere. Since then, the practice of inter-basin transfer has fallen out of favor for genetic and pathogen control reasons. The current egg take goal for Chinook is 10 million. Coho egg take goals are 500,000 for the yearling release of only 75,000 fish. The disparity between egg and smolt numbers is a result of a past problem with soft-shell disease, which has been largely solved with iodine bath treatment, but the high egg take goal is still in place. PacifiCorp and CDFG understand that egg take goals have been set as a guide to reach production goals rather than as an absolute number.

E4.3.2.2 Production Constraints

In 1996, CDFG prepared a document entitled "Iron Gate Fish Hatchery Production Goals and Constraints." The goals are discussed in the previous section and summarized in Table E4.3-1. Production constraints refer to directives regarding hatchery practices for the purpose of minimizing hatchery-related environmental impacts. Such directives include:

- For all species cultured, only fish volitionally entering the hatchery are used as brood stock. Stocks from other drainages or other Klamath River tributaries are not spawned or cultured at the hatchery. This has generally been the practice since the hatchery began operation.

- The annual egg allotment for all species are distributed throughout the duration of the spawning run in proportion to the instantaneous magnitude of the run. Maintaining genetic diversity by distributing egg allotment throughout the spawning run takes precedence over meeting numeric production goals.
- No eggs or juveniles of any species in excess of the production goals are kept at the hatchery. At the end of the spawning run, any eggs or juveniles on hand and in excess of production goals are destroyed unless needed for CDFG-approved inland programs. Excess eggs or juveniles are not stocked in anadromous waters.
- All adult salmon entering the Iron Gate fish hatchery are destroyed in the following manner: The heads of all adipose-clipped salmon are removed from carcasses and sorted for coded-wire tag processing. Carcasses are donated to nonprofit organizations that have submitted applications to the hatchery manager. The hatchery manger has the authority to determine the allocation of the carcasses to be donated. Carcasses not donated to nonprofit organizations are disposed of at a refuse disposal site or returned to the river as directed by the Northern California-North Coast Region Manager. All adult steelhead processed in the hatchery are returned to the river. Any dead steelhead are disposed of as provided above for salmon.
- All juvenile salmon and steelhead are released into the Klamath River at the hatchery release facility. Iron Gate fish hatchery stocks or production are not stocked in other drainages or in other tributaries to the Klamath River. Any exception to or modification of the mitigation program requires the joint written approval of the Regional Manager and the CDFG Inland Fisheries Division Chief.

E4.3.2.3 Juvenile Salmon and Steelhead Production

Historical production of juvenile fish at Iron Gate fish hatchery from 1965 to 2001 is illustrated in Figures E4.3-2, 4.3-3, and 4.3-4 for Chinook, coho, and steelhead, respectively. The Chinook graph shows yearling release numbers stacked on top of smolt numbers. For the coho and steelhead graphs, the fingerling and yearling smolt releases are shown side-by-side for each year. Note that coho and steelhead fingerling releases were discontinued for the most part in the early 1980s.

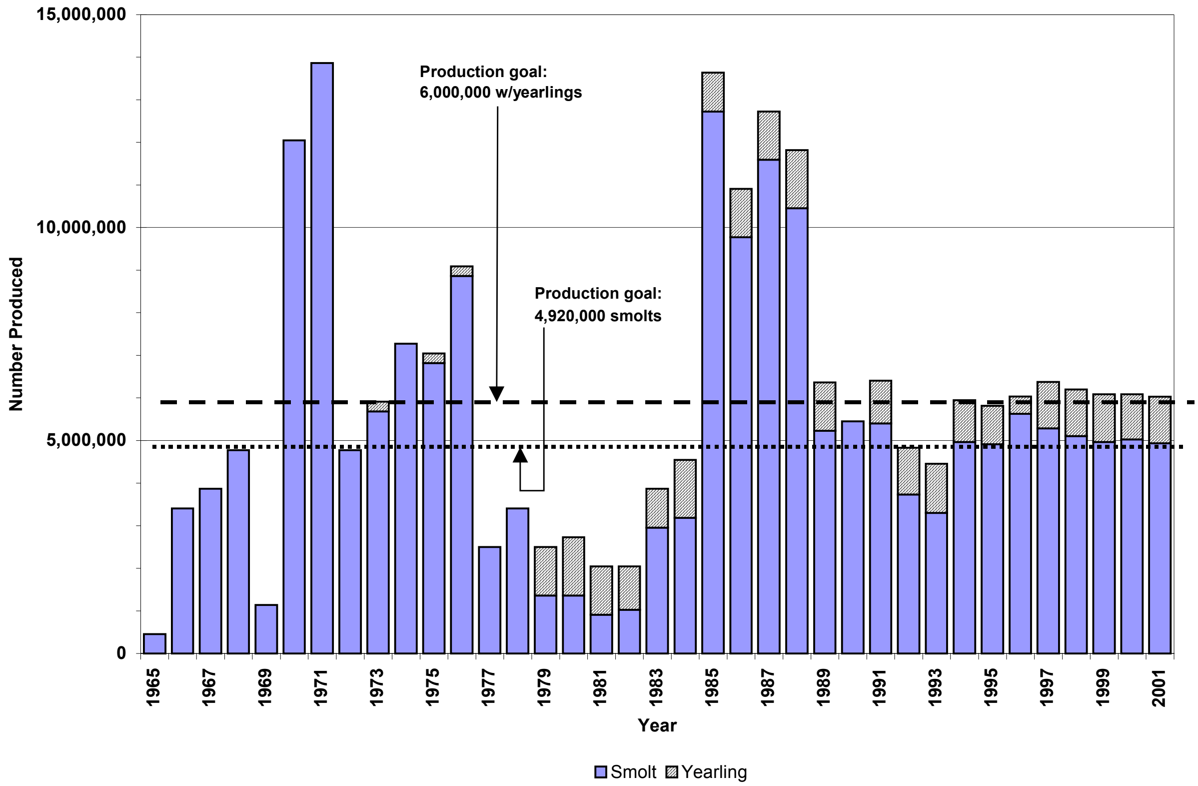


Figure E4.3-2. Chinook production at Iron Gate fish hatchery, 1965-2001.

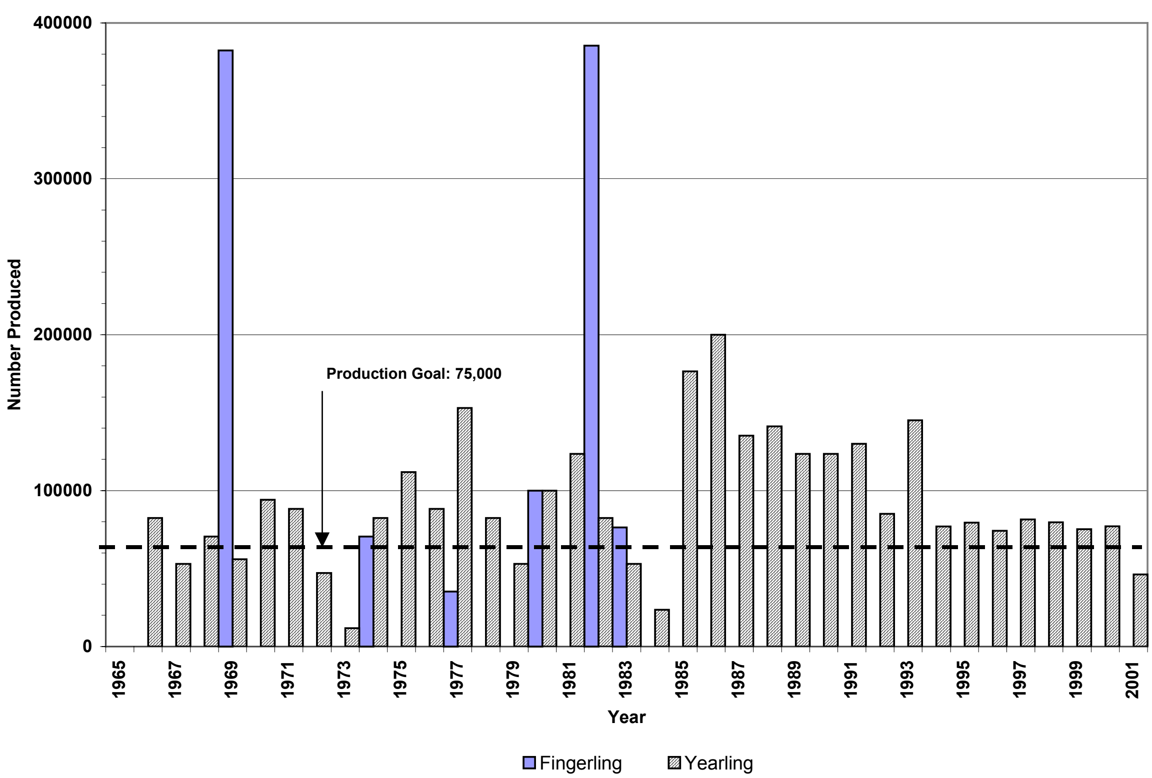


Figure E4.3-3. Coho production at Iron Gate fish hatchery, 1965-2001.

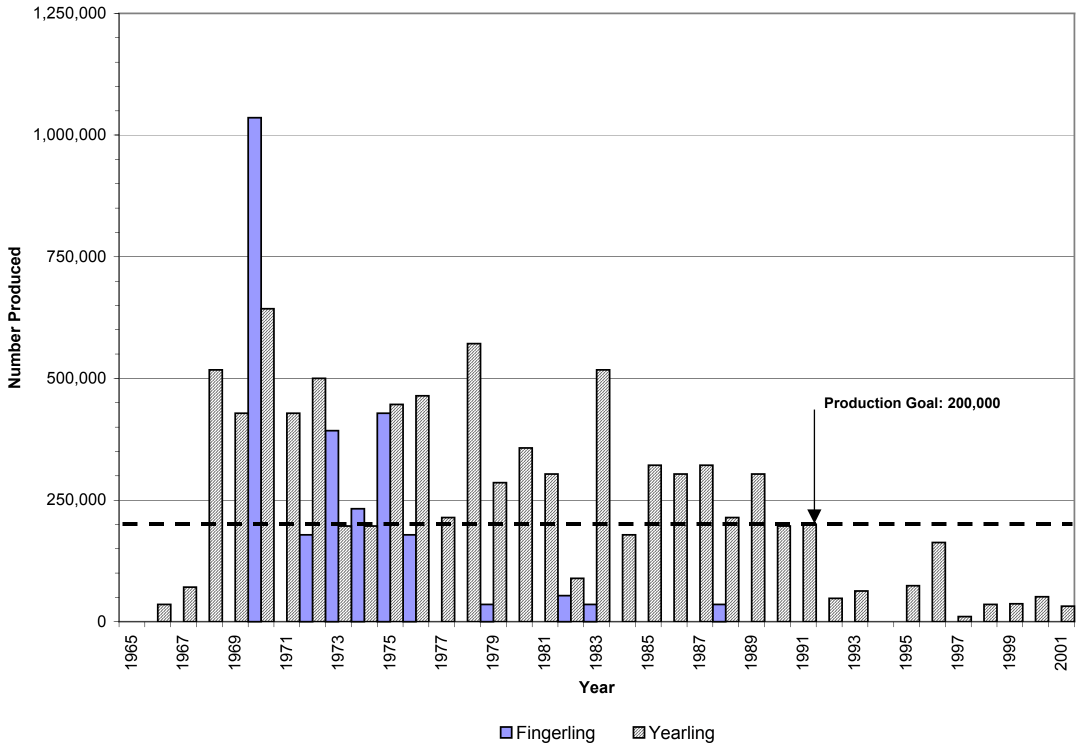


Figure E4.3-4. Steelhead production at Iron Gate fish hatchery, 1965-2001.

Chinook production has fluctuated substantially among years during the period preceding 1989. Numbers of Chinook smolts ranged from 454,546 smolts in 1965 to 12,727,288 smolts in 1985. The 8-year period from 1977 through 1984 showed relatively low production, well below production goals. After 1989, production of smolts has been consistently at or close to goals. With the exception of the mid 1970s and 1990, yearling release numbers have been close to the goal of 1,080,000. No yearlings were produced in 1974, 1977, 1978, or 1990.

Coho production has varied from zero to 200,000 yearling smolts. The production goal of 75,000 yearlings has been met in 26 of the last 37 years, or 70 percent of the time. Production was frequently below target during the 1970s. Production in the 1980s was usually above target with much greater numbers in the late 1980s. Since 1994, production has been maintained very close to production goals. Fingerling releases were made periodically prior to 1984, and were relatively large in 1969 and 1982, corresponding to relatively large adult returns.

Steelhead production has varied widely through the years ranging from a high of 642,857 yearlings in 1970 to a low of 10,702 in 1997. Production has steadily declined since the peak year in 1970. Production goals were met in most years prior to 1991. The goal of 200,000 smolts has not been met since 1991. Fingerling releases have been made in the past, but not since 1988. During the 1980s, fingerling releases of 200,000 to 300,000, were common, with a peak of 1.1 million in 1970.

E4.3.2.4 Adult Returns

Returns of adult salmon to the Iron Gate fish hatchery from 1964 to 2002 are shown in Figure E4.3-5. The values shown do not include jacks (defined as fish less than 22 inches in length). Chinook returns to the hatchery ranged from 954 fish in 1969 to 22,681 fish during the years from 1963 to 1999. Return numbers have increased slowly and erratically over the years. In 2000 and 2001, record numbers of Chinook returned to Iron Gate fish hatchery, with 71,151 returning in 2000, which most biologists credit favorable ocean conditions.

Coho returns have ranged from zero to 3,546 fish, averaging 830 fish (see Figure E4.3-5). Coho returns to Iron Gate fish hatchery have increased on average over the years, but very erratically. What has changed the most are the magnitude of the return in the peak years, such as 1997 when 4,000 adult coho returned to the hatchery. These are interspersed with returns as low as 500 fish. There is some indication of a 3-year cycle, which would be typical for coho in the absence of environmental variation.

Steelhead returns also have been erratic, ranging from 12 to 4,411 fish (see Figure E4.3-5). In the years prior to 1969, the run size was in the range of 400 to 1,500 fish. During the next 20 years, the run size increased to a range of 100 to 4,000 fish. From 1990 to 1999, the run dropped below 100 fish. Since that time the run has recovered somewhat. In 2003, the egg take met collection goals for the first time in a decade.

E4.3.2.5 New Considerations

During the course of PacifiCorp's evaluation of the Iron Gate fish hatchery, the Hatchery Subgroup identified four specific investigations that would provide information related to future hatchery operations. The results of these investigations are presented in Section 7.0 of the Fish Resources FTR and are summarized below.

<u>Incubation Water</u>

The concept of heating egg incubation water at Iron Gate fish hatchery to accelerate egg development was examined as a potential means to produce larger salmon and steelhead trout smolts. Steelhead and late Chinook lots are considered to be undersized at release. Undersized steelhead may contribute to residualism. Undersized Chinook may exacerbate wild/hatchery fish competition for thermal refugia in the lower river in June. The evaluation indicated that accelerating the incubation of steelhead eggs may help the hatchery management address the residualism issue. The cost of heating water for steelhead eggs is minor and can be accomplished as part of the normal O&M program. For fall Chinook, however, it was concluded that accelerating late Chinook lots would artificially shift fitness towards the later portion of the run thereby altering the run timing of the stock. Another consideration of this practice would be the thermal influence this heating would have on the hatchery effluent and on the Klamath River.

