Fish Species of the Pelton Round Butte Hydroelectric Project Area

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INTRODUCTION

Nearly 50 year ago, Portland General Electric Company (PGE) obtained licenses for the construction and operation of the Pelton Round Butte Hydroelectric Project (Project) on the lower Deschutes River. The Federal Energy Regulatory Commission license for the operation of the Project is scheduled for renewal. As part of the relicensing process, the Oregon Department of Fish and Wildlife (ODFW) requested an analysis of fish resources in the Project area. PGE commissioned S. P. Cramer and Associates to compile and summarize available information for selected fish species occurring in the Project area.

This report provides detailed information on a total of 25 fish species (18 native species and 7 introduced species) in the area affected by the Project. For each species, the report describes general characteristics of the species, including physical appearance, global distribution, life history(ies), habitat requirements, and inter/intraspecific interactions. The report also provides information specific to the Deschutes River Basin for each species, including population size and distribution, fisheries, limiting factors, and ecological role.

Terminology used and information included in this report are geared toward the educated layperson; however, information in this report may also help resource managers determine impacts of management actions on these species.

The various species and their associated abundance and distribution in the Project area as described in this report reflect existing conditions within the Deschutes River Basin. Potential changes in species assemblage in the basin that would be expected as a result of reestablishment of passage around the Project are not considered in this report.

Description of Project Area

The Project is located in the Deschutes River Basin beginning at river mile (RM) 100 on the Deschutes River upstream of its mouth at the Columbia River (Figure 1). The Project has three developments — the Round Butte, Pelton, and Reregulating developments. Each development includes a dam, powerhouse, and reservoir.

Round Butte is the largest of the three developments. Round Butte Dam is 440 feet high and creates a reservoir with approximately 4,000 surface acres. The reservoir, Lake Billy Chinook, extends up lower reaches of three rivers; it extends 13 miles up the Metolius River, 9 miles up the Deschutes River, and 7 miles up the Crooked River.

Pelton Dam is 204 feet high and creates a reservoir with approximately 611 surface acres. The reservoir, Lake Simtustus, extends 7 miles to the base of Round Butte Dam.

The presence of the Project affects fish resources in upstream and downstream areas, as well as in the immediate Project vicinity. Upstream, the Project could influence movement of, distribution of, and available habitat for species inhabiting tributary waters to the Project. The Project's influence on upstream areas extends only to the point where upstream barriers to passage occur. The Project itself is presently the upstream limit of migration for anadromous populations in the lower Deschutes River.