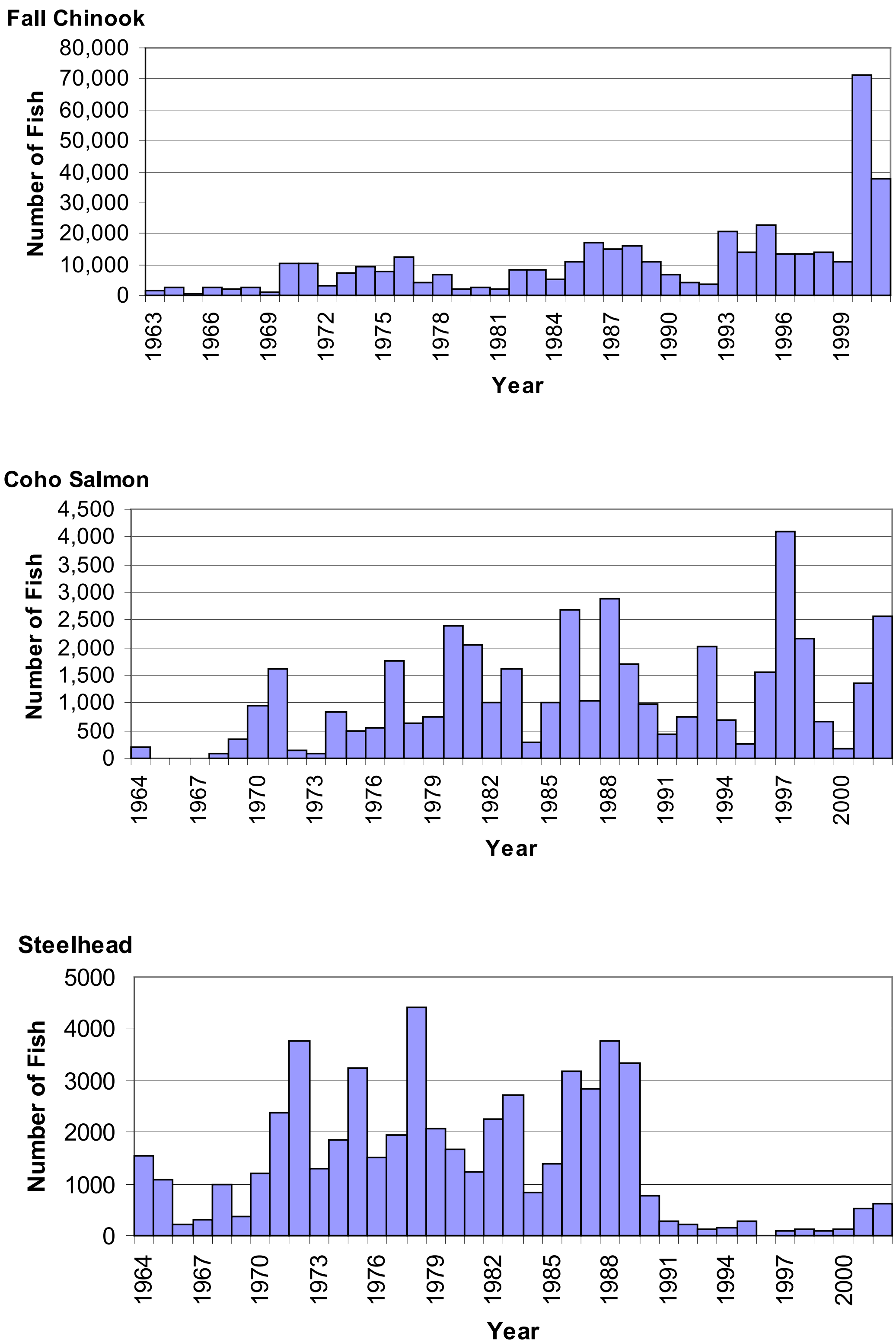


Figure E4.3-5. Adult returns of salmon and steelhead to Iron Gate fish hatchery, 1964 to 2002.

Chinook Tagging and Marking

Currently, about 5 percent of the Iron Gate fish hatchery Chinook are tagged with coded wire tags and marked with an adipose fin clip. All steelhead and coho are marked in some fashion with fin and/or maxillary clips. CDFG wants to increase the percentage of Chinook tagged at the Iron Gate fish hatchery to match the percent tagged at the Trinity River fish hatchery (25 percent) to achieve a constant fractional marking (CFM) rate in the Klamath-Trinity River basin. A CFM rate would greatly assist management of the Chinook fisheries in the basin for both wild and hatchery-origin fish.

Spring Chinook Production

To evaluate the feasibility of re-establishing a run of spring Chinook salmon at Iron Gate fish hatchery, life history requirements were examined first, then water availability and quality, and finally facility requirements. A reality check then was made with regard to production potential. Biological considerations, both pro and con, of producing spring-run Chinook were identified. Results of the feasibility evaluation, presented in the Fish Resources FTR, Section 7, highlight opportunities as well as several major biological concerns or constraints that would need to be considered if spring-run Chinook were to be produced at the hatchery. It was concluded that such a hatchery program for spring-run Chinook would be difficult and has a likelihood of failure.

Fall Chinook Yearling Production

Hatchery fall Chinook smolts compete with wild fish for thermal refugia in the lower river in early summer when flows in the Klamath River drop and temperatures climb. A shift in production from springtime smolt releases to fall yearlings could lessen this competition. The need for new facilities and water and the biological pros and cons of shifting more production to yearlings were evaluated (see the Fish Resources FTR, Section 7). It was concluded the any shift towards yearling production would reduce the hatchery fall Chinook run size in proportion to the shift. Although the return rate for yearlings is about three times greater than smolts by number, it is about one third as great by weight. However, the reduced hatchery run size may be offset, at least partially, by increased survival (via less competition) of wild fish.

E4.4 FISHERIES MANAGEMENT FRAMEWORK

This section describes the management framework that has been developed by various federal and state agencies for the fisheries resources in the Project area. Native American tribes, NGOs, and local citizen groups also have expressed fish resource interests and objectives, which are summarized below.

E4.4.1 State Fish Management

E4.4.1.1 Oregon Department of Fish and Wildlife

ODFW has established a fish management plan for the Klamath basin in Oregon (Klamath River Basin Fish Management Plan). See OAR 635-500-3600 through 635-500-3880. The plan incorporates and is supplemented by more general ODFW fish management policies. These policies, which in some instances contemplate implementation through the development of more specific watershed plans, include:

- Native Fish Conservation Policy (OAR 635-007-0502 through 635-007-0509)
- Wildlife Diversity Plan (OAR 635-100-0001 through 635-100-0035) (including provisions for the protection of Oregon sensitive, threatened, or endangered fish)
- Fish Passage Requirements (OAR 635-412-0020 through 635-412-0030)
- Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through 635-415-0025)

The management policies for specific aquatic species included under the Klamath River Basin Fish Management Plan for waters in the Project area are:

- Klamath River basin, all waters: Lost River and shortnose suckers shall be managed according to the adopted recovery plan for these species; bull trout (which are not present in the Project area) shall be managed for natural production; nongame fish shall be managed for natural production within their native habitats; warmwater game fish shall be managed for natural production and stocked fish; crayfish and introduced bull frogs shall be managed for natural production. (OAR 635-500-3630(1))
- Klamath River, from state line to Upper Klamath Lake: Redband trout shall be managed for natural production. (OAR 635-500-3640)
- J.C. Boyle reservoir: Redband trout shall be managed for natural production; provide a consumptive fishery for warmwater game fish. (OAR 635-500-3820)

E4.4.1.2 California Department of Fish and Game

CDFG has a management plan in place for the wild trout area (WTA) in the Project area. Along with general statewide management guidelines (Fish and Game Codes), the management of the aquatic resources focuses on wild trout in the upper portion of the Klamath River, anadromous fisheries below Iron Gate dam, and water quality and quantity throughout the California section of the river. This plan is summarized in the following subsections. There is no official management plan for the Project reservoirs in California.

E4.4.1.3 Upper Klamath River Wild Trout Management Plan, 2000-2004

CDFG established the California Wild Trout Program (WTP) in 1971 to maintain natural and attractive trout fisheries, where perpetuation of wild strains of trout is given major emphasis, in contrast to the planting of domesticated catchable-sized trout on a "put-and-take" basis (CDFG, 2000). As of January 1999, the California Fish and Game Commission had designated 29 stream segments and 3 lakes as wild trout waters. The Klamath River upstream from Copco reservoir was designated as a WTA in 1974 and has since been managed under the WTP (CDFG, 2000). This designation only applies to the riverine section and not the reservoir. The goals of California's WTP are to maintain a wild trout fishery and to maintain and enhance trout habitat conditions. In summary, the goals of California's WTP are:

1. Maintain a wild trout fishery of sufficient size and number to provide:
   - A mean catch rate of not less than one trout per hour

   - The opportunity to catch large fish, with at least half the trout caught longer than 9 inches
   - The protection and perpetuation of native fishes, particularly *Ceratomyxa*-resistant rainbow trout, Lost River suckers, and shortnose suckers

2. Maintain and enhance trout habitat conditions. Minimum maintenance standards include:
   - Water temperatures not exceeding 70°F and not exceeding 60°F for longer than 12 hours
   - Water transparency and suspended sediment loading not exceeding standards set by the North Coast Regional Water Quality Control Board
   - The river being free of any pollutants that could negatively affect the fishery or detract from the aesthetic value of the WTA
   - Spawning habitat in Shovel Creek being improved and protected to ensure optimal recruitment to the wild trout fishery
   - Stable flows being maintained at a level sufficient to support the trout fishery at existing or greater levels
   - Preserving the aesthetic character of the stream and adjoining streamside habitat

E4.4.2 Federal Fish Management

E4.4.2.1 U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries

Within the Project area, USFWS and NOAA Fisheries (formerly NMFS) implement the federal ESA for several species of resident and anadromous fish, respectively, that are listed as threatened or endangered under the Act. To address Project actions that affect the endangered shortnose and Lost River suckers, USFWS issued biological opinions related to PacifiCorp's Klamath Hydroelectric Project operations in 1996 and most recently in 2002 (USFWS, 1996, 2002). USBR received a new Biological Opinion from USFWS in 2002. In 1999 and 2002, NOAA Fisheries issued a Biological Opinion on the effects of the USBR project on coho that incorporated coverage for PacifiCorp's operation of Iron Gate dam. Specific objectives and requirements have been stipulated as a result of these ESA consultations. These are summarized in the following paragraphs.

1996 Biological Opinion on Suckers for PacifiCorp's Klamath Hydroelectric Project

PacifiCorp's terms and conditions for compliance with the 1996 Biological Opinion are as follows:

- Monitor incidence of sucker entrainment at PacifiCorp's East Side and West Side hydroelectric facilities
- Develop methods for PacifiCorp and USBR to cooperatively implement Upper Klamath Lake water operations for the benefit of endangered suckers

- Determine status of endangered suckers in PacifiCorp's Klamath River reservoirs

- Assist in the purchase and restoration of the Lower Williamson River property to benefit larval suckers and Upper Klamath Lake water quality

- Implement PacifiCorp operation and maintenance activities in a fashion that protects endangered species

- Assist Klamath basin resource agencies in funding a basinwide sucker genetics study.

In 2002, the long-term Biological Opinion for USBR's Klamath Irrigation Project was issued by NMFS (NOAA Fisheries, 2002) and USFWS (USFWS, 2002), and directed operational changes at PacifiCorp's Link River associated facilities for the protection of federally listed sucker species. PacifiCorp's specific responsibilities for compliance with the Biological Opinion include:

- A minimum flow release below Link River dam of 250 cfs from July 27 through October 17
- West Side shutdown from July 27 through October 17
- East Side diversion reduced to 200 cfs at night from July 27 through October 17

<u>Biological Opinions on Coho for USBR's Klamath Irrigation Project</u>

PacifiCorp's responsibilities for compliance with the Biological Opinion for the USBR have been updated yearly (starting in 1999) and include per NOAA Fisheries 2002 Biological Opinion:

- Releasing identified monthly instream flows downstream from Iron Gate dam

- Completing a ramping rate study, including a description of the ramping operations that occur at Iron Gate dam and the resulting Klamath River stage changes between the dam and the Shasta River, and an inventory of potential fish stranding areas related to river stage changes

E4.4.2.2 The Klamath River Basin Fishery Resources Restoration Act

The Klamath River Basin Fishery Resources Restoration Act (Public Law 99-552 or "Klamath Act"), was adopted by Congress on October 27, 1986. The Klamath Act directed the Secretary of the Interior to form the Klamath River Basin Fisheries Task Force (Task Force), to provide advice on the recovery of anadromous fish runs of the Klamath River. A Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program (LRP) and an Environmental Impact Statement (EIS) for the lower River were completed by the Task Force in 1991.

The LRP generally directs that fishery restoration is to be achieved through fish habitat protection and fish habitat restoration, from a total watershed perspective. The LRP also advocates that distinct population groups of anadromous fish remaining in the Klamath River be protected from over-harvesting and poaching.

Tribal Fish Management

Several Native American tribes have interests in the fisheries of the Project area, from both cultural and biological perspectives. The general fisheries management objectives of these tribes include:

- Restoration of fish habitat for all in-river life histories to include: physical habitat, water quality, and water quantity
- Hatchery operation that provides restoration of fish populations and adequately mitigates for lost production, while minimizing impact to natural production
- Fisheries recovery downstream from Iron Gate dam to sustainable harvest levels and fish passage and fish restoration upstream of Iron Gate dam
- Restoration of fisheries to historic levels with anadromous access to historic range (including salmonoids and lamprey)

Each Tribe has specific goals, which are identified in the consultation record provided in Appendix E-1A.

Nongovernment Organizations

Several NGOs have expressed an interest in the relicensing of the Project. Some of these organizations have expressed specific interests in the fisheries resources of the Project area, including economic and biological interests. Information provided thus far is summarized as follows:

- American Rivers objectives focus on river habitat restoration, fisheries restoration of listed and nonlisted species, restoration of natural ecosystem function, and aquatic and terrestrial connectivity.
- The Wilderness Society's objectives relate to water quality and quantity and restoration of recreational, commercial, and tribal fisheries.
- Goals for Trout Unlimited include protecting, preserving, and restoring native trout and salmon and their habitats; ensuring that water quality provides appropriate habitat for diverse native cold water fish populations; addressing fish passage issues; and restoring ecological and habitat integrity.
- Management objectives for the Pacific Coast Federation of Fishermen's Association are to improve population numbers and survival of anadromous salmonids throughout the basin, increase habitat access, particularly fish passage upstream from Iron Gate dam, improve water quality and quantity, and improve existing spawning and rearing habitat.

The Upper Klamath Outfitters Association's objectives are related to minimum water flow and minimum water release.

E4.5 CONSULTATION WITH APPLICABLE AGENCIES, TRIBES, AND THE PUBLIC

PacifiCorp began its relicensing consultation effort for the Project using the basic approach established by the Traditional Licensing Process. The Traditional Licensing Process was initiated in December 2001 by the distribution of the First Stage Consultation Document in which PacifiCorp provided on overview of the Project and resources in the Project area, and proposed certain studies needed to support development of the license application.

In response to comments on the First Stage Consultation Document, PacifiCorp revised its proposed study plans and re-distributed them in the form of a draft Second Stage Consultation document. In response to stakeholder interest and concerns, the relicensing process has evolved into a robust collaborative effort with over 40 stakeholders engaged in a long-term collaborative effort to develop study plans, review and interpret results, and potentially agree on PM&E measures.

In August 2001, technical work groups were established to review and attempt to reconcile issues related to the study plans and a fish passage advisory body was convened to address approaches related to fish passage and "dam-out" alternatives assessment. Following a series of meetings and in response to stakeholder requests, PacifiCorp committed in February 2002 to a "high level" assessment of fish passage alternatives including potential dam-out scenarios. With this commitment, stakeholders agreed to engage in a long-term collaborative effort to develop study plans, review and interpret results, and potentially agree on PM&E measures. Please see the consultation record provided in Appendix E-1A.

Beginning in February 2002, stakeholders developed a Process Protocol to guide the long-term collaborative effort and a collaborative structure comprised of a Plenary Group (all interested stakeholders) and seven technical working groups, which convene each month for facilitated meetings. Recognizing time constraints for completing relicensing studies, the collaborative group endorsed the need to implement elements of those studies that had not yet been agreed on. Stakeholders also worked simultaneously to agree on study plan portions that were critical for initiating field work and modeling work while also reviewing and finalizing study plans.

The Plenary Group serves as the managing body of the collaborative process and has been comprised of all participants in the collaborative process. Two of the work groups – the Aquatics Work Group and Fish Passage Work Group – are tasked with addressing issues and studies related to aquatic resources as presented in this chapter of the Exhibit E. The assignment and approval of all Fish Passage Work Group and Aquatic Work Group study plans and all related final consensus decisions is the responsibility of the Plenary Group.