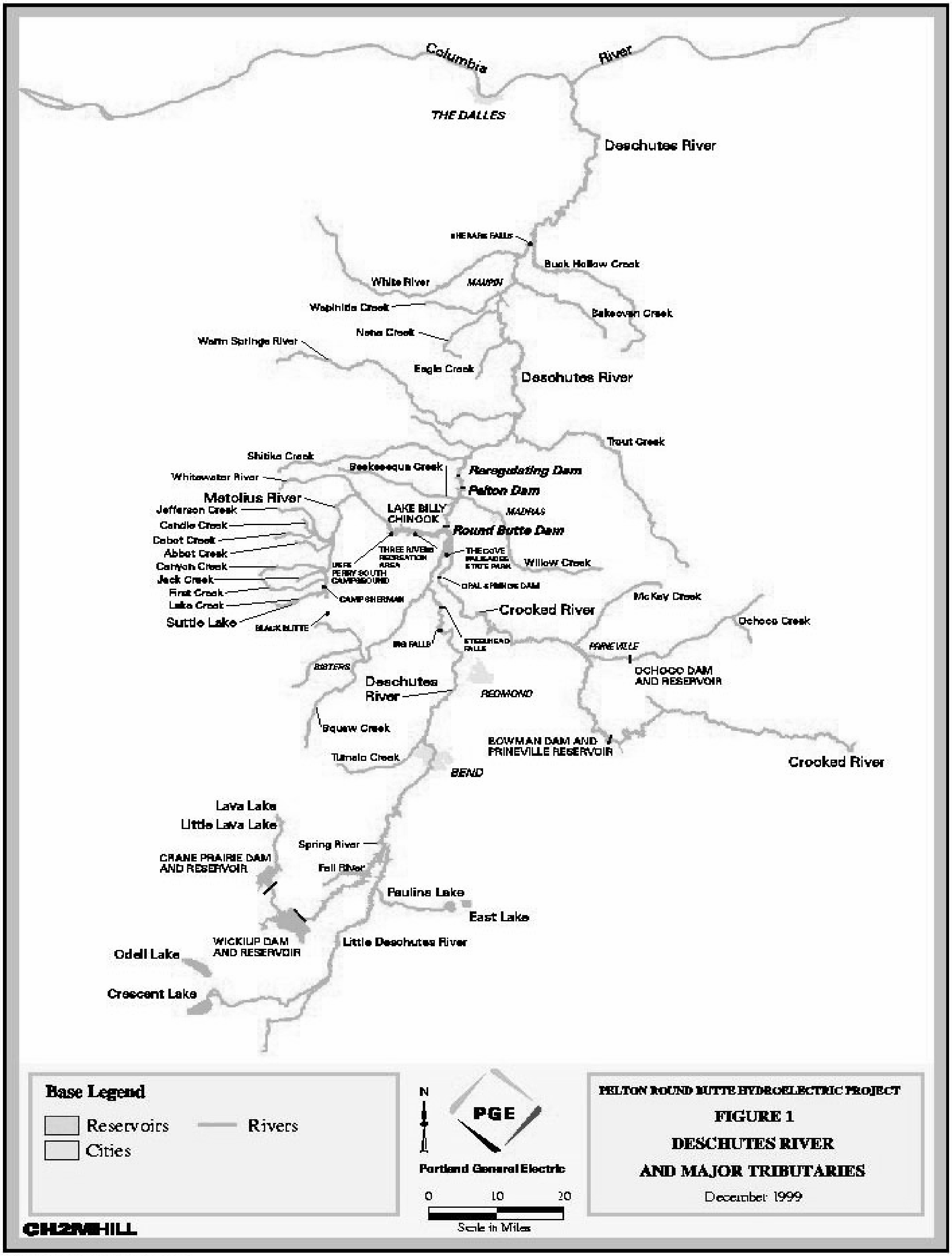

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Figure 1. Deschutes River and Major Tributaries

For the purposes of this report, discussions of fish resources in the Project area are organized according to the six general areas within or influenced by the Project: (1) the Metolius River Basin, (2) the Deschutes River upstream of Lake Billy Chinook to Steelhead Falls, (3) the Crooked River upstream of Lake Billy Chinook to Bowman Dam, (4) Lake Billy Chinook, (5) Lake Simtustus, and (6) the Deschutes River downstream of the Project.

Metolius River Basin

The Metolius River originates from springs at the base of Black Butte then flows south and east 28.6 miles to Lake Billy Chinook (Figure 2). The river is swift flowing, with an average gradient of 35 feet per mile. It has an average width of 50 feet and a well defined channel. Lake Creek, the largest tributary of the Metolius River, originates at Suttle Lake and flows 5.2 miles before entering the Metolius River at RM 39.4. Downstream of Lake Creek, several small tributaries, including First, Jack, Canyon, Abbot, Candle, and Jefferson creeks, as well as the Whitewater River enter the Metolius River from the west.

The Metolius River is noted for its stable flow pattern. Flows average 100 to 110 cfs at the source of the Metolius River, and tributaries and springs farther downstream contribute an additional 1,300 cfs. Average high flows in June are 1,653 cfs, while average low flows in October are 1,360 cfs. The average annual flow of the Metolius River near Grandview is 1,489 cfs (Fies et al. 1996a). Water diversion for domestic and irrigation purposes are minor.

Water quality for fish in the Metolius River is excellent because of the substantial flow contribution from springs. Water temperatures fluctuate between 39 and 54ºF. Daily maximum temperatures during summer months range from 47 to 54ºF (Fies et al. 1996a).

Fies et al. (1996a) identified habitat factors limiting fish production in the Metolius River. These factors are high water velocities and poor pool-to riffle ratios, inadequate large woody material, low water temperatures, unscreened irrigation diversions on Lake Creek, and partial migration barriers on Lake Creek. Some large woody material has been removed from the Metolius River, but some recruitment of large woody debris is occurring.

Deschutes River from Steelhead Falls to Lake Billy Chinook

Fish can move freely in the reach of the middle Deschutes River between Lake Billy Chinook (RM 120) and Steelhead Falls (RM 128) (Figure 3). This reach of the river flows through a deep, steep-walled rimrock canyon. Historically, Steelhead Falls was a partial barrier to upstream passage of fish, and Big Falls (RM 132.3) was the upstream limit of fish migration (Nielson 1950). Steelhead Falls was fitted with a fish ladder in 1922 (Nehlsen 1995), but the ladder was blocked in the late 1960s to stop migration of nongame fish into upper reaches of the Deschutes River (Fies et al. 1996).

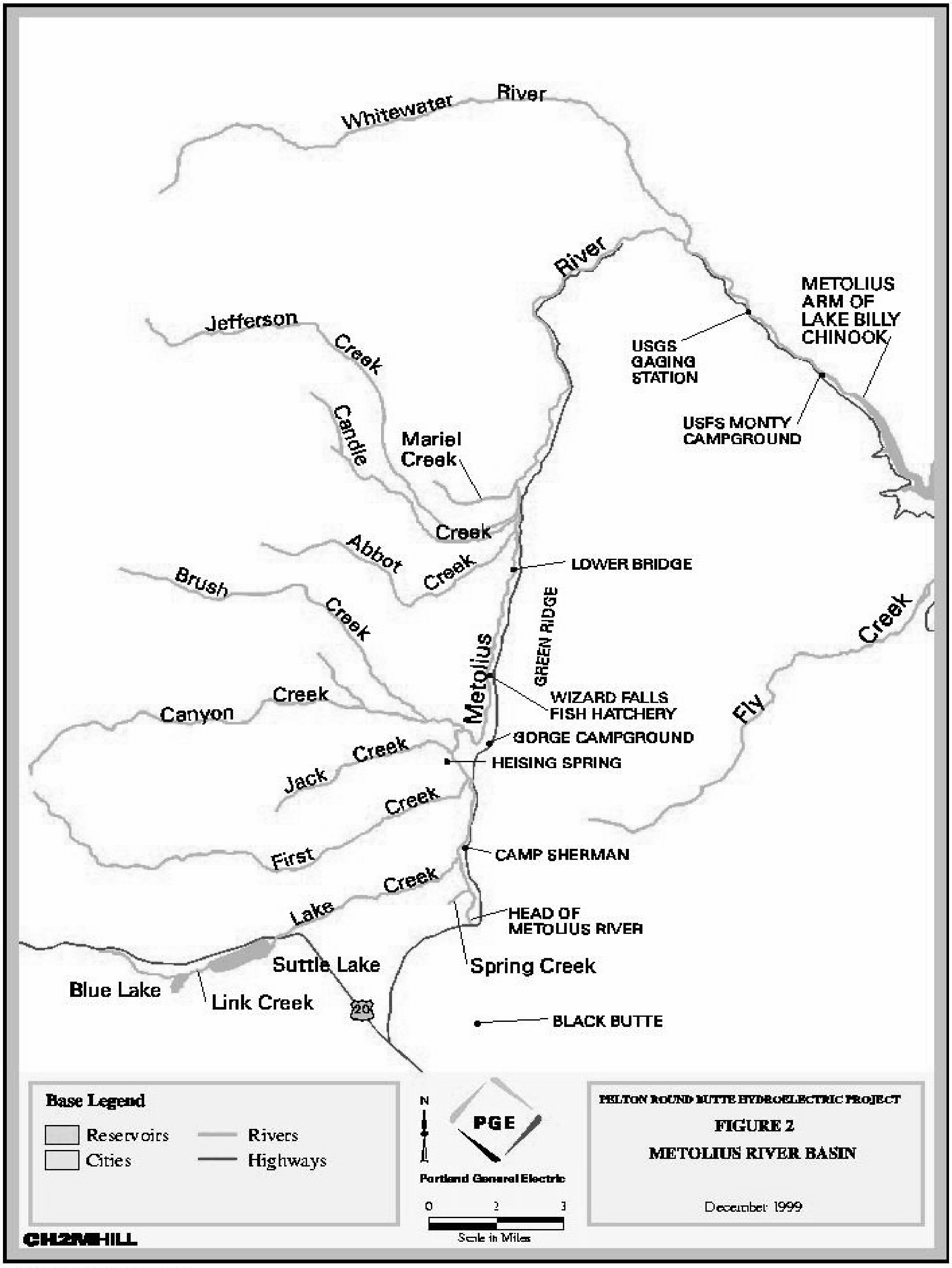

Figure 2. Metolius River Basin

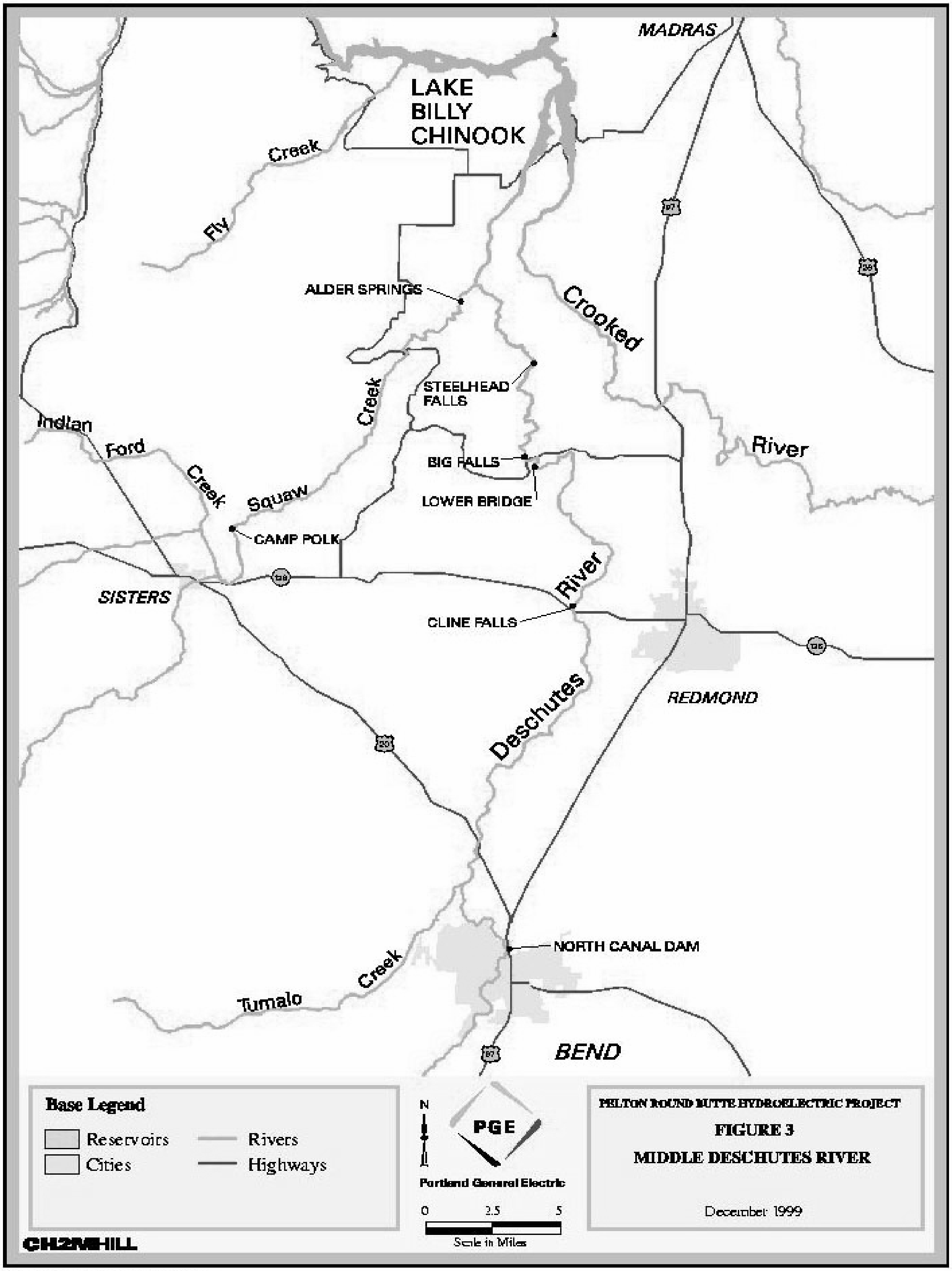

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Figure 3. Middle Deschutes River

Deschutes River flow and temperature records are collected at Lower Bridge (RM 134). The average annual flow of the Deschutes River at Lower Bridge is 1,908 cfs. Summer water flows as low as 30 cfs and temperatures as high as 81ºF have been measured at Lower Bridge. Factors affecting fish production in the Deschutes River upstream of Lake Billy Chinook are wide flow fluctuations (as a result of irrigation diversion), high water temperatures, and natural and artificial passage barriers (Fies et al. 1996b).

Squaw Creek enters the Deschutes River below Steelhead Falls at RM 123.1. Historically, large numbers of game fish spawned and reared in Squaw Creek, but numerous small dams and water diversion for irrigation resulted in low, warmwater flows in Squaw Creek below Sisters, Oregon (RM 22). The Oregon Department of Environmental Quality has identified turbidity, low dissolved oxygen, nutrients, streambank erosion, decreased streamflow, and insufficient stream structure as factors limiting fish production in Squaw Creek (Fies et al. 1996b).

Lower Crooked River (Bowman Dam to Lake Billy Chinook)

The section of the Crooked River from Bowman Dam (RM 70) to Lake Billy Chinook (RM 6) and its major tributaries, including McKay and Ochoco creeks, are included within the area discussed in this report (Figure 4). However, fish resources in the several hundred miles of minor tributaries to the lower Crooked River are not described in this report. The upper and lower reaches of the lower Crooked River flow through steep canyons cut into basalt and volcanic ash formations. The middle or Prineville Valley reach meanders through a wide floodplain (Stuart et al. 1996).