The Aquatics Work Group is tasked with addressing instream flow issues as well as describing impacts to aquatic resources including habitat, connectivity, and species interaction. Studies include analysis of Project effects on sediment transport and river geomorphology, evaluation of ramping, fisheries assessment, instream flow scoping and analysis, investigation of trout movement, effects of flow fluctuation on aquatic resources, investigation of trout and anadromous fish genetics, and investigation of the fish disease *Ceratomyxa shasta* in the Klamath River. The Aquatics Work Group met 18 times between September 2001 and June 2003.

The Fish Passage Work Group (formerly the Advisory Team and Task Force) is working to address fish passage engineering issues, Iron Gate fish hatchery, and reintroduction of anadromous fish above Iron Gate dam. Studies being addressed by this group include fish passage planning and evaluation (including an engineering pre-feasibility study), modeling using the EDT and KlamRAS models, entrainment, and investigation of juvenile anadromous fish behavior and survival throughout the Project area. The Fish Passage Work Group met 19 times between August 2001 and June 2003.

A total of 10 study plans related to fisheries have been developed by these two work groups. Three of these study plans have been agreed on by the Plenary Group. The study plans (and their agreement dates where applicable) are as follows:

- Study Plan 1.7 Evaluation of Ramping Effects on Fish Downstream of Link Dam, Keno Dam, JC Boyle Dam, JC Boyle Powerhouse, Copco No. 2 Dam, and Iron Gate dam (not agreed on)
- Study Plan 1.8 Instream Flow Scoping Plan (agreed on August 2002)
- Study Plan 1.9, Fisheries Assessment (not agreed on)
- Study Plan 1.10, Fish Passage Planning and Evaluation (not agreed on)
- Study Plan 1.12 Instream Flow Analysis Study Plan (not agreed on)
- Study Plan 1.15, Investigation of Trout Movement in the JC Boyle bypass and peaking reaches (agreed on April 2003)
- Study Plan 1.16, Evaluation of Effects of Flow Fluctuation on Aquatic Resources within the J.C. Boyle peaking reach (not agreed on)
- Study Plan 1.17, Investigation of Trout and Anadromous Fish Genetics in the Klamath Hydroelectric Project Area (not agreed on)
- Study Plan 1.18, Investigation of Juvenile Anadromous Fish Behavior and Survival through Upper Klamath Lake and the Hydroelectric Project (not agreed on)
- Study Plan 1.21, Investigation of *Ceratomyxa shasta* (agreed on April 2003)

Several federal, state, tribal, and non-government entities convened in November 2003 for a Joint Agency Meeting with PacifiCorp to (1) hear what PacifiCorp was proposing as Project operational changes and enhancement measures in the license application and (2) provide comment on unresolved issues. The 2 day meeting primarily focused on the proposed PM&E measures. The general agenda was that PacifiCorp would provide by resource proposed measures and provide opportunity for comment. Stakeholders were also provided the opportunity to provide written comments to the facilitator. Meeting notes and handouts are provided in the consultation record (Appendix E-1A).

Potential fisheries PM&Es were developed somewhat independently by each stakeholder group. Therefore, there was considerable redundancy of proposed measures. In most cases, the recommendations were not specific, but rather generalized to cover a particular issue or concern. In some cases, recommendations were for additional study or mere consideration of issues as they might arise in the future. Not every agency/stakeholder had recommendations for each of the issues, and all stakeholders may not have agreed to those of others. Therefore, specific stakeholder origin for each proposed recommendation is not provided in this section.

A summary of the recommendations categorized by common topic or issue is presented below. PacifiCorp's responses to these recommendations also are provided. Categories include:

- Anadromous Fish Passage/Re-introduction
- Instream Flows
- Flow Fluctuations
- Resident Fish Passage
- Geomorphology/Gravel Augmentation
- Fish Health/Disease
- Flow Management Downstream of Iron Gate Dam
- Iron Gate Hatchery

E4.5.1 Anadromous Fish Passage/Re-introduction

In general, the primary recommendations from the Joint Agency Meeting regarding anadromous fish in the Project Area were targeted at providing fish passage above Iron Gate dam up to the Link River dam. These include fish passage at Iron Gate dam, the Copco dams, and improvements at the existing fish ladders at J.C. Boyle and Keno dams. Other specific recommendations included the continued application of integrative modeling tools, such as EDT, to assess basin fish production potential associated with any re-introduction of anadromous fish above Iron Gate.

PacifiCorp Response:

The issue of run sustainability is an important one from the applicant's perspective. It is PacifiCorp's view that given the costs of constructing the facilities, impacts on other resource areas, and risks to existing native fish populations, it must be demonstrated that the re-introduction effort will produce healthy, viable anadromous fish populations. Otherwise, the re-introduction program becomes a long-term supplementation effort requiring large and continuing releases of hatchery fish into the upper Klamath River basin, providing little benefit to the species of interest. If the runs were not sustainable without hatchery supplementation, continuing the Iron Gate hatchery program would return more adult fish to the basin, thereby, better achieving PacifiCorp's mitigation obligation for Project impacts to anadromous fish species.

Given the findings of previous fish re-introduction reviews, current basin environmental conditions, impacts to important resource areas such as river rafting, resident fish sport fishing and power generation, PacifiCorp is proposing to alter Project operations and facilities in a manner that emphasizes the protection of these tangible benefits instead of the highly uncertain benefits that may accrue to the public from the re-introduction of anadromous fish to stream reaches above Iron Gate dam at this time. However, this does not mean that anadromous fish passage and re-introduction have been abandoned. Instead, PacifiCorp is proposing a five-pronged approach for addressing this issue:

1. Construct and improve existing fish passage facilities
2. Decommission the East Side and West Side developments associated with the Link River dam
3. Continue habitat and fish passage modeling efforts
4. Conduct fish passage survival studies
5. Maintain hatchery production at Iron Gate Fish Hatchery

E4.5.2 Instream Flows

Instream flow recommendations were general in nature and were mostly noted to ensure that PacifiCorp take into account fish habitat, geomorphological issues, riparian areas, and native species when dealing with instream flows.

PacifiCorp Response:

PacifiCorp conducted instream flow studies in all riverine reaches of concern. Site-specific and envelope habitat suitability criteria for rainbow trout and literature-based criteria for suckers were used in PacifiCorp's analyses. On the basis of these analyses, in conjunction with anticipated impacts on other non-fish resources, PacifiCorp has proposed minimum instream flows for each stream reach.

PacifiCorp and the stakeholders will continue to further develop and analyze instream flow information. Continuing efforts will include:

1. Approve rainbow trout and sucker HSC curves
2. Develop a habitat time series
3. Complete bioenergetics modeling efforts
4. Conduct peaking analysis
5. Discuss modeling results as they relate to fisheries and other interrelated studies (e.g., recreation, geomorphology, etc.)
6. Develop river flow regime recommendations for aquatic resources

E4.5.3 Flow Fluctuations

Recommendations regarding flow fluctuations were entirely focused on J.C. Boyle peaking operations. The two general recommendations made were (1) to reduce peaking operations (with no specific measure) and (2) to employ conservative measures relative to the range of peaking and daily fluctuations (again, no specific measures).

PacifiCorp Response:

The peaking operation at J.C. Boyle was a major focus of several studies involving multiple resources areas. On the basis of these study results, PacifiCorp proposes several limitations on the peaking operations. These include (1) increasing the base flow within the peaking reach from about 325 cfs to 425 cfs, (2) reducing the amplitude of flow fluctuations by limiting peaking to one-unit operation (rather than two-unit) during a peaking cycle, and (3) reducing the down ramping rate from 9-inches per hour to 4-inches per hour when river flows are less than 1,000 cfs. In addition, PacifiCorp is proposing to install a flow continuation bypass valve at the powerhouse to eliminate the sudden declines in flow that can now occur as a result of unscheduled turbine shutdowns.

E4.5.4 Resident Fish Passage

Several fish passage recommendations were made for specific facilities, such as improvements/replacement of the existing ladder at J.C. Boyle dam, and the installation of ladders at the Copco developments. However, most of the recommendations appear to have been made to ensure that PacifiCorp address fish passage issues at each of their facilities. These included facilities for both upstream fish passage and downstream protection for entrained resident fish as well as potential future anadromous fish.

PacifiCorp Response:

Regarding the upstream passage facilities at J.C. Boyle dam, PacifiCorp conducted an engineering review and an analysis of several sources of information to assess whether the current ladder was restricting the upstream passage of rainbow trout. In addition, a trout radiotelemetry study was conducted to determine if adult trout were tending to move upstream toward the dam and ladder, and, if so, whether they were passing through the ladder without delay. Results of these studies indicated that the ladder is functioning properly, and that few of the downstream fish are inclined to migrate upstream toward the dam. Therefore, PacifiCorp does not propose to reconstruct the ladder, but does propose to make some modifications to entry conditions at the ladder based on the engineering evaluation.

PacifiCorp is proposing to upgrade the downstream fish passage facilities at J.C. Boyle dam from the current stationary screens to a gulper system. These facilities are intended to provide safe downstream passage primarily for trout. Also proposed are upstream and downstream fish passage facilities at the Spring Creek and Fall Creek diversions.

PacifiCorp does not believe that upstream passage facilities are needed for resident fish at the two Copco dams because there are no known migratory populations in Iron Gate or Copco reservoirs that would benefit.

Regarding the need for downstream passage facilities for resident fish at the two Copco dams and Iron Gate dam, PacifiCorp assessed the issue of fish entrainment and turbine-induced mortality by reviewing existing information on fish populations in the Project reservoirs coupled with a review of entrainment and mortality studies conducted elsewhere. Hydroacoustic surveys of fish in Copco and Iron Gate reservoirs also were conducted in 2003 to determine the spatial distribution of fish in relationship to the dams. Based on the results of these studies, PacifiCorp concludes that the likely level of resident fish entrainment mortality is not likely causing significant adverse affects on resident fish populations at or below these Project developments.

E4.5.5 Geomorphology/Gravel Augmentation

No specific recommendations were made regarding gravel augmentation at specific locations. The recommendations were simply that PacifiCorp should address sediment issues either through the removal of facilities, gravel augmentation, or de-inundate reservoirs to make them usable for spawning. Gravel augmentation was recommended in general, with specifics to be determined after results of the geomorphology studies were available.

PacifiCorp Response:

PacifiCorp completed a fluvial geomorphology study for the Project area and downstream of Iron Gate dam. Based on the study results and consideration of specific fish enhancement opportunities, PacifiCorp is proposing gravel augmentation for the J.C. Boyle bypass reach to enhance rainbow trout spawning habitat and for areas downstream of Iron Gate dam to enhance spawning habitat for anadromous fish.

E4.5.6 Fish Health/Disease

The two issues identified regarding fish health/disease were that of water quality (mainly temperature) and impacts associated with *C. shasta*, ich, and columnaris that PacifiCorp operations might be exacerbating.

PacifiCorp Response:

PacifiCorp conducted a study of *Ceratomyxa shasta* that included a review of previous information for the Klamath basin as well as additional field and laboratory work. Some study efforts are continuing. On the basis of the study results to date, no specific changes in Project operations have been proposed by PacifiCorp or the stakeholders to address *C. shasta* concerns. As new information becomes available from ongoing studies or possibly future studies, PacifiCorp will continue to work with the fisheries resource management agencies and tribes in identifying opportunities to address fish health issues to the extent that Project operations might be able contribute to these efforts.

E4.5.7 Flow Management Downstream of Iron Gate Dam

The stakeholder recommendations for fisheries below Iron Gate Dam were not specific in nature, but rather focused on wanting PacifiCorp to work closely with other agencies, especially USBR, to ensure that the operation of their Project minimizes impacts to downstream fisheries, specifically anadromous fisheries. Coordination of flow releases with those in the Trinity River (USBR) was specifically cited as a need to help avoid lower river fish kills. Other coordination topics included minimum instream flows, ramping, introduction of non-native species, and selective elevation water withdrawals from Iron Gate reservoir.

PacifiCorp Response:

PacifiCorp will continue to cooperate with USBR and other resource management agencies and tribes to address ongoing fisheries and water management issues and emergency event responses to the extent that PacifiCorp's operations can contribute to these issues. However, PacifiCorp does not have nor should it have responsibility to make resource management decisions.

E4.5.8 Iron Gate Hatchery

Stakeholder recommendations for Iron Gate Fish Hatchery included its full funding by PacifiCorp and potential modifications of hatchery operations, such as new production goals and the use of only native stocks at the hatchery.

PacifiCorp Response:

PacifiCorp proposes to maintain its current obligation of funding for production and operation of Iron Gate Fish Hatchery. PacifiCorp will continue to work with CDFG in its efforts to improve production efficiency and effectiveness and minimize conflicts between hatchery-reared and naturally produced salmon and steelhead. It is recognized that CDFG, as operator of the hatchery, is responsible for making decisions associated with brood stock selection, juvenile release strategies, and other fish husbandry activities. While PacifiCorp is responsible for the facilities and funding of most of the hatchery operations, PacifiCorp is not responsible for making fish resource or hatchery management decisions.

PacifiCorp proposes to purchase and construct mass-marking facilities for use at the hatchery. The purpose of the mass-marking facilities would be to increase the proportion of fall Chinook salmon smolts that are tagged and marked from the current 5 percent to 25 percent. The increased tagging rate will facilitate improved harvest management as well as research efforts associated with hatchery and wild fish interactions.

E4.6 STATUS OF FISH RESOURCES STUDIES

E4.6.1 Completed Studies

Fisheries resources studies that have been completed are discussed below.

Fisheries Investigations. These study elements include the river and reservoir fish sampling that was conducted in 2001 through 2003 and a review of literature regarding fish resources in the immediate Project area and areas upstream and downstream that could be affected by the Project (Study Plan 1.7). Also included is the trout fry distribution and relative abundance study element added in 2003. The 2003 reservoir hydroacoustics evaluation conducted in Copco and Iron Gate reservoirs has been completed, but additional reservoir sampling is planned for 2004 (see below). Results of the fisheries investigations are included in the Fish Resources FTR, Sections 2 and 3.

Evaluation Of Ramping Effects. This study is complete. The results are presented in the Fish Resources FTR, Section 6.

Fish Passage Planning and Evaluation. This study includes five elements: fish passage engineering, Iron Gate fish hatchery evaluation, fish production/passage modeling, a review of trout passage at J.C. Boyle dam, and a characterization of resident fish entrainment and turbine mortality. All of these study elements are complete (presented in the Fish Resources FTR, Section 7) except for the fish production/passage modeling (see Section E4.6.2).

Investigation of Trout Movement in the J.C. Boyle Bypass and Peaking Reaches. This study, which examined movement of radio-tagged adult trout, was completed in 2003 and the results are presented in the Fish Resources FTR, Section 5.

Investigation of *Ceratomyxa shasta*. The spring/summer 2003 sampling is complete and the results are presented in the Fish Resources FTR, Section 8. Additional sampling was collected in fall 2003 (see below).

Investigation of Trout and Anadromous Fish Genetics. This study is complete and the results are presented in the Fish Resources FTR, Section 9.

E4.6.2 Studies Currently Underway

The studies or study elements currently underway are discussed below.

E4.6.2.1 Instream Flow Analysis

The Aquatic Work Group and their Instream Flow Subgroup are examining this issue. The Subgroup was formed to work through technical issues and toward agreed on instream flow input, analysis, and recommendations. PacifiCorp recognizes, and requests that FERC also recognize, that additional collaboration, refinement of model input variables, and analyses are needed with stakeholders to meet the PacifiCorp's commitment to complete the instream flow study needed to provide a good technical basis for instream flow recommendations. This includes such items as working collaboratively to develop and produce agreed upon modeling input, and consequently modeling results and recommendations.

PacifiCorp constructed its own rainbow trout envelope curves that were used for the instream flow analysis. However, these curves have not been reviewed by the Instream Flow subgroup. As such, stakeholders have technical uncertainty surrounding the instream flow analysis presented in this application. PacifiCorp and the stakeholders will continue to develop Klamath River HSC curves.