Flow releases from Bowman Dam into the lower Crooked River are regulated by the Bureau of Reclamation and managed by the Ochoco Irrigation District. Bowman Dam typically releases 200 to 250 cfs during the summer irrigation season, and 30 to 75 cfs during the winter storage season. Summer water temperatures of the Bowman Dam releases average 47 to 50ºF, and winter water temperatures average 37 to 40ºF.

Several factors impact fish populations in the Crooked River below Bowman Dam. Water released from Bowman Dam is frequently turbid because of suspended sediments in Prineville Reservoir behind Bowman Dam (Silvernale et al. 1976). The river is generally turbid downstream to RM 18, where spring inflow contributes to good water clarity and cooler river temperatures (Stuart et al. 1996). In addition, Bowman Dam spills water, causing high levels of nitrogen that can be fatal to fish eggs and fish. Nitrogen supersaturation levels have been as high as 109 percent in the Crooked River below Bowman Dam.

Poor riparian condition, water withdrawal for irrigation, and overall poor water quality characterize fish habitat conditions in the Prineville Valley section of the lower Crooked River. From Prineville downstream to Highway 97, low flows and minimal shade have resulted in summer stream temperatures as high as 80ºF. A minimum flow of 10 cfs is bypassed at RM 28, where the North Unit Irrigation District diversion occurs (Stuart et al. 1996).

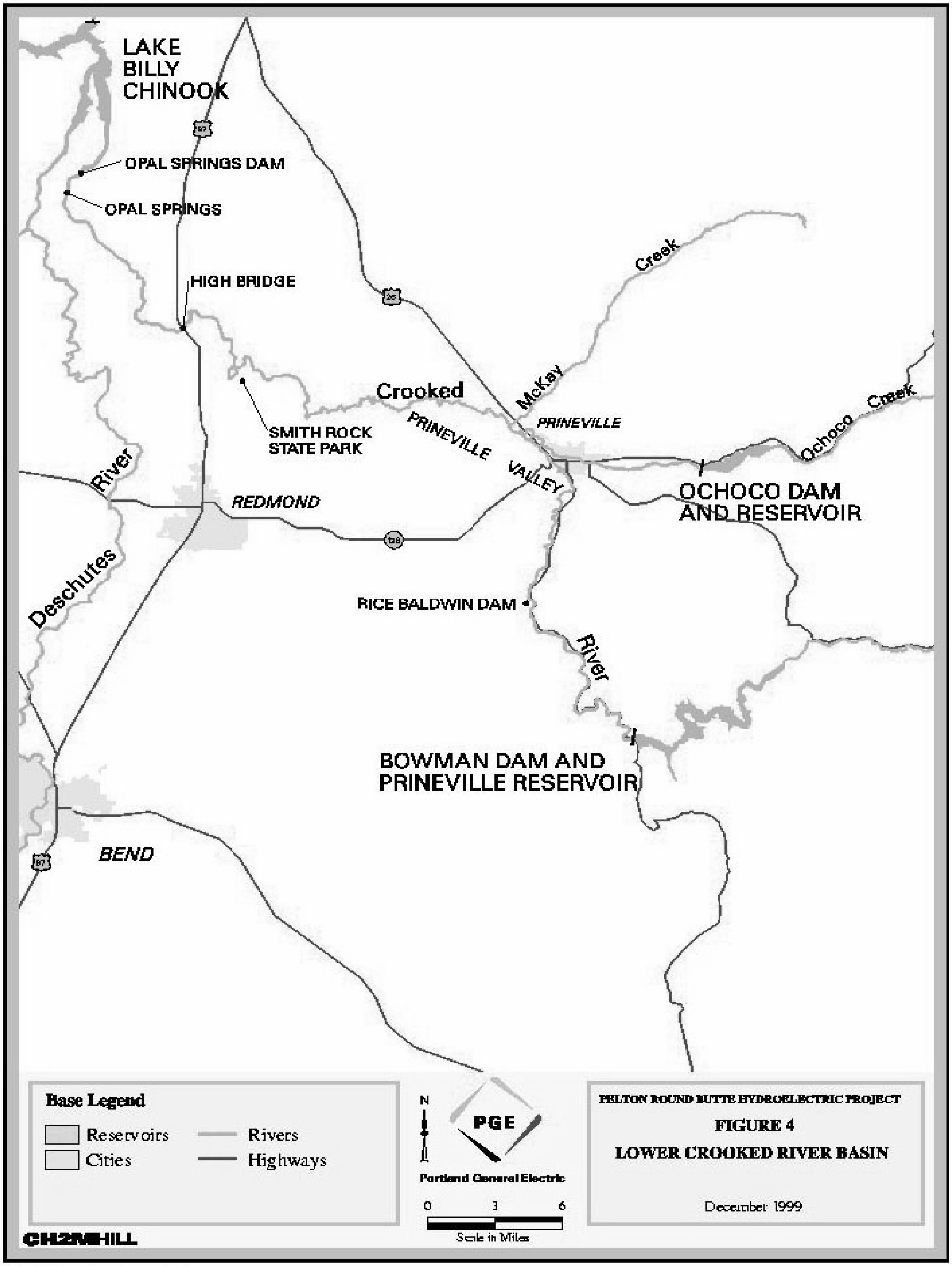

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Figure 4. Lower Crooked River Basin

At RM 18 below the Highway 97 bridge, springs augment flows with cooler water temperatures and better water quality. These springs discharge up to 240 cfs (Stuart et al. 1996). The average annual flow of the Crooked River below Opal Springs, at RM 7.0 is 1,564 cfs.

Opal Springs Dam, located about 1 mile upstream of Lake Billy Chinook, is a small hydroelectric dam operated by the Deschutes Valley Water District. Since 1982, this dam has been a barrier to upstream passage of fish (Stuart et al. 1996). However, this barrier will be modified to accommodate passage if passage at the Pelton Round Butte Project is reestablished.

Lake Billy Chinook

Lake Billy Chinook (Figure 5) has approximately 62 miles of shoreline, much of which is comprised of cliffs and steep talus slopes. The maximum depth of the reservoir is 415 feet (Ratliff and Schulz 1999). Over 60 percent of the reservoir has a depth greater than 100 feet (Mullarkey 1967), and only 6 percent of the reservoir is less than 10 feet deep (Stuart et al. 1996). The reservoir usually stratifies thermally beginning in May each year, with the thermocline (the horizon between the warmer surface layer and the cooler water below) at a depth of 20 to 25 feet. Summer surface water temperatures in the reservoir rarely exceed 75ºF. Water temperature layers disappear in late September or early October (Stuart et al. 1996).

The Metolius and Crooked rivers contribute most of the water to Lake Billy Chinook (Mullarkey 1967). The Metolius River is cooler than the Deschutes and Crooked rivers. The Crooked River is generally more turbid and has higher alkalinity than the Deschutes and Metolius rivers.