In order to address the instream flow study tasks, PacifiCorp and relicensing stakeholders will continue to meet to work on the following:

- Agree on rainbow trout and sucker HSC curves
- Develop a habitat time series
- Complete bioenergetics modeling efforts
- Conduct peaking analysis
- Discuss modeling results as they relate to fisheries and other interrelated studies (e.g., recreation, geomorphology, etc.)

- Develop river flow regime recommendations for aquatic resources

It is anticipated that the above tasks will be completed by the end of May 2004. Following conclusion of these tasks, a final instream flow report will be distributed to FERC and interested stakeholders by the end of June 2004. At that time, PacifiCorp will review this additional information, and revise as appropriate the Project Operations and PM&E measures included in this License Application.

E4.6.2.2 Anadromous Fish Production/Passage Modeling

The Habitat Modeling Group will continue working in 2004 work to develop an approach for reintroducing anadromous salmonids to the upper basin. The tasks to be completed in 2004 deal with both modeling issues and finding solutions to the problems identified in previous reviews regarding reintroduction. A description of the tasks and a time frame for completing each is presented below:

- Conduct a parameter-by-parameter review of the habitat and fish passage inputs used in modeling stream habitat in both the Project area and the Upper Klamath River basin (above Keno dam). As can be seen from the preliminary EDT results presented above, the accuracy of key assumptions regarding harvest, dam, and reservoir survival have tremendous influence on resulting estimates of production. The parameter review is expected to be complete by April 2004.

- Identify and model other anadromous species that could be candidates for reintroduction to the upper basin. (Complete by June 2004.)

- Develop criteria for modeling a “restored condition” for habitat in the upper basin. Based on these criteria develop a suite of actions that would meet habitat objectives and goals. Different actions and approaches would be combined and modeled as separate scenarios to determine the best reintroduction strategy. Information on expected benefits, when these benefits are likely to be achieved, and how they may effect the implementation of different fish passage facilities and their location would be described. This task would start in June 2004 and continue until completed.

- Identify reintroduction strategies including broodstock source, stocking strategy, numbers of fish released, their location, and the facilities needed. Also, identify the parties that will need to be contacted to assist in this effort (start in May 2004). To assist in evaluating broodstock options, PacifiCorp completed an investigation of salmonid genetics in the Klamath River basin in 2003. The report is included in the Fish Resources FTR, Section 9.

- Identify those issues that parties outside of the Habitat Modeling Subgroup will need to address before reintroduction can take place. For example, parties outside the Subgroup will need to provide input (both policy and technical) on issues such as anadromous fish impacts on disease prevalence and competition with resident redband trout populations. (May 2004)

- Identify critical data gaps and uncertainties that will need to be addressed through data collection or other methods (modeling, etc.). Priority would be given to those data gaps that are needed for decision-making. This task would be on going throughout the process.

PacifiCorp will be submitting the results of Habitat Modeling Subgroup efforts to the stakeholders for review and comment as they are completed.

E4.6.2.3 Additional Reservoir Sampling with Hydroacoustics

Hydroacoustic surveys and netting activities will be repeated in October 2003 and April 2004 to develop a more thorough understanding of habitat use in the deeper areas of the Copco and Iron Gate reservoirs. The final technical report will be available to FERC and stakeholders by July 2004.

E4.6.2.4 Evaluation of Effects of Flow Fluctuations on Aquatic Resources within J.C. Boyle Peaking Reach

This evaluation of flow fluctuation effects on aquatic resources in the J.C. Boyle peaking reach integrates the findings of various other studies, most of which have just recently been completed and documented in the final technical reports referenced in the methods above. The instream flow analysis, including a bioenergetics fish model, is ongoing. Also, the EDT fish production modeling, which may provide some valuable insight to the peaking analysis, will continue to be used as a tool to assess effects of habitat quality conditions on fish production potential. Although these ongoing modeling efforts may produce some useful information, most of the other information identified in the methods above will be integrated and summarized by end of April 2004 for distribution to and discussion by the Aquatics Work Group.

E4.6.2.5 Investigation of *Ceratomyxa shasta*

Additional sampling was collected in fall 2003, for which a final report will be available for FERC and stakeholders in summer 2004.

E4.7 PROPOSED ENHANCEMENT MEASURES FOR FISH RESOURCES

PacifiCorp proposes to implement enhancement measures for fisheries resources at their Project developments as described in this section. Description of the measures include an explanation of their rationale and anticipated benefits for fish resources. In some cases, further discussion of an enhancement measure with agencies and stakeholders is planned before specific actions can be finalized. Table E4.7-1 summarizes the costs (at a conceptual level using 2003 dollars) for the measures discussed below.

In addition to these fisheries measures, PacifiCorp is also proposing enhancement measures relative to water quality. Enhancing water quality, such as improving water temperature and dissolved oxygen conditions, also will benefit fish. These proposed measures are described in detail in Section E3.8

Table E4.7-1. Estimated Costs of Project Proposed Enhancement Measures

Development	Resource Proposed Enhancement Measure	Total (Thousands of Dollars)
Capital Costs		
East Side	Decommission	416
West Side	Decommission	492
Iron Gate	Fish Tagging at Iron Gate Hatchery	795
Copco No. 1	Copco Ranch Irrigation Upgrades	540
J.C. Boyle/Iron Gate	J.C. Boyle Bypass - Iron Gate Gravel Augmentation (30-year period)	461
J.C. Boyle	J.C. Boyle: Surface Collector (Gulper)	5,132
J.C. Boyle	J.C. Boyle: Fish Ladder Upgrades	500
J.C. Boyle	J.C. Boyle: Synchronous Bypass Valve	6,161
J.C. Boyle	J.C. Boyle: Instream Flow Bypass	225
J.C. Boyle	J.C. Boyle bypass gage	60
Copco No. 2	Copco No. 2: Bypass Flow Gate Improvements	75
Fall Creek	Fall Creek: Conventional Diagonal Screen	464
Fall Creek	Fall Creek: Fish Ladder	45
Fall Creek	Spring Creek: Fish Ladder	400
Fall Creek	Spring Creek: Conventional Diagonal Screen	229
Fall Creek	Spring Creek: Parshall Flume	45
	Total Capital Cost	**15,133**

Table E4.7-1. Estimated Costs of Project Proposed Enhancement Measures

Development	Resource Proposed Enhancement Measure	Total (Thousands of Dollars)
O&M Costs (30-year Period)		
Iron Gate	Iron Gate Fish Hatchery Tagging labor	557
Iron Gate	Iron Gate Fish Hatchery Tag equipment maint.	423
Iron Gate	Iron Gate Fish Hatchery tag materials (added tags)	2,224
Iron Gate	Iron Gate Fish Hatchery minor upgrades	3,000
Copco No. 1	Copco Ranch Irrigation	241
J.C. Boyle/Iron Gate	Gravel Augmentation Monitoring	268
J.C. Boyle	J.C. Boyle: Surface Collector (Gulper)	3,000
J.C. Boyle	J.C. Boyle: Synchronous Bypass Valve	145
J.C. Boyle	J.C. Boyle: Instream Flow Bypass	145
J.C. Boyle	J.C. Boyle bypass gauge	300
Fall Creek	Fall Creek: Conventional Diagonal Screen	870
Fall Creek	Fall Creek: Fish Ladder	580
Fall Creek	Spring Creek: Fish Ladder	580
Fall Creek	Spring Creek: Conventional Diagonal Screen	870
Fall Creek	Spring Creek: Parshall Flume	73
	Total O&M Cost	**13,276**

E4.7.1 East Side and West Side Decommissioning

E4.7.1.1 Proposed Measure

The East Side and West Side facilities will be decommissioned. The forebay and intakes that currently supply water from Link River dam to the East Side and West Side facilities will be rendered inoperable. Downstream of intake gates, concrete water tight bulkheads will be constructed. Forebay walls, and spillway and intake structures will be removed. Penstocks and flowlines will be dismantled and removed from the site along with their associated support structures. The steel surge tank at East Side along with the concrete support pedestal will also be removed. All areas that have been disturbed will be regraded and hydroseeded.

The East Side and West Side powerhouses will have any components associated with power generation that contain chemical or hazardous materials removed from the site including transformers, batteries, tanks, and asbestos based products. All windows and doors will be sealed to prevent public access. The incoming potable water lines will be disconnected and the septic systems will be disconnected and backfilled. The penstocks to the turbine and the draft tube discharge will be sealed assuring that access is prevented. The transmission line (No. 56-8) from East Side powerhouse to a tap-point on transmission line 11 will also be removed.

These measures will be implemented within the first year following issuance of the new license.

E4.7.1.2 Associated Fisheries Benefits

The decommissioning of the East Side and West Side developments will eliminate any fish entrainment and associated turbine-induced mortality that currently occurs at these facilities. While this benefit may not be noticeable for resources in general, the elimination of take for federally listed sucker species is expected to benefit their recovery.

The restoration of higher flows in the Link River may also benefit the upstream movement of listed suckers as well as redband trout through the fish passage facilities at Link River dam to spawning areas in or above Upper Klamath Lake.

It is unknown whether the restoration of higher flows in the Link River would benefit fish rearing. However, the expected increase in dissolved oxygen that would be expected from higher flows would benefit fish that are attracted to the transitional area between the Link River and Keno reservoir.

E4.7.2 Instream Flows and Ramping Rates

E4.7.2.1 J.C Boyle Bypass Reach

Proposed Measures

Minimum Flow
A minimum flow of 100 cfs will be released from J.C. Boyle dam at all times to enhance usable fish habitat while maintaining high water quality in the J.C. Boyle bypass reach. This release will result in a minimum instream flow of roughly 320–350 cfs at the lower end of the bypass reach due to the input of approximately 220–250 cfs of spring flow within this reach. The release flow will consist of 20 cfs from the fish bypass conduit and 80 cfs from the fish ladder and its attraction flow system. A gauge will be constructed at the tope of the bypass reach to monitor flows.

Ramping Rates
Downramp rates will not exceed 150 cfs per hour, except for flow conditions beyond the Project's control (e.g., inflows to the J.C. Boyle reservoir that change at rates greater than above ramp rate). This rate is primarily applicable to spill, and planned maintenance events. To the extent possible, flow changes will occur during the night to help reduce the risk of potential fish stranding associated with river spill events.

Associated Fisheries Benefits

Minimum Flows
The minimum flow release of 100 cfs from J.C. Boyle dam, combined with the approximately 220–250 cfs accretion of spring water that occurs throughout this reach, would provide near maximum habitat conditions for adult trout and suckers based on PacifiCorp's instream flow study results. The 100 cfs, when added to the accretion flow, would provide slightly less habitat (compared to a no-flow release) for juvenile trout and fry. However, the habitat-versus-flow relationship for these life stages are relatively flat over a wide range of flows, indicating that the

margin habitats where small fish generally reside would be maintained. Since fry are known to occur in this reach, maintenance of margin habitat is important.

The 100 cfs release would also maintain the excellent water quality that occurs in most of this reach as a result of spring water accretion.

<u>Ramping Rates</u>
The current FERC license allows the flow release from J.C. Boyle dam to be dropped at a rate of 9 inches per hour as measured at the gauge located at the J.C. Boyle powerhouse. This is equivalent to about 700 cfs per hour (when river flows are between 400 and 3,000 cfs). Therefore, the proposed downramp rate of 150 cfs would represent a flow reduction rate of about 5-fold compared to the current licensed rate. However, because there is limited power generation benefit to down ramp rapidly at J.C. Boyle dam, the proposed rate is intended to be conservative to minimize the potential of stranding fish. A slower ramping rate also would be expected to provide a more gradual transition time for adult trout to relocate. This especially could be important during per-spawn staging and during spawning.

It is also proposed that down ramping would be done at night to the extent possible. This proposal is based on the results of studies indicating that juvenile trout are less vulnerable to stranding at night during winter conditions (see the review of these studies in the Fisheries FTR, Section 6). During such cold-water conditions, trout tend to hide in interstitial areas of substrate, whereas during night they are out of substrate and can respond to dropping flows.

E4.7.2.2 J.C. Boyle Peaking Reach

<u>Proposed Measures</u>

<u>Minimum Flows</u>
An increased minimum flow level and adjustments in peaking operations are proposed in the J.C. Boyle peaking reach to enhance usable fish habitat and decrease the reach's unproductive varial zone, while preserving water quality, and recreational boating and angling.

A minimum release of 200 cfs plus J.C. Boyle bypass accretion will be provided at the USGS gauge downstream of the J.C. Boyle powerhouse (USGS gauge No. 11510700). This flow release will provide approximately 425 cfs into the J.C. Boyle peaking reach. The minimum flow may be met through an additional release of 100 cfs (200 cfs total) from J.C. Boyle dam or a release of 100 cfs at the powerhouse (plus 100 cfs from J.C. Boyle dam).

<u>Ramping Rates</u>
As measured at USGS gauge No. 11510700 downstream of the J.C. Boyle powerhouse, flow upramp rates will not exceed 9 inches (in water level) per hour. Flow downramp rates will not exceed 9 inches per hour for flows above 1,000 cfs, and will not exceed 4 inches per hour for flows less than 1,000 cfs.

Peaking operations will continue at the powerhouse. However, the daily Project-controlled flow change (or flow magnitude change, that is, the difference between lowest and highest flow in a 24-hour period) during peaking operations will not exceed 1,400 cfs (as measured at USGS gauge No. 11510700 downstream of the J.C. Boyle powerhouse). This limit of flow change to 1,400 cfs per 24-period will preclude no load to full two-unit peaking events (420 cfs to

3,420 cfs at gauge). Two-unit operation will occur if inflows are high enough to run both units, or run one unit in continuous operation and the second one operated in peaking fashion. Peaking of the second unit will only occur while the first unit is in operation.

The J.C. Boyle powerhouse will operate in compliance with proposed flow restrictions, but with the following exceptions for electric system reliability purposes associated with a Generation Alert defined as follows.

In the event of an imminent system disturbance as defined by the North American Electric Reliability Council (NERC), the J.C. Boyle units may be loaded as determined to be necessary by PacifiCorp Real Time generation control personnel. Proposed flow guidelines will not restrict full load operations in the event of a NERC Level 2 Alert (see below). Loading of all available generating resources may be necessary to avoid consequences of a NERC Level 3 Alert. If the J.C. Boyle units are loaded to cover a system emergency, PacifiCorp will provide documentation of the event and the extent to which the plant was loaded. Down ramping guidelines will be followed when units are unloaded.

- **NERC Level 1 Alert**: All available resources in use. CONTROL AREA, RESERVE SHARING GROUP, or LOAD SERVING ENTITY foresees or is experiencing conditions where all available resources are committed to meet firm load, firm transactions, and reserve commitments, and is concerned about sustaining its required OPERATING RESERVES, and Non-firm wholesale energy sales (other than those that are recallable to meet reserve requirements) have been curtailed.

- **NERC Level 2 Alert**: Load management procedures in effect. CONTROL AREA, RESERVE SHARING GROUP, or LOAD SERVING ENTITY is no longer able to provide its customers expected energy requirements, and is designated an ENERGY DEFICIENT ENTITY. ENERGY DEFICIENT ENTITY foresees or has implemented procedures up to, but excluding, interruption of firm load commitments.

- **NERC Level 3 Alert**: Firm load interruption imminent or in progress. CONTROL AREA or LOAD SERVING ENTITY foresees or has implemented firm load obligation interruption. The available energy to the ENERGY DEFICIENT ENTITY, as determined from Alert 2, is only accessible with actions taken to increase transmission transfer capabilities.

This limit on powerhouse operations will provide greater flow stability for aquatic resources but continue to provide a balance of whitewater boating and angling opportunities (periods of optimal wading-based fishing and standard whitewater boating flows), as one unit can provide raftable flows. Low flow periods (that is, flows of 700 cfs or lower at Iron Gate dam) will have limited one-unit peaking time “windows” for standard whitewater boating (which relies on flows of 1,500 to 1,800 cfs). Anglers will conversely have larger time “windows” for angling opportunities.

<u>J.C. Boyle Powerhouse Bypass Valve</u>

Under existing conditions, the J.C. Boyle powerhouse does not have the means to maintain downstream river levels in the event of either or both generating units are tripped off line (unscheduled outage). Upon a plant trip, the river stage drops according to plant discharge. Flow capacity through each unit is roughly 1425 cfs. In the case of a unit trip when both units are operating, the river drops 1.3 feet. If both units are operating and they both trip, the river will drop approximately 3 feet. If either event was to occur, river stage is not corrected until the generating unit is back in service, water is released at the canal spillway, or water is released at the dam. Also, in the event both units trip, the canal cannot contain enough of the backed-up water and the canal spillway gate is opened. Spill amount and duration at this location is dependent on amount of flow in the canal at time of unit trip and the time it takes to close the canal headgate.

To reduce the opportunity for river stage changes in response to unit trips at the J.C. Boyle powerhouse, PacifiCorp is proposing to install synchronized bypass valves on each of the two units. The intent of the valves is to maintain the river level even if a unit trips off-line. The two bypass valves should also eliminate use of the canal spillway, as water would not be backed up in the event of a unit trip.

Installation of the bypass valves at the J.C. Boyle powerhouse starts with connections into each of the existing 9.5-ft diameter penstocks that lead to the units. These connections will be made at the first 51-ft.-long penstock segments just upstream of the powerhouse. (See Figure E4.7-1.)

The new bypass lines would run upstream and parallel to the powerhouse until it is possible to make a 90-degree bend around the powerhouse. After the bends the bypass lines would run mostly covered to a discharge structure located on the fill area adjacent to the powerhouse tailrace and pointing in a downstream river direction.

The discharge structure would have two 9.5-ft. diameter stainless steel shutoff butterfly valves and two 4-ft. stainless steel fixed cone valves. The butterfly valves would be normally in the opened position but would be designed for emergency closure in the event of an operational failure of the respective fixed cone valve. A hooded discharge structure and energy dissipation structure are also included to prevent large amounts of spray that could have negative impacts switchyard equipment downstream of the powerhouse.

Associated Fisheries Benefits

Minimum Flows

Minimum flows will be released at J.C. Boyle dam and/or at the J.C. Boyle powerhouse to meet the flow release of 200 cfs at the gauge downstream of the powerhouse. Combined with the spring water accretion flow (about 220–250 cfs) that occurs in the bypass reach, a minimum flow of about 425 cfs would be maintained in the 17-mile peaking reach. This is an increase of about 100 cfs compared to current minimum flow conditions. PacifiCorp's results of the instream flow study analysis for rainbow trout, using envelope habitat suitability curves, indicate that the new base flow of 425 cfs would nearly maximize the instream habitat (Weighted Usable Area – WUA) for adult trout and provide about a 2 percent increase in WUA compared to the current base flow. The increased minimum flow would slightly reduce the WUA for rainbow trout juveniles and fry.

The habitat response to the increased minimum flow for suckers would be similar to that described for trout based on the preliminary WUA results. Habitat for adult suckers would increase slightly, while habitat for juvenile suckers would decrease slightly.

The proposed increase in the minimum flow for the peaking reach would also increase the area of the streambed that is continually wetted (typically defined as the wetted perimeter across a given cross-section of stream). The amount of the streambed that would be subjected to watering-dewatering events (the varial zone) would be reduced during periods of flow fluctuations.

For the total streambed area (all habitat types), the increase in minimum flow from the current 325 cfs to the proposed 425 cfs would increase the wetted perimeter of the river, on average, by 6.5 feet or about 5.3 percent (Table E4.7-2). In riffle areas, the average increase in wetted perimeter would be about 11.3 feet (8.0 percent). This increase in wetted perimeter is expected to increase the biomass of aquatic macroinvertebrates. An increase in macroinvertebrate biomass is expected to positively affect the growth and condition of fish in this reach.

Table E4.7-2. Difference in wetted perimeter of the J.C. Boyle peaking reach under current and proposed minimum flows.

Minimum Flow (cfs)	**Wetted Perimeter (all habitat types)**	**Wetted Perimeter (riffle habitat)**
325 cfs (current minimum flow)	122.8 ft	141.3 ft
425 cfs (proposed minimum flow)	129.3 ft	152.6 ft
Difference in wetted perimeter	+ 6.5 ft	+11.3ft
Percent difference	+ 5.3%	+ 8.0%

Ramping Rates

The proposed ramping rates at the J.C. Boyle powerhouse will benefit fish resources in the following ways:

- The proposed down ramp rate of 4 inch/hr when flows at the gauge are <1,000 cfs will reduce the potential for small fish to become stranded because the stream bank gradients and corresponding water-edge recedance rate (which most relates to stranding potential) is greater at flows <1,000 cfs compared to higher flows. In most areas of the J.C. Boyle peaking reach, the toe-of-bank, which defines the edge of the predominate active stream bed, occurs at the waters edge at flows of approximate 1,000 cfs. Therefore, reducing down ramp rates when the water level is below this point would be most effective at reducing the risk of fish stranding. The 4 inch/hr rate will attenuate to about 3 inch/hr at Frain Ranch (RM 214.3) and to about 2 inch/hr near Shovel Creek (RM 201.5) (see Section E42.2.1). Although studies conducted in the J.C. Boyle peaking reach did not indicate that much fish stranding was occurring at the current rate of 9 inch/hr, there were limited numbers of trout fry observed in the study area. The other abundant riverine species, such as speckled dace and marbeled sculpin, did not appear to be very prone to stranding at the current ramp rate. Nevertheless, more restrictive downramping would be prudent in light of potential increases in the recruitment of trout fry into this reach that may result from other PM&E, such as gravel augmentation in the upstream bypass reach and improvements to the Copco Ranch irrigation diversions.

Figure E4.7-1. J.C. Boyle - Synchronous Bypass Valve.

(11x17 front)

Figure E4.7-1

(11x17 back)

- Restricting powerhouse operations to one turbine (of 2) ramping at a time will limit the amplitude of flow change and the associated streambed de-watering that occurs during each peaking cycle. The proposed increase in minimum base flow from 325 cfs to 425 cfs will also contribute to a reduction of the flow-change amplitude (see discussion above). Studies conducted in 2003 indicate that adult trout as well as trout fry moved very little during a one-unit peaking cycle.

Bypass Valves

Currently, when the J.C. Boyle powerhouse encounters an emergency shutdown, water flow from the powerhouse ceases abruptly, creating a rapid decline in river stage. Although flow is usually restored, at least partially, within several minutes, the potential exists for fish to become stranded during these events. If the flow is not restored quickly enough stranded fish could die. The installation of the proposed synchronous bypass valves at the powerhouse will eliminate this fish stranding potential, due to unscheduled unit trips.

Another anticipated benefit of the installation of the bypass valves is the elimination of the use of the canal spillway. Past use of the spillway has resulted in erosion of the hillside leading down to the bypass reach and subsequent increases in turbidity in this otherwise clear water segment of river.

E4.7.2.3 Copco No. 2 Bypass Reach

Proposed Measures

A minimum flow of 10 cfs will be released from Copco No. 2 dam at all times. Flow downramp rates will not exceed 125 cfs per hour, except for flow conditions beyond the Project's control (e.g., inflows to the J.C. Boyle reservoir that change at rates greater than above ramp rate). This rate is primarily applicable to planned maintenance events. To the extent possible, flow changes will occur during the night to reduce the risk of potential fish stranding associated with river spill events. The 10 cfs will be regulated through an automated gate that allows for changes in water surface elevation in the forebay of the dam.

Associated Fisheries Benefits

Minimum Flow

Fish sampling performed in the Copco No. 2 bypass reach in 2001 and 2002 indicated that speckled dace and marbled sculpin (both native species) are by far the most abundant fish in the reach (see Section 4.2.1.1.5). Much fewer numbers of rainbow trout, chubs, largemouth bass, crappie, and yellow perch were collected. With the exception of speckled dace and marbled sculpin, most of the fish in the reach likely originate from downstream movement of fish out of Copco reservoir or from upstream movement of fish out of Iron Gate reservoir. There is no known fish spawning areas in the reach, most likely due to low abundance of small-sized substrate.

An instream flow study was done in the Copco No. 2 bypass reach in 2003. The preliminary results for rainbow trout and suckers indicated that there is very little instream habitat (WUA) for the adult life stages of these species at the current minimum flow of 10 cfs (see Section 4.2.2.1). Habitat for adult trout and suckers would be maximized at flows between 200 cfs to 300 cfs.

Habitat for trout fry and juveniles, and juvenile suckers would be most abundant at the lowest flows simulated (50 cfs).

While the results of the instream habitat modeling analysis indicate that an increase in the minimum flow would benefit the adult life stages of trout and suckers, the limited use of this reach by these species suggests that only a minimal gain of fish resource value would be realized with more flow. While more flow might increase the abundance of these species, water quality conditions, especially water temperature, would continue to be a limiting factor. In balancing the potential small gain in fisheries benefits with the loss of hydropower generation, PacifiCorp proposes to maintain the current 10 cfs in the Copco No.2 bypass reach and focus fisheries PM&E's in other Project areas.

Ramping Rates
Fish use of the Copco No. 2 bypass reach is limited, as previously stated, and is most likely due to low flows and compromised water quality. Down ramping in this reach is rare and occurs primarily when Copco No.1 is coming off of a spill event or during scheduled maintenance shut-down of the Copco No.2 powerhouse. Such events may strand some fish in the bypass reach. The proposal is to limit downramping to 125 cfs per hour. Ramping of flows through the Copco No. 2 bypass will be accomplished at the Copco No. 1 Development. For flows less than 3,200 cfs control will be through the Copco No. 2 dam. The proposed ramp rate of 125 cfs per hour is equivalent to less than 2-inches per hour in most of the expected flow ranges. In addition, the proposal to down ramp at night will further minimize the potential for fish stranding, especially during the winter when small trout, and perhaps other species, tend to be more closely associated with the bottom substrate during the daytime.

E4.7.2.4 Fall Creek Bypass Reach

Proposed Measure

A minimum flow of 5 cfs will be released into the Fall Creek bypass reach, and a minimum flow of 15 cfs minimum flow will be maintained downstream of the bypass confluence with powerhouse tailrace. Flow release control structures associated with the proposed fish passage facilities at the dam will be constructed to maintain the continuous 5 cfs release at the dam. Of the 5 cfs minimum flow, approximately half will consist of the fish ladder flow and the other half will be the fish screen bypass flow.

Associated Fisheries Benefits

The Fall Creek bypass supports a population of rainbow trout, nearly all of which are smaller than 150 mm. Preliminary results of the instream flow analysis indicate that the proposed 5 cfs minimum flow will nearly maximize the available habitat for juvenile sized (<150 mm) trout in the bypass reach. This will result in a increase of juvenile trout habitat of about 45 percent.

The proposed 15 cfs minimum flow for the stream reach downstream of the tailrace confluence with the bypass channel is the same minimum flow as stipulated in the current FERC license. The flow requirement is largely moot because of the powerhouse flow continuation valves, which maintains flow in lower Fall Creek even if the powerhouse is not operating. The flow would only pertain to those rare occasions when the powerhouse or diversion canal is in the process of being shut down and flow is being returned to the bypass channel. This process must be done slowly enough to allow the required 15 cfs to reach the lower creek before the canal diversion is completely shut off.

E4.7.2.5 Spring Creek

A minimum flow release to the Spring Creek bypass reach will be provided at the Spring Creek diversion (to Fall Creek). A specific release amount has not yet been determined, and will be developed in consultation with appropriate federal and state agencies. Studies will be completed to identify the appropriate minimum instream flow for the Spring Creek bypass reach. It is expected that upon completion of the studies and consultation with appropriate agencies, a minimum instream flow will be identified that balances water-dependent resource needs.

E4.7.2.6 Downstream of Iron Gate Dam

Proposed Measure

The instream flow schedule and ramp rates below Iron Gate dam will be maintained according to USBR's Klamath Project Operations Plans consistent with Biological Opinions issued by USFWS and NOAA-Fisheries. Current ramp rates below Iron Gate dam will be maintained according to USBR's Klamath Project Operations Plans consistent with Biological Opinions issued by NOAA-Fisheries. These instream flows and ramp rates have been developed based on extensive study and Biological Opinions issued by NOAA-Fisheries to protect ESA-listed species. The instream flow scheduled stipulated in the latest Klamath Project 2003 Operations Plan (April 10, 2003) is shown in Table E4.7-3.

Table E4.7-3. Iron Gate Dam flows, by time step, (values in CFS) for water year type.

Time Step	Above Average Water Years	Below Average Water Years	Dry Water Years	Critically Dry Water Years
Oct	1345	1345	879	920
Nov	1337	1324	873	912
Dec	1387	1621	889	929
Jan	1300	1334	888	1011
Feb	1300	1806	747	637
Mar 1-15	1953	2190	849	607
Mar 16-31	2553	1896	993	547
Apr 1-15	1863	1742	969	874
Apr 16-30	2791	1347	922	773
May 1-15	2204	1021	761	633
May 16-31	1466	1043	979	608
Jun 1-15	827	959	741	591
Jun 16-30	934	746	612	619
Jul 1-15	710	736	547	501
Jul 16-31	710	724	542	501
Aug	1039	1000	647	517

Sep	1300	1300	749	722

Source: Biological Opinion, Klamath Project Operations (NOAA Fisheries, 2002)

The NMFS 2002 Biological Opinion for USBR Klamath Irrigation Project and correspondingly the Klamath Project 2003 Operations Plan both include the following down ramping criteria at Iron Gate dam: (1) decreases in flows of 300 cfs or less per 24-hour period and no more than 125 cfs per 4-hour period when Iron Gate dam flows are above 1,750 cfs; and (2) decreases in flow of 150 cfs or less per 24-hour period and no more than 50 cfs per 2-hour period when Iron Gate dam flows are 1,750 cfs or less.

Associated Fisheries Benefits

The proposed down ramp rates at Iron Gate dam are about seven times slower than the rates currently stipulated in the current FERC license. Although the FERC rates are similar to those generally regarded as safe in other salmonid streams under most conditions (Hunter, 1992) such rates have been associated with limited fish stranding under some extreme or unique site-specific conditions. Therefore, the conservative down ramping rates proposed for Iron Gate dam will ensure that fish stranding attributable to Project operations will be avoided. With these conservative rates and given the infrequency of flow reductions at Iron Gate dam, it is likely that some downstream fry stranding or side channel entrapment that would otherwise occur during natural hydrologic events can be minimize by Iron Gate dam operations.

E4.7.2.7 Summary of Proposed Instream Flow and Ramp Rate Measures

The proposed measures for each of the future Project reaches has been identified in the preceding sections. Table E4.7-4 provides a summary of these measures.

Table E4.7-4. Proposed instream flow and ramp rate measures for river reaches affected by the Klamath Hydroelectric Project.

River Reach	Instream Flow	Ramp Rate
J.C. Boyle Bypass (dam to powerhouse)	A minimum release of 100 cfs from the dam at all times. This release will result in a minimum instream flow of roughly 320 cfs at the lower end of the bypass reach due to the input of approximately 220 cfs of spring flow within this reach.	150 cfs per hour from the dam (downramp rate) with the exception of conditions beyond the Project's reasonable control (e.g. inflow is changing at rate greater than above ramp rate). This rate is primarily applicable to spill events, and planned maintenance events. When practical flow changes will occur during the night.

Table E4.7-4. Proposed instream flow and ramp rate measures for river reaches affected by the Klamath Hydroelectric Project.