Fish habitat in Lake Billy Chinook is characterized by steep topography, boulder bottoms, and good water quality. A few sandy beaches are present in secluded coves. Silt and sand deltas have been created at the mouths of the three major tributary rivers. Aquatic vegetation is sparse in the reservoir. Some woody material has accumulated along the shoreline (Stuart et al. 1996). The steep banks of Lake Billy Chinook limit fish species that use shoal or shallow waters. Species of fish adversely affected by limited shallow water areas are rainbow trout, brown trout, and smallmouth bass. Kokanee use and benefit from the open water.

Lake Billy Chinook is only moderately productive for fish in terms of nutrient levels and zooplankton densities. For example, zooplankton densities are over three times greater in Paulina and Odell lakes than in Lake Billy Chinook. The density of zooplankton is approximately 13,000 organisms per cubic meter in Lake Billy Chinook compared to Paulina Lake, which has over 75,000 organisms per cubic meter (Stuart et al. 1996).

Lake Billy Chinook is a popular reservoir for anglers. Approximately 27,000 angler trips are made on the reservoir each year (Thiesfeld et al. 1995).

Lake Simtustus

Lake Simtustus (Figure 5) has approximately 18 miles of shoreline and is contained between steep canyon walls. The maximum depth of Lake Simtustus is 165 feet, and only 12 percent of the reservoir is less than 10 feet deep. During summer months, Lake Simtustus has a

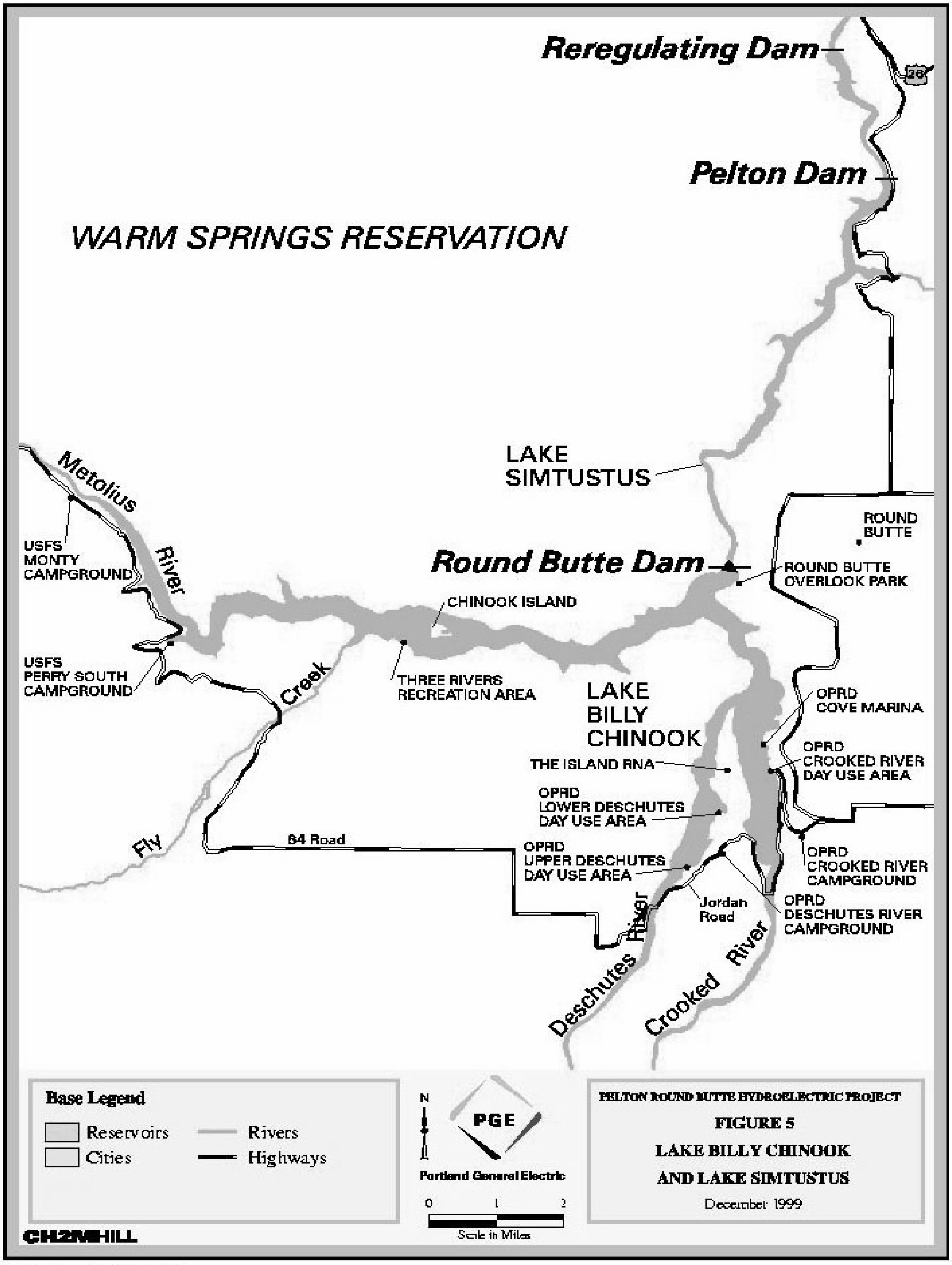

Figure 5. Lake Billy Chinook and Lake Simtustus

well defined thermocline at a depth of 15 to 25 feet. Surface water temperature rarely exceeds 70ºF (Stuart et al. 1996).