River Reach	Instream Flow	Ramp Rate
J.C. Boyle Reach Downstream of powerhouse	A minimum release of 200 cfs plus J.C. Boyle bypass accretion will be provided at the USGS gauge downstream of the J.C. Boyle powerhouse. This flow release will provide approximately 420 cfs into the J.C. Boyle peaking reach. The minimum flow may be met through an additional release of 100 cfs from the dam or a release of 100 cfs at the powerhouse.	Up ramp: Project-controlled flow increases will not exceed 9 inches per hour. Down ramp: Project controlled flow decreases will not exceed 9 inches per hour (for flows above 1,000 cfs at USGS gauge) and will not exceed 4 inches per hour (for flows less than 1,000 cfs) Daily variation: Project controlled daily flow variation (difference between lowest and highest flow in 24 hour period) will not exceed 1,400 cfs at the USGS gauge No. 11510700) Peaking: Peaking operations will continue at the powerhouse, however the magnitude of daily flow variation will not exceed 1400 cfs from the powerhouse as noted above. The limit of flow magnitude to 1400 cfs per daily period will cease 2-unit peaking events where the powerhouse goes from off (approximately 420 cfs at USGS gauge) to 2-unit full load (2850 cfs at powerhouse – approximately 3270 cfs at USGS gauge) in a 24-hour time period. This does not preclude 2-unit operation if inflows are high enough to run both units or have one unit in operation and the second one operated in a peaking fashion. The timing of peaking operations will be similar to current operations that provide raftable flows throughout the summer (June – August). Unless in a Generation Alert Status[1], the general intent is to have the powerhouse ramp to raftable (minimum 1500 cfs at the USGS gauge No. 11510700) flows by noon on Sunday, Monday, Tuesday, Thursday, and Friday and 10 AM on Saturday. Wednesdays will have no set schedule. The J.C. Boyle flow -phone, and flow information website will continue operation as status quo. Actual powerhouse operations -flows and related raftable time periods will be determined by incoming flows as driven by USBR releases at Iron Gate dam and climatic conditions.
Copco No. 2 Bypass (dam to powerhouse)	A minimum instream flow of 10 cfs from the dam. Release facility will be constructed to monitor flow releases.	125 cfs per hour (downramp rate) with the exception of conditions beyond the Project's reasonable control. To extent practical, flow changes will be limited to a total magnitude change of 1600 cfs in a daily period. This rate is primarily applicable to planned maintenance events.
Klamath River (Copco No. 2 tailrace to Iron Gate reservoir)	None	None

Table E4.7-4. Proposed instream flow and ramp rate measures for river reaches affected by the Klamath Hydroelectric Project.

River Reach	Instream Flow	Ramp Rate
Iron Gate dam	The instream flow schedule below Iron Gate dam will be maintained according to USBR's Klamath Project Operations Plans consistent with biological opinions issued by USFWS and NOAA-Fisheries.	Current ramp rates below Iron Gate will be maintained according to USBR's Klamath Project Operations Plans consistent with biological opinions issued by USFWS and NOAA-Fisheries. Absent ESA ramp rates, PacifiCorp will base ramp rates on Hunter criteria (Hunter, 1992). When practical, flow changes will occur during the night.
Fall Creek Bypass	A minimum of 5 cfs into the bypass plus a 15 cfs continuous flow downstream of the bypass confluence. Release structure will be constructed to maintain continuous release at the dam.	None
Spring Creek Bypass	To be developed in consultation with appropriate federal and state agencies.	None

[1] Generation Alert: The J.C. Boyle powerhouse will operate in compliance with proposed flow restrictions but with the following exceptions for electric system reliability purposes:

- In the event of an imminent system disturbance as defined by the North American Electric Reliability Council (NERC), the J.C. Boyle units may be loaded as determined to be necessary by PacifiCorp Real Time generation control personnel. Proposed flow guidelines will not restrict full load operations in the event a NERC Level 2 Alert (see below). Loading of all available generating resources may be necessary to avoid consequences of a NERC Level 3 Alert. If the J.C. Boyle units are loaded to cover a system emergency, PacifiCorp will provide documentation of the event and the extent to which the plant was loaded. Down ramping guidelines will be followed when units are unloaded.
- **NERC Level 1 Alert**: All available resources in use. CONTROL AREA, RESERVE SHARING GROUP, or LOAD SERVING ENTITY foresees or is experiencing conditions where all available resources are committed to meet firm load, firm transactions, and reserve commitments, and is concerned about sustaining its required OPERATING RESERVES, and Non-firm wholesale energy sales (other than those that are recallable to meet reserve requirements) have been curtailed
- **NERC Level 2 Alert**: Load management procedures in effect. CONTROL AREA, RESERVE SHARING GROUP, or LOAD SERVING ENTITY is no longer able to provide its customers expected energy requirements, and is designated an ENERGY DEFICIENT ENTITY. ENERGY DEFICIENT ENTITY foresees or has implemented procedures up to, but excluding, interruption of firm load commitments.
- **NERC Level 3 Alert**: Firm load interruption imminent or in progress. CONTROL AREA or LOAD SERVING ENTITY foresees or has implemented firm load obligation interruption. The available energy to the ENERGY DEFICIENT ENTITY, as determined from Alert 2, is only accessible with actions taken to increase transmission transfer capabilities.

Reference: NERC Operating Manual, Appendix 9B.

E4.7.3 Resident Fish Passage Upgrades

E4.7.3.1 J.C. Boyle Development

Proposed Measure

A surface collection system (gulper) is proposed for the J.C. Boyle forebay to exclude fish from the power intake and to facilitate downstream fish passage. The system will include a full-depth guide net barrier extending from the fishway exit to the left bank. A floating barge will provide approximately 200 cfs of attraction flow and surface collection of downstream migrants.

Collected fish will be conveyed past the dam via a 24-inch bypass pipe with a flow of approximately 20 cfs. A general arrangement drawing of the facilities is presented in Figure E4.7-2.

The guide net design parameters will follow NOAA Fisheries SW Region criteria for fingerlings including a maximum approach velocity of 0.4 fps, net opening size of 0.25 inch or less, and a minimum open area of 40 percent. The guide net will be removable for floods or on a seasonal basis. The surface collector will meet similar criteria for salmonid fry, including a maximum approach velocity of 0.4 fps, a sweeping velocity of 2 times the approach velocity, maximum screen openings of 1.75 mm, and a minimum open area of 27 percent. The bypass pipe will meet criteria requirements for a minimum water depth of 0.75 feet, and minimum velocity of 2 fps. The outfall will be sited near the location of the existing bypass pipe outfall at the upstream end of the J.C. Boyle bypass reach.

Modifications are also proposed for the J.C. Boyle fish ladder. The existing bar spacing on the fishway exit pool trashrack will be increased to facilitate the passage of adult fish. An additional weir will also be added to the fishway entrance pool to decrease the height of the existing step.

Associated Fisheries Benefits

The existing fish screens and ladder at the J. C. Boyle development met design criteria when constructed in 1957. Both facilities appear to be in good condition and maintained to meet the original design criteria. However, neither of these facilities meets current ODFW fish passage criteria for resident fish.

The proposed gulper system is a surface collector technology, which has been used successfully at the other projects (most notably the Puget Sound Energy Baker River Project) for years. In addition, recent planning studies in Oregon for Round Butte and Cougar Lake, gulpers have been proposed. In concept, the gulper is a 200-cfs floating surface collector with guide nets placed in a reservoir to provide downstream migrating fish a passage option preferable to turbine intakes. The gulper would take in 200 cfs from the surface of the lake and bypass 20 cfs with the fish into the bypass pipe for delivery to the river below the dam. Pumps internal to the floating gulper return 180 cfs back to the reservoir. This will allow actively downstream migrating fish a safe passage alternative to the attraction flows created at the powerhouse canal intakes. The gulper also will provide safe passage and potential collection for anadromous salmonid smolts in the event that they are successfully re-introduced into the basin upstream of J.C. Boyle.

The increase in bar spacing on the exit pool trash rack will allow adult fish to pass through more easily and with less delay. The additional weir to be added to the fishway entrance will lower the height of the entrance, effectively increasing the ability of fish to enter the ladder system.

E4.7.3.2 Fall Creek/Spring Creek

Proposed Measure

Canal screens and fish ladders are proposed for both the Fall Creek and Spring Creek diversions. The canal screens will be diagonal-type screens meeting NOAA Fisheries SW Region criteria for salmonid fry, including a maximum approach velocity of 0.4 fps, a sweeping velocity of 2 times the approach velocity, maximum screen openings of 1.75 mm, and a minimum open area of

27 percent. The bypass pipes will be 12 inches in diameter with 2.5 cfs of flow each. General arrangement drawings of the canal screens are presented in Figure E4.7-3.

The Fall Creek fish ladder will be a pool- and weir-type ladder consisting of six pools. The pools will be constructed from rock and include a 0.5-foot vertical jump for each pool. The existing flashboards will be notched at the exit pool to permit a fishway flow of 2.5 cfs.

The Spring Creek fish ladder will be a timber or concrete pool- and weir-type ladder consisting of eight pools. The pools will be 4 feet by 5 feet in plan with 0.5-foot vertical jumps. A fishway control structure consisting of a 24-inch diameter CMP culvert and manually-operated slide gate will provide 2.5 cfs of fishway flow. General arrangement drawings of the fish ladders are presented in Figure E4.7-3.

Associated Fisheries Benefits

Currently there are no upstream fish passage or screening facilities on either Fall Creek or Spring Creek. The fish ladders proposed for each diversion will allow trout and other species to freely access upstream spawning and rearing habitat. The downstream screening facilities will prevent fish from becoming entrained into the canals and then through the Fall Creek powerhouse.

E4.7.4 Modify Copco Ranch Irrigation Diversions

E4.7.4.1 Proposed Measure

PacifiCorp’s Copco Ranch (a nonhydro facility not related to the Project) is located adjacent to the Klamath River in the California segment of the peaking reach. To irrigate, the ranch currently diverts water for flood-irrigation purposes from several sites on the mainstem river and from Shovel Creek and its tributary, Negro Creek. It is proposed that the current gravity Klamath River mainstem diversions be replaced with screened pump systems and that the irrigation–water delivery be changed from field flooding to a pressurized sprinkler system. Water diversions from Shovel and Negro Creek would be eliminated. Additional riparian area enhancements for terrestrial resources would be implemented along these two creeks as well (see Section E5, Wildlife and Botanical Resources).

E4.7.4.2 Associated Fisheries Benefits

The replacement of the unscreened irrigation diversions on the main stem Klamath River with a pressurize pump system will eliminate the current entrainment of fish into the various ditches on the Copco Ranch and the diversions on Shovel and Negro creeks. Also, the use of a pressurized sprinkler system for field irrigation will increase slightly the base flow of the river, potentially benefiting fish. Currently the ranch diverts roughly 67.5 cfs from the mainstem Klamath River for irrigation use; the water demand with a more efficient irrigation system is expected to reduce the diversion amount.

Figure E4.7-2. J.C. Boyle Development Gulper System.

(11x17 front)

Figure E4.7-2

(11x17 back)

Figure E4.7-3. Spring Creek - Canal Screen and Fish Ladder.

(11x17 front)

Figure E4.7-3

(11x17 back)

Shovel Creek, which enters the main river on the ranch, provides the primary spawning habitat for trout in the California segment of the peaking reach. Most of the trout fry that originate from spawners in Shovel Creek remain in the creek during the summer as an apparent adapted strategy for good survival and recruitment back to the main river. Although the current diversions on Shovel and Negro Creeks are screened, the diversion of water itself undoubtedly reduces the fish rearing capacity of lower Shovel Creek where most of the trout rearing occurs. Therefore, the increase in summer base flow in Shovel Creek resulting from the elimination of irrigation diversions (15 cfs) onto Copco Ranch would be expected to increase the production and subsequent recruitment of trout into the peaking reach of the Klamath River.

E4.7.5 Gravel Augmentation

E4.7.5.1 Proposed Measures

Project effects on fluvial geomorphology and sediment transport are difficult to detect and differentiate from the large-scale natural and anthropogenic impacts operating in the system. However, Project reservoirs have trapped bed load over the years. The gravel component of this bed load is of particular interest because of its value as spawning substrate for fish.

Gravel augmentation mitigation and enhancement measures are proposed to address the impacts that Project reservoirs have had on spawning gravel. In general, the gravel augmentation proposal is designed to be an adaptive mitigation measure with an initial augmentation followed by recurring augmentation based on detailed monitoring of the added material over the life of the new license. Monitoring will document the movement of gravels from the augmentation sites, accumulation of gravels in formerly gravel-starved sites downstream of the augmentation sites, and use of the augmented gravels by spawning fish. The volume of the initial augmentation in selected reaches is calculated as 10 to 20 percent of the average annual volume of tributary and hillslope inputs trapped in the upstream Project reservoir(s). The range of 10 to 20 percent adjusts the results of the sediment budget to reflect the fact that only a fraction (probably less than 10 percent) of the total tributary sediment yield in each reach is composed of spawnable material. Given the long-term reduction in gravel supply below Project dams, gravel augmentation could begin with a larger volume to fill in-channel storage sites. A significant fraction of the tributary yield is sand, and since sand starvation was not identified as a significant Project impact, sediment augmentation will not include this component of sediment trapped in Project reservoirs.

The specific methods of augmenting gravel will depend on the logistics of the selected augmentation sites, as well as other regulations regarding water quality and aquatic and riparian habitat. In general, it would be preferable to create a gravel stockpile along the bank of the river that would erode during high flows, or to add gravel directly during high flows, so that turbidity would not be an issue. In many rivers, the regulations require that background turbidity not be exceeded by more than 20 percent. Such requirements often mean that gravel added during summer baseflows must be double- or triple-washed, adding significantly to the cost.

To monitor the augmented gravel, placed material will be surveyed and permanently monumented so that the surface area and volume of the initial deposit can be resurveyed. Tracer particles may also be included in the placed material so that rates of travel can be calculated for the placed material. Tracers could include stones of exotic lithology or particles outfitted with radio tags or magnets to facilitate recovery. The rate at which gravel is transported downstream from the augmentation sites would be a principal basis for determining future augmentation volumes.

The following sections outline proposed mitigation and enhancement measures for gravel augmentation in the J.C. Boyle bypass and below Iron Gate dam.

J.C. Boyle Bypass

The J.C. Boyle bypass reach was historically somewhat sediment starved because of limited upstream sources and because peak flows through this high gradient reach would have limited its deposition. Now, however, most flow is diverted from the reach into the J.C. Boyle power canal, and most of the remaining flow in the bypass reach consists of spring water. This new hydrologic and water quality condition provides an opportunity to enhance spawning habitat with the addition of gravel. Therefore, it is proposed to initially place 100 to 200 cubic yards of spawnable-sized gravel in the upstream end of the bypass reach and monitor its movement through several high-flow events. Additional augmentation sites could be selected based on observations of fish spawning and consideration of other channel conditions that would be expected to contribute to spawning site suitability. Further augmentation volumes and perhaps new placement sites will be determined by the results of the monitoring.

Downstream of Iron Gate Dam

Gravel augmentation in this reach may be the most beneficial method of offsetting Project effects on sediment transport and fluvial geomorphology. Bedload trapped in Copco reservoir and in Iron Gate reservoir could theoretically have all been an upstream source of spawnable material before the completion of those two dams. Therefore, it is proposed that 1,755 to 3,510 cubic yards of spawnable gravel initially be placed throughout the upper section of this reach. Since the results of the geomorphology study indicate that Project impacts on sediment transport and fluvial geomorphology are overwhelmed by other processes downstream of the Shasta River, gravel augmentation is proposed only for the reach between Iron Gate dam and the Shasta River confluence. Approximately 75 percent of this total volume (1316 to 2632 cubic yards) should be placed just downstream of Iron Gate dam where access is easy and significant bed coarsening was documented. The remaining volume should be split into three similar sized placements (146 to 293 cubic yards each) could be distributed at several sites between Bogus Creek and the Shasta River confluence. The volumes and frequencies of recurring gravel augmentation in this reach would be based on monitoring of the initial gravel placements.

E4.7.5.2 Associated Fisheries Benefits

J.C. Boyle Bypass

Observations made by snorkeling in the J.C. Boyle bypass reach as well as the results of a trout movement study conducted in 2003 (see Fisheries FTR Sections 3.0 and 5.0) demonstrated that considerable trout spawning occurs in the bypass reach. Flow in the lower two-thirds of the reach consists primarily of high quality spring water, which is known to be conducive to spawning success and high egg survival. The availability of suitably-sized spawning gravel is very limited, however. Most of the trout were observed spawning in marginally suited "patch gravels" behind boulders and in the area below the emergency spillway that contains gravel only because of the artifact of its recruitment from hillside erosion below the emergency spillway. These observations lead to the conclusion that the limitation of gravel in this reach is limiting trout spawning.

Historically, before J.C. Boyle dam was constructed, it is believed that most trout in the Oregon segment of the Klamath River spawned in Spencer Creek or in gravel depositional areas now inundated by J.C. Boyle reservoir (see Fisheries FTR Section 7.0). It is doubtful that trout successfully spawned in the reach now defined as the bypass because of the combination of natural high flows (nondiverted) in the springtime and the high gradient through this reach. Now, however, the prevailing lower flow of mostly spring water has provided suitable water quality and water velocity conditions for spawning. The missing ingredient is gravel. Therefore, the addition of gravel to this reach is expected to greatly enhance trout spawning and subsequent recruitment of fry into both the bypass and down stream peaking reaches. Other non-trout fish species also would use these areas for spawning.

Iron Gate dam

The potential benefits to fisheries below Iron Gate dam from gravel augmentation is simply to provide a more "natural" substrate composition in the river reaches than currently exists, especially in the areas immediately below the dam, which have been most affected by blocked gravel recruitment. The segment of river from Iron Gate dam to the confluence with the Shasta River currently supports the highest concentration of fall Chinook spawning in the Klamath River. Clearly, this segment of river provides suitable water quality, temperature, and channel morphology for successful spawning. Therefore, the proposed gravel augmentation in this river segment is expected to enhance spawning success for fall Chinook salmon and potentially for other fish such as steelhead trout.

E4.7.6 Iron Gate Hatchery

E4.7.6.1 Continue Iron Gate Hatchery Production

PacifiCorp proposes to fund 80 percent of the production and operation costs of the Iron Gate Hatchery to meet current production goals (see Table 4.3-1). The hatchery has been successful at meeting production goals on nearly all years, and the number of adult returns to the Klamath River have been considered good. The facility has been largely free of disease outbreaks and other major sources of mortality. Broodstock selection has, and will continue to be based on procedures used by CDFG to minimize adverse genetic consequences to the hatchery stock and naturally spawning fish in the Klamath River. PacifiCorp will continue to work with CDFG in their efforts to improve production efficiency and effectiveness and to minimize conflicts between hatchery-reared and naturally-produced salmon and steelhead trout. This may result in shifts in production goals requiring operational changes or new facilities. At this time PacifiCorp proposes to maintain the current production goals as outlined in Table E4.7-5.

Table E4.7-5. Iron Gate fish hatchery production goals and constraints.

Species	Egg Allotment	Stocking Goals and Constraints			
		Type	Number	Minimum Release Size	Target Release Dates[1]
Fall Chinook	10,000,000	Smolt	4,920,0002	90/lb.	June 1 - 15
		Yearling	1,080,0003		October 15 - November 15
Coho	500,0004	Yearling	75,000	10-20/lb.	March 15 - May 1
Steelhead	1,000,000	Yearling	200,000	6 inches5	March 15 - May 1

[1] If unusual circumstances dictate, releases may deviate from the target release dates on approval from the Regional Manager.
[2] In years when yearlings are not reared at the Fall Creek ponds, the smolt production will be 5,100,000
[3] Approximately 900,000 shall be reared at Iron Gate fish hatchery and 180,000 shall be reared at the Fall Creek ponds and released from Iron Gate fish hatchery. If the Fall Creek ponds are not operated, the production goal shall be 900,000 yearlings.
[4] A large number of coho eggs must be taken to meet the hatchery production goal because of reduced egg survival caused by soft-shell disease.
[5] By September 1, steelhead numbers in the hatchery shall be reduced as necessary to meet but not exceed the production goal.

E4.7.6.2 Anticipated Fisheries Benefits

Adult fall Chinook and coho salmon and steelhead trout, which originate from smolt releases at the Iron Gate fish hatchery, have contributed significantly to the ocean and in-river commercial and sport fisheries since the late 1960s. Based on smolt-to-adult survival studies conducted on Iron Gate fall Chinook salmon, the hatchery production contributes about 50,000 fish annually to these fisheries plus escapement back to the hatchery. Maintaining the current production at the hatchery will continue to provide these benefits.

E4.7.6.3 Increase Marking and Tagging Rate for Iron Gate Fish Hatchery Chinook

PacifiCorp proposes to purchase/construct facilities and provide the necessary equipment to expand the marking and tagging of fall Chinook salmon smolts produced at the Iron Gate Hatchery from the current 5 percent rate to 25 percent. The proposal includes the purchase of a mass-marking system for use at the hatchery. The system uses automated fish-marking equipment that reduces handling stress on the fish compared to manual methods. The system also will meet the need to mark the required numbers of fish in the available 6-week timing window.

The purpose of the mass-marking trailer is to increase the number of fall Chinook salmon smolts that are marked at the hatchery prior to release. Currently, about 5 percent of the Iron Gate Hatchery Chinook are tagged with coded wire tags (CWT) and marked with an adipose fin clip. The commitment to increase the tagging rate is based on the anticipation that CDFG will want to increase the percentage of Chinook tagging at IGH to match the percent done at the Trinity River Hatchery so as to achieve a “constant fractional marking” (CFM) rate in the Klamath-Trinity River Basin. This measure has been endorsed by the Klamath Fisheries Management Council (see letter to Todd Olson, dated June 4, 2003). They note benefits to include 1) assessing the abundance and long term productivity of naturally spawning populations, 2) assessing the performance of the hatchery, 3) assisting in the development of annual harvest management measures, and 4) helping evaluate the effects of artificially produced fish on the remaining naturally occurring salmon populations in the basin.

E4.7.6.4 Associated Fisheries Benefits

Increased tagging of fall Chinook salmon at the Iron Gate Hatchery will have positive benefits to the harvest and general fisheries management in the Klamath River Basin. Having a higher and constant fractional marking rate allows fisheries managers to calculate management metrics with greater precision thus potentially allowing better and more timely management decisions. Relative and absolute hatchery contribution and straying rates would be important management metrics benefiting from increased CFM rates within the Klamath-Trinity Basin. Specific management activities that would benefit include:

- Evaluation of mortality and survival
- In-river harvest management
- Hatchery evaluations
- Hatchery / wild interaction studies

E4.7.7 Maintenance Scheduling

E4.7.7.1 Proposed Measure

PacifiCorp will consult with appropriate agencies on the annual scheduled outages for Project maintenance events where flows in Project reaches are required to be outside the normal operations.

E4.7.7.2 Associated Fisheries Benefits

Consultation and coordination with agencies will ensure that times are selected to complete maintenance activities that do not impact sensitive life stages of fish.

E4.8 CONTINUING IMPACTS ON FISH RESOURCES

The ongoing operation of the Project will continue to influence fish resources even with the proposed Project operations and enhancement measures. These continuing effects, as they relate to fish and aquatic resources, are briefly described below.

The Project reservoirs will continue to inundate habitat that historically supported riverine species. The reservoirs support resident populations of mostly non-native fish species (e.g., largemouth bass and perch), which provide for a popular sport fishery. Downstream fish passage for resident fish is not proposed at all Project reservoirs. Therefore, some fish, especially small YOY individuals, may become entrained through Project powerhouses. However, it is not believed that the level of mortality associated with turbine entrainment causes population-level impacts. Adult federal ESA-listed shortnose and Lost River suckers may be dispersed from their native habitat downstream into Project reservoirs. The presence of these species is an artifact of the Project footprint (i.e., reservoirs).

Resident fish will have upstream access through the JC Boyle Development. Upstream movement between Iron Gate and Copco reservoirs will remain restricted by the presence of the

Copco dams. The loss of habitat connectivity between these two reservoirs will have little effect on the mainly warmwater fish communities that inhabit the reservoirs.

Although measures are proposed to restrict both the rate and amplitude of flow fluctuations caused by power peaking at the J.C. Boyle powerhouse, some effects on fish and other aquatic resources are expected to continue in the downstream reach. There will continue to be a reduction in wetted streambed area available to benthic organisms under the base flow conditions of the peaking cycle. There will also be the ongoing potential to strand small fish during down ramping, although this will be reduced through protective operational measures.

In balancing power and nonpower resources, the proposed instream flows will continue to be lower than historic flows in the Project peaking and bypass reaches (J.C. Boyle, Copco No. 2, and Fall creek). This reduction in flow will continue to reduce the available aquatic habitat in those reaches.

The feasibility of re-introducing anadromous fish to areas upstream of Iron Gate dam is continuing to be assessed by the stakeholder work groups. Project developments without fish passage facilities (Copco No. 1 and No. 2 and Iron Gate) will continue to prevent upstream movement of anadromous fish. Such barriers preclude access to the river/tributaries in and upstream of the Project area that historically may have been available to them.

The current mitigation for the construction of Iron Gate dam is the production of fall Chinook salmon, coho salmon, and steelhead trout at the Iron Gate fish hatchery. PacifiCorp will continue its obligation for funding most of the fish production and facility maintenance, assuming that anadromous fish passage facilities are not constructed at Project dams. In the event that anadromous fish passage is provided, the role of Iron Gate fish hatchery in supplementing anadromous fisheries in the Klamath River basin would be re-assessed. The current production at the hatchery provides an average annual return of about 50,000 adult Chinook salmon to the sport and commercial fisheries plus escapement. PacifiCorp will continue to work with CDFG hatchery management staff in their efforts to improve production efficiency and effectiveness. Hatchery operations are expected to have some continued effect on naturally produced salmon and steelhead trout. PacifiCorp will work with hatchery staff to implement measures to minimize conflicts between hatchery-produced and naturally-produced salmon and steelhead trout. The proposed increase in the marking and tagging rate for fall Chinook salmon smolts produced at the hatchery will assist in these efforts.

E4.9 INFORMATION SOURCES

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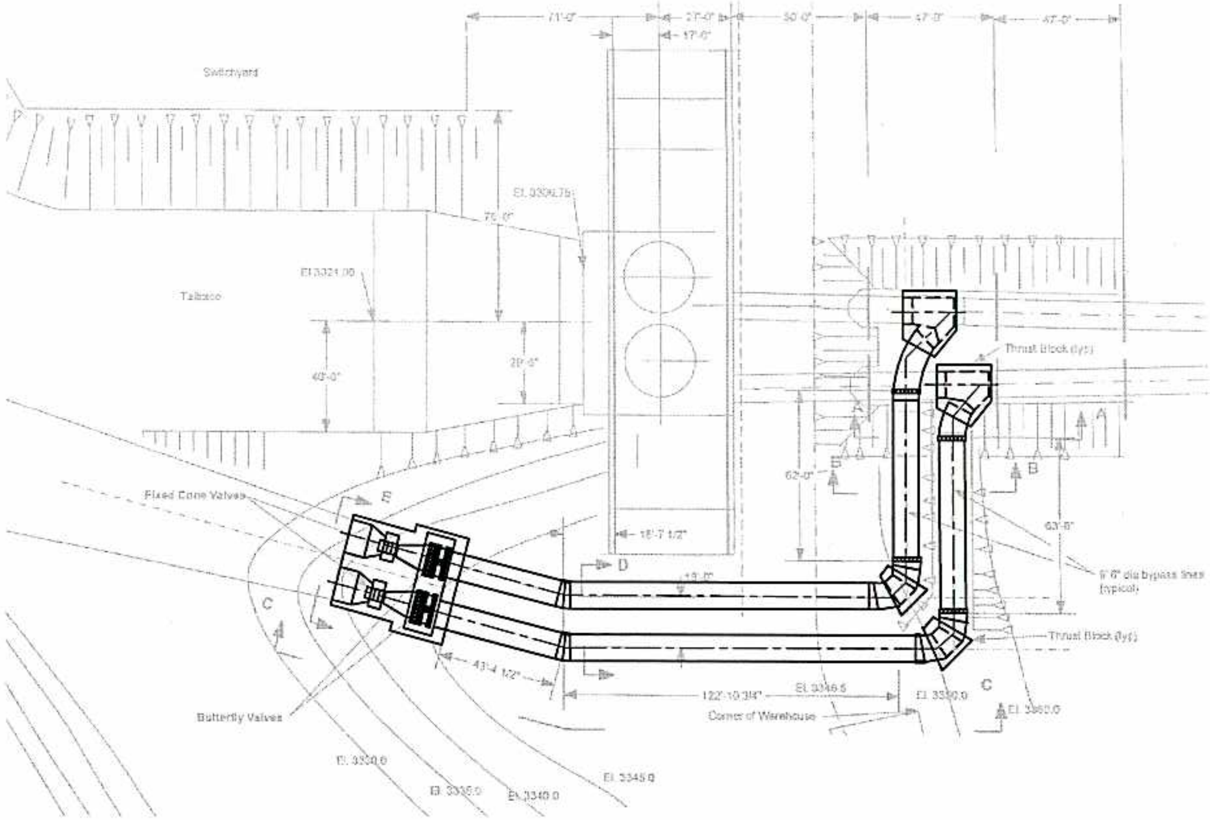
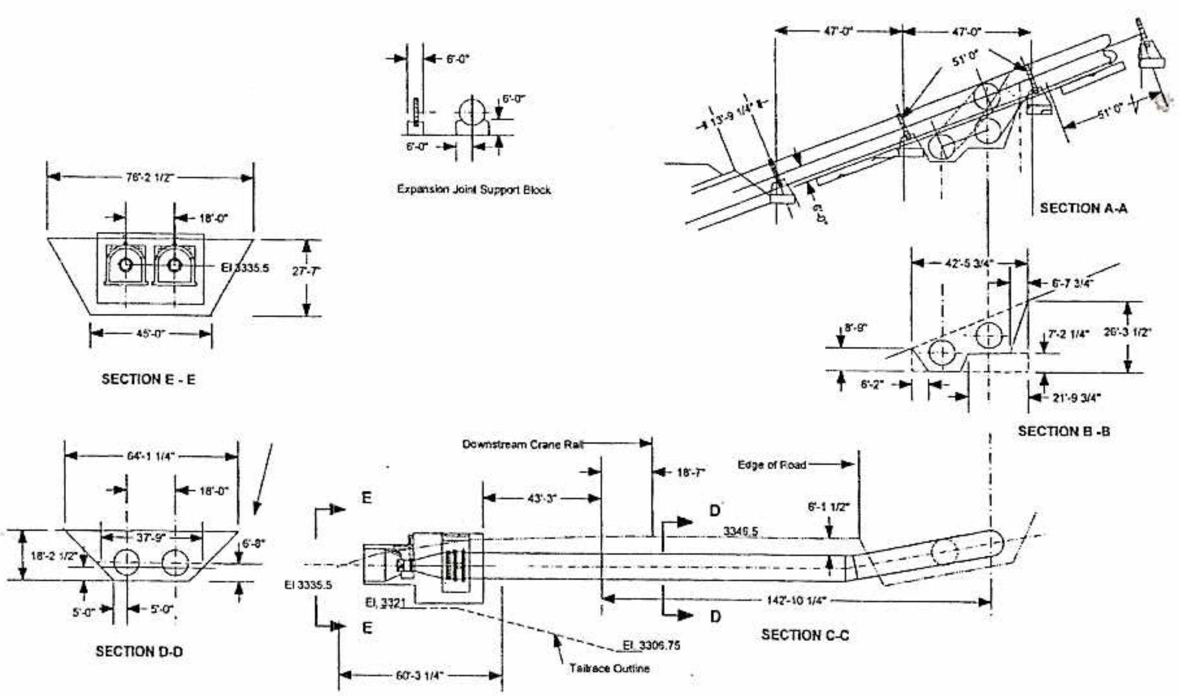


GENERAL ARRANGEMENT - PLAN

SCALE: N.T.S.