Fish habitat in Lake Simtustus is characterized by steep sides, boulder bottoms, and generally good water quality. While Kokanee benefit from the reservoir's open-water environment, the steep sides of Lake Simtustus limit the abundance and distribution of fish that prefer shoreline environments, including rainbow and brown trout, and smallmouth bass. A few sandy beaches are located in coves. Silt and sand are present in the deltas created by Willow and Seekseequa creeks. There are a few small patches of aquatic vegetation that are associated with sandy beaches. Some woody material has accumulated on the banks (Stuart et al. 1996). Spawning habitat for game fish is poor because there are a limited number of tributaries to this reservoir.

Nitrogen and phosphorus levels indicate the reservoir is fairly productive. Dissolved oxygen levels are good. Zooplankton levels in Lake Simtustus are higher than in Lake Billy Chinook, but still low compared to other Central Oregon lakes. Zooplankton densities in Lake Simtustus average about 15,500 organisms per cubic meter (Stuart et al. 1996).

Lake Simtustus experiences less angling activity than does Lake Billy Chinook. Approximately 6,500 angler trips are made on Lake Simtustus each year (Stuart et al. 1996).

Lower Deschutes River (Reregulating Dam to the Mouth)

The Deschutes River below the Project flows through a narrow canyon 700 to 2,200 feet deep. The average gradient of the lower Deschutes River from the Reregulating Dam at RM 100 to the mouth at RM 0 is 12.3 feet per mile. The three largest tributaries to the lower Deschutes River are the Warm Springs River, White River, and Shitike Creek, which all enter from the west (Figure 6). Trout Creek, Bakeoven Creek, and Buck Hollow Creek are the three major tributaries entering the lower Deschutes River from the east. Access for anadromous fish in the White River is blocked by White River Falls at RM 2.2.

Flow in the lower Deschutes River is relatively stable, reflecting the unusually uniform flow regime of the river as a whole and the regulated outflow from the Project. The Deschutes River has a more uniform flow than any other river in the United States of comparable size or larger (USGS 1914). The average annual flow at the mouth of the Deschutes River is 5,800 cfs, the sixth largest annual flow among Oregon rivers (Aney et al. 1967).

Water temperatures in the lower Deschutes River sometimes exceed State of Oregon water quality standards during summer and fall months. Only extended periods of very cold weather causes ice formation that could affect fish (ODFW 1997).

There are two primary sources of sediment in the lower Deschutes River — natural sediment originating from glacial action on Mount Hood and sediment originating from agricultural and timber harvest activities (ODFW 1997). Riparian areas in the lower Deschutes River have been affected by grazing, farming practices, timber harvest, road construction and railroad construction. The Project has prevented the natural recruitment of bedload and large woody material into the lower Deschutes River from sources above the Project.