GENERAL ARRANGEMENT - SECTION

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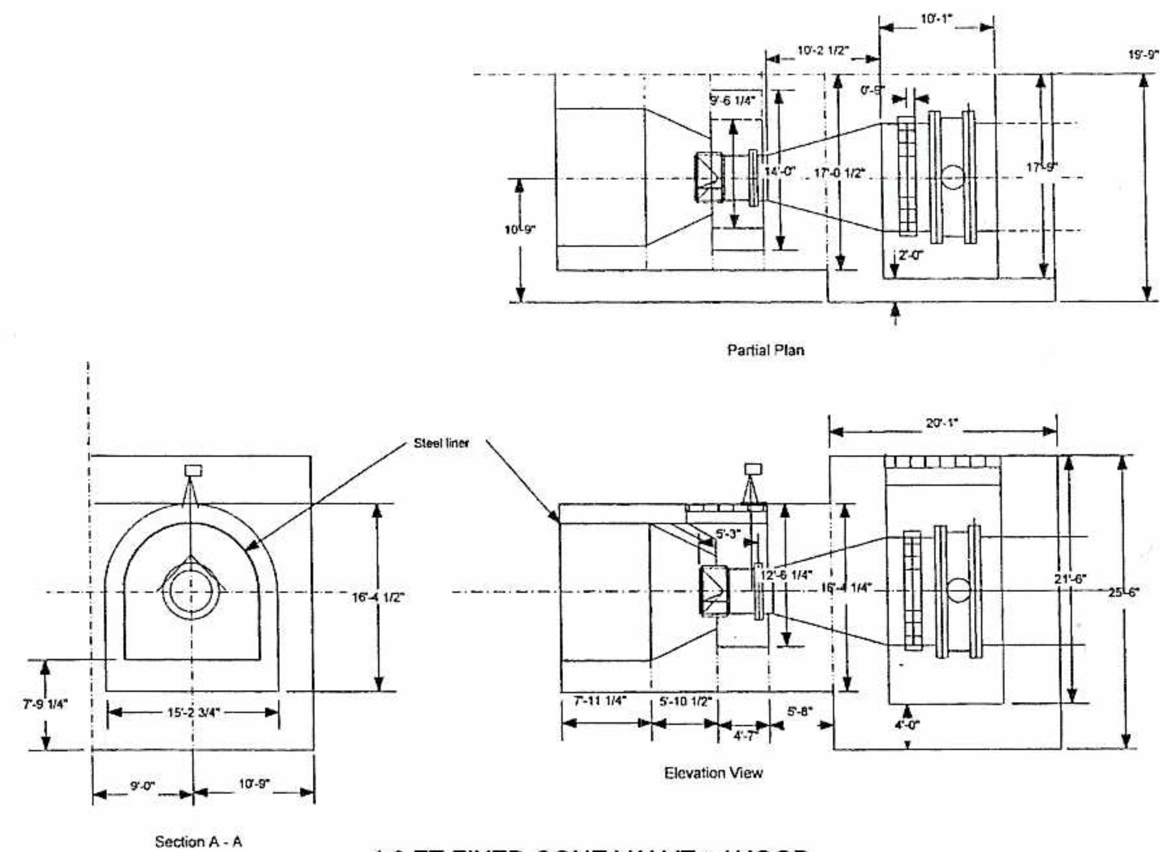

4.0 FT FIXED CONE VALVE w/ HOOD PLAN AND SECTION

SCALE: N.T.S.

PRELIMINARY DESIGN CONCEPTS AND DRAWINGS DEVELOPED BY BLACK & VEATCH, MAY 2002.

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APPLICATION FOR KLAMATH HYDROELECTRIC PROJECT LICENSE
PROJECT NO. 2082

KLAMATH HYDROELECTRIC PROJECT
J.C. BOYLE - SYNCHRONOUS BYPASS VALVE

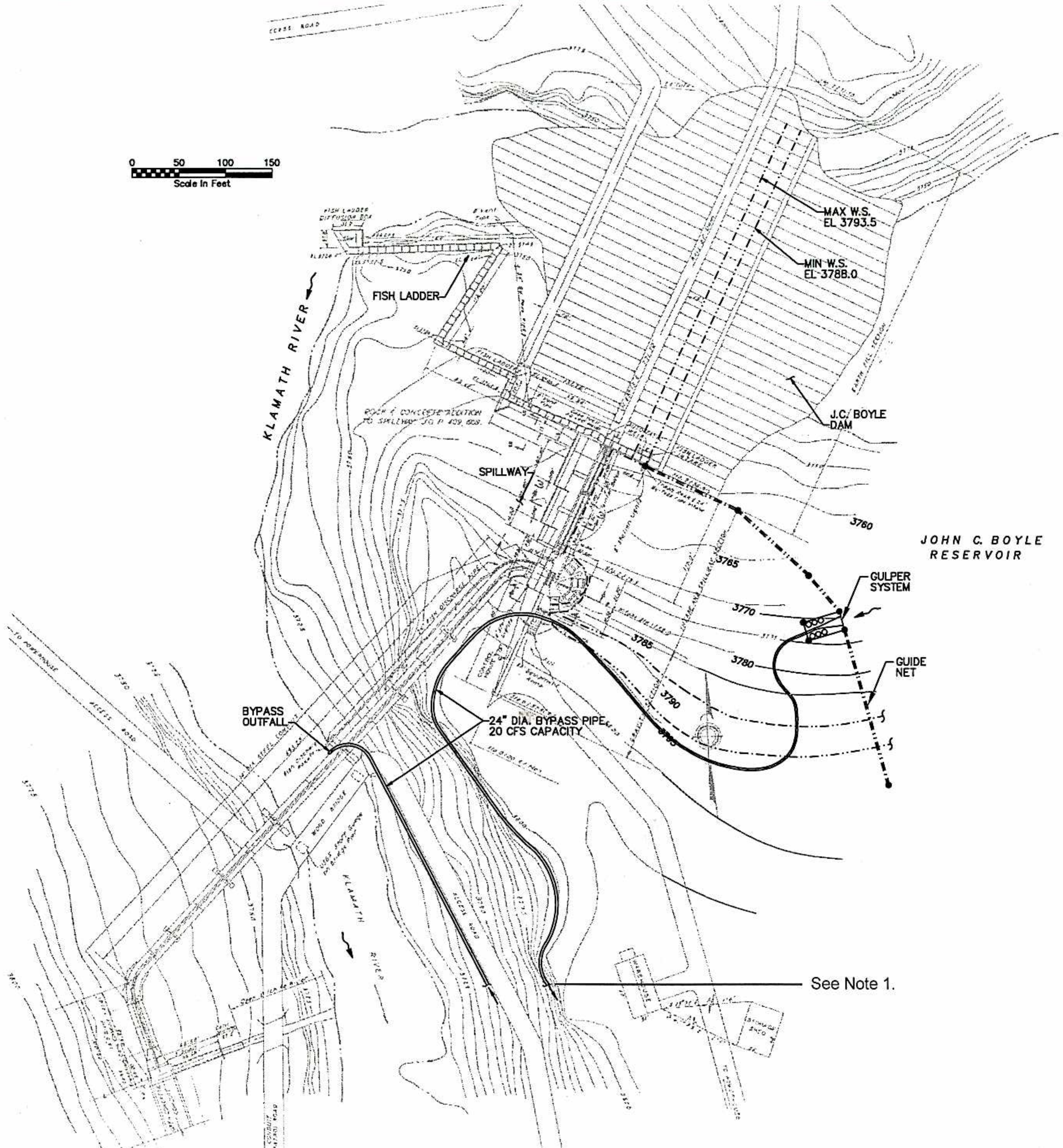
SCALE AS SHOWN

SCALE: INCHES

Figure 4.7-1

PROJ# 165267 SHEET 10 OF 11 165267CV03 REV. 0

CAD No:165267CV03.DWG SCALE: PLOT SCALE: 1 =



J.C. BOYLE GULPER SYSTEM
1" = 50'-0"

Notes:

1. The bypass pipe consists of 1,100 feet of 24 inch CMP following natural contours at an approximate slope of 3 percent

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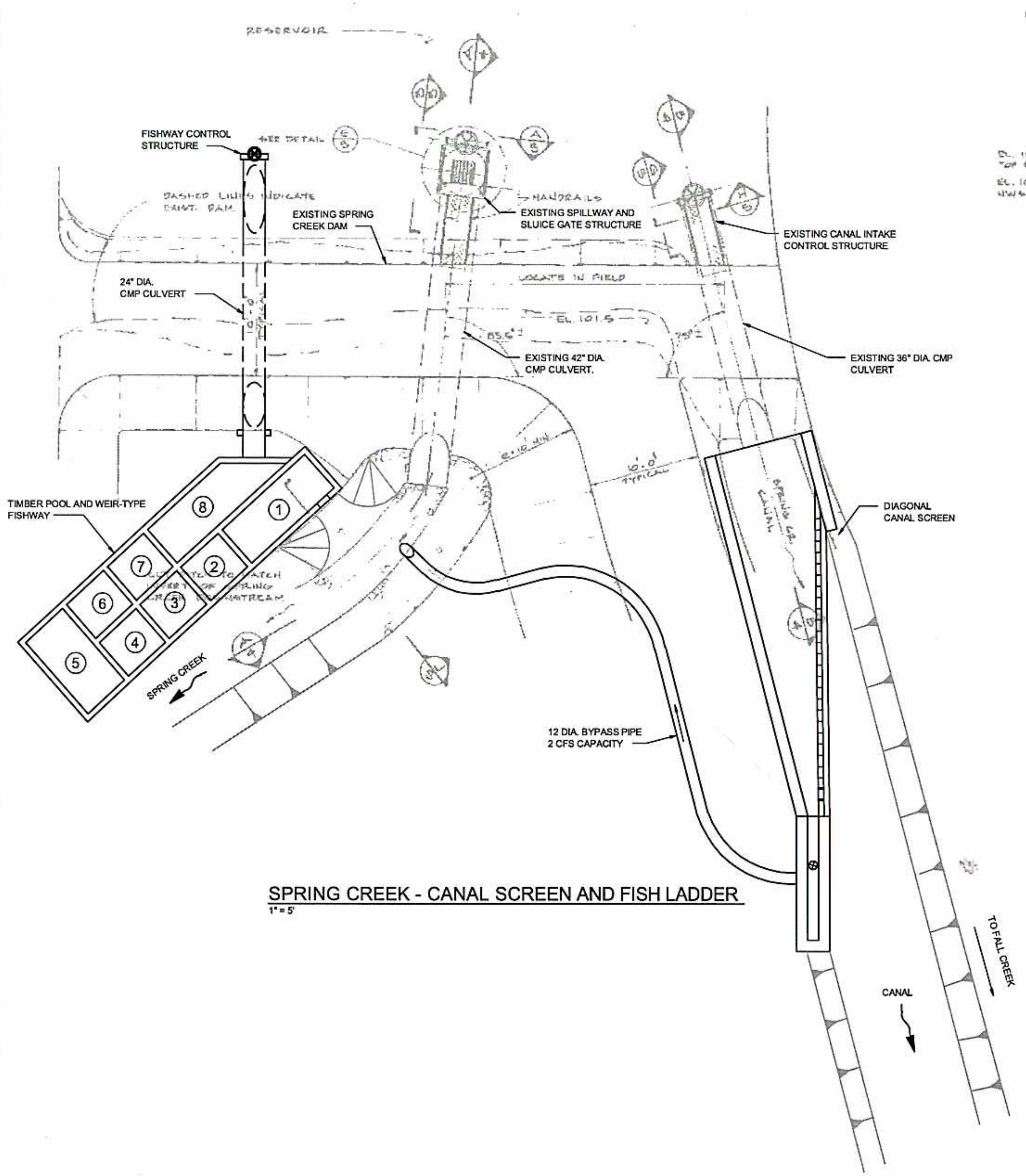
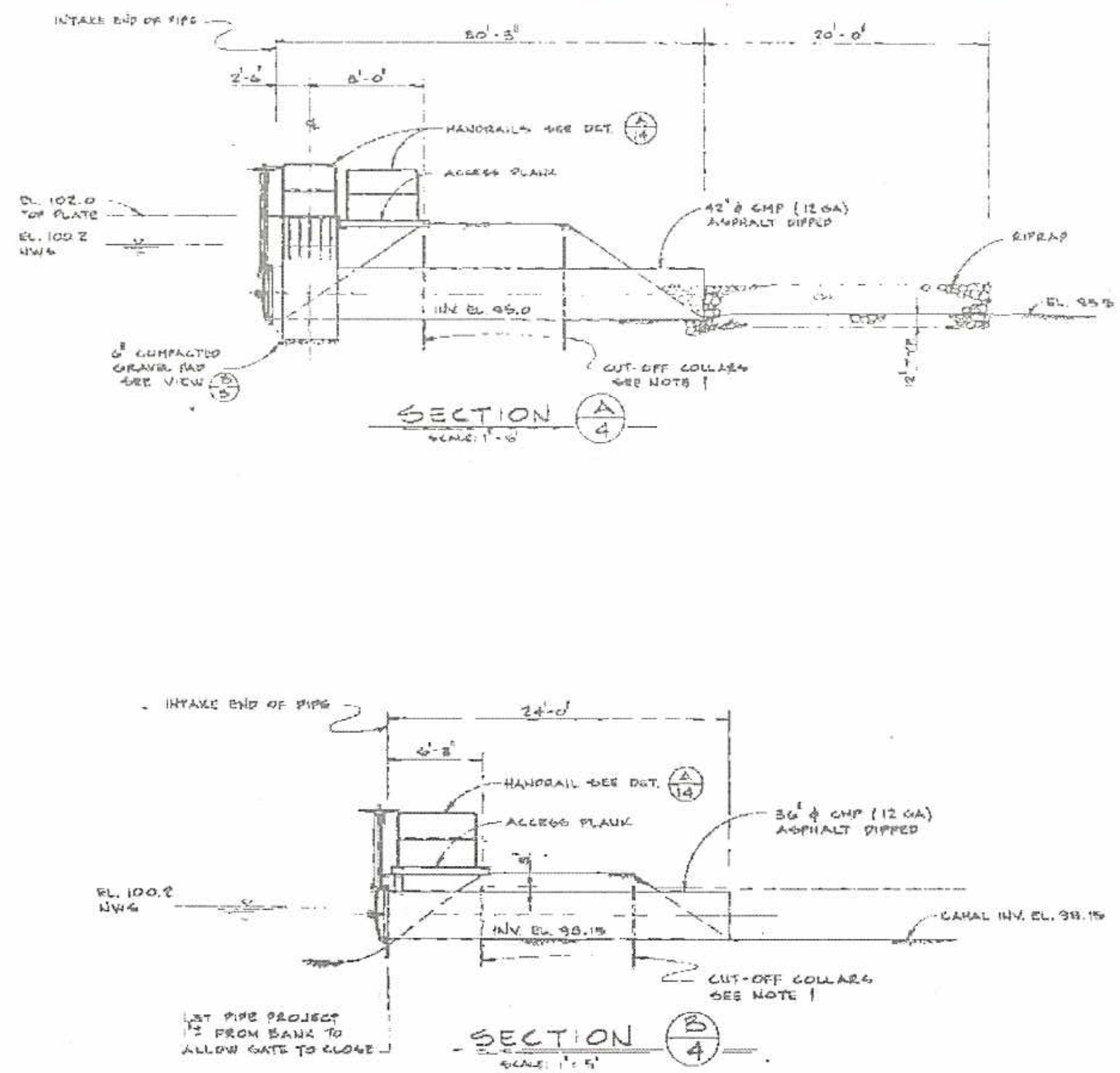
KLAMATH HYDROELECTRIC PROJECT
J. C. BOYLE DEVELOPMENT
GULPER SYSTEM

Figure 4.7-2



SPRING CREEK - CANAL SCREEN AND FISH LADDER
1" = 5'



NOTES:

1. THE TWO CUTOFF COLLARS SHALL BE LOCATED UNDER THE SHOULDER AS SHOWN. THE COLLARS SHALL BE PREFABRICATED AND ASPHALT DIPPED. THE JOINT BETWEEN THE COLLAR AND THE CONDUIT SHALL BE WATER TIGHT. THE COLLARS SHALL EXTEND FROM THE OUTSIDE OF THE CONDUIT 24" IN ALL DIRECTIONS EXCEPT FOR THE INTAKE CONDUIT WHERE THE COLLAR EXTENDS ONLY TO 3" ABOVE THE TOP OF THE PIPE.

2. THE GRATING ON THE SPRING CREEK SPILLWAY STRUCTURE, THE TRASHRACKS ON THE FALL CREEK PENSTOCK INTAKE STRUCTURE, AND ALL GRIPSTRUT ACCESS PLANKS AND PLATFORMS SHALL BE BOLTED DOWN. THE CONTRACTOR SHALL SUBMIT TO THE ENGINEER, A PLAN FOR BOLTING EACH OF THESE ITEMS DOWN. APPROVAL MUST BE RECEIVED FROM THE ENGINEER PRIOR TO INSTALLATION.

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KLAMATH HYDROELECTRIC PROJECT
SPRING CREEK - CANAL SCREEN AND FISH LADDER

SCALE AS SHOWN
SCALE: INCHES

Figure 4.7-3