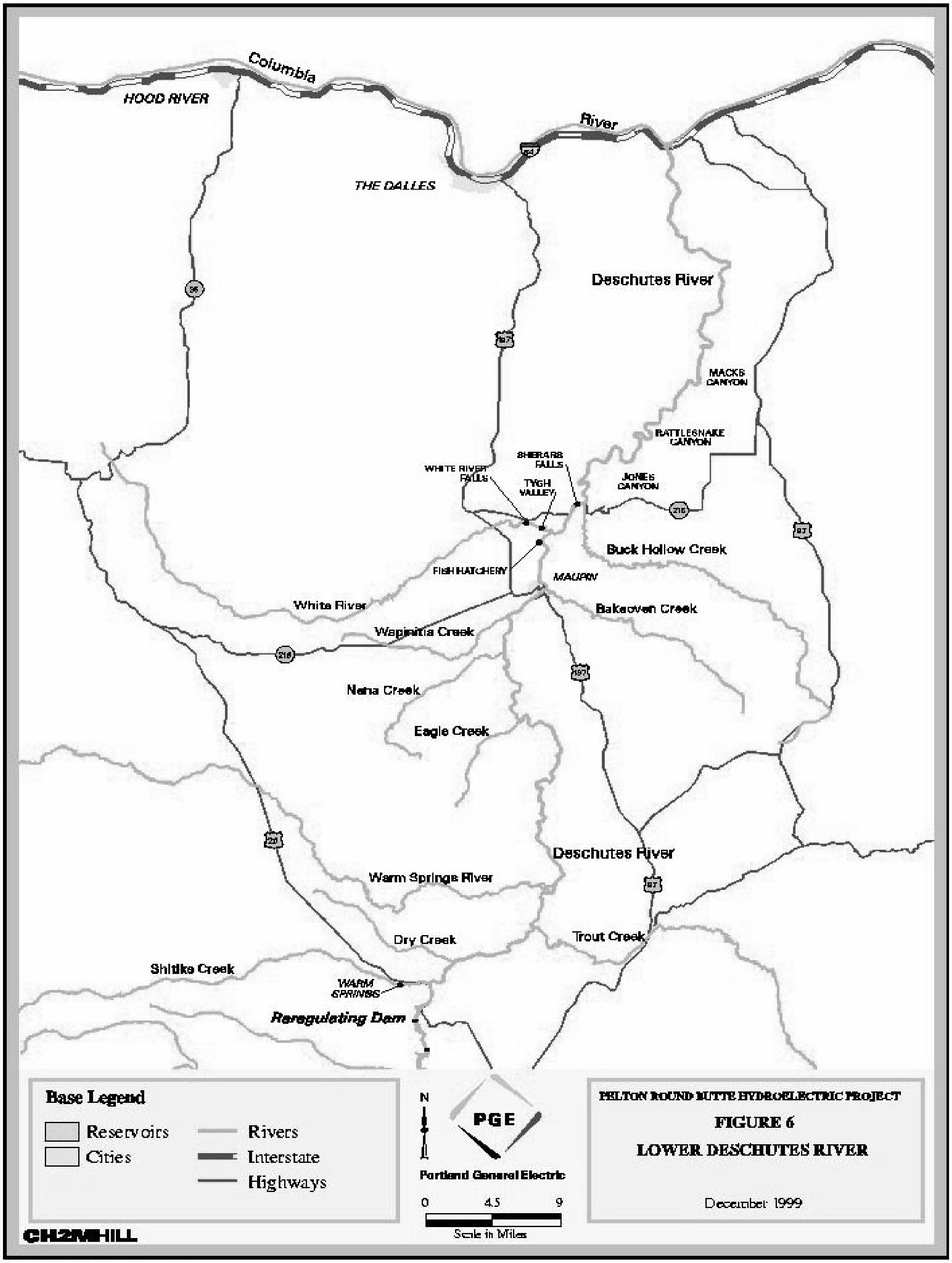

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Figure 6. Lower Deschutes River

Fish Species in the Project Area

Fish species described in this report represent those that are common and/or of particular interest in the area affected by the Project. The report describes the following 18 native species (including 2 with both anadromous and resident life histories) and 7 introduced species:

Native Species		Introduced Species
Anadromous Fish:	Resident Game Fish:	
chinook salmon	bull trout	brown trout
sockeye salmon	kokanee salmon	smallmouth bass
(anadromous form of *Oncorhynchus nerka*)	(resident form of *Oncorhynchus nerka*)	goldfish
		black crappie
steelhead trout	rainbow trout	brown bullhead catfish
(anadromous form of *Oncorhynchus mykiss*)	(resident form of *Oncorhynchus mykiss*)	tui chub
		threespine stickleback
Pacific lamprey	mountain whitefish	
Sculpin:	Sucker:	
shorthead sculpin	largescale sucker	
torrent sculpin	bridgelip sucker	
slimy sculpin		
mottled sculpin	Other:	
prickly sculpin	chiselmouth	
	northern pikeminnow	
Dace:	redside shiner	
longnose dace		
speckled dace		

Other species that may occur in the Project area were not included in this report. For example, white sturgeon, walleye, and other species of fish in the lower Columbia River undoubtedly move short distances up the Deschutes River.

The following sections describe individual fish species present in the Project Area. Readers will note that the extent of the information varies greatly among the descriptions of the individual species. This disparity reflects the fact that much more information is available for game fish than for nongame species.

CHINOOK SALMON

Oncorhynchus tshawytscha

Other common names: Spring salmon, king salmon, tyee, spring, chinook, king, quinnat (Scott and Crossman 1973)

General

APPEARANCE

The body of a chinook salmon is streamlined, laterally compressed, and deeper than other species of salmon. Adult chinook salmon reach lengths of 36 inches and weights over 30 pounds. The head of a chinook salmon makes up 20 percent of the total length and is cone shaped. The eyes are relatively small. The snout is rather blunt, narrow, and turned down at the tip; especially in breeding males. The mouth is located on the end of the snout and is turned up at the tip. Chinook salmon are unable to completely close their mouths. The maxillary extends well beyond the eye, especially in adults (Scott and Crossman 1973).

Chinook salmon have a long, narrow, dorsal fin located at the center of the body. The dorsal fin has 10 to 14 soft rays. A rather fleshy adipose fin is located behind the dorsal fin. The tail is broad with a shallow fork and pointed tips. The anal fin has a long base with 14 to 19 soft rays. The pelvic fins are located on the belly, are rounded, and have 10 to 11 soft rays. The pectoral fins are low on the body, rather long, with pointed tips and 14 to 17 soft rays. The scales are round, small and, in breeding fish, deeply embedded (Scott and Crossman 1973).

Breeding males have a compressed body and head, hooked snout, gaping mouth, enlarged teeth, and embedded scales, and individuals have different coloration. Individual females have different coloration, but, unlike the males, the body shape of breeding females changes little (Scott and Crossman 1973).

Adults in the ocean are iridescent green to blue-green with gold flecking or sheen on the back and top of the head. The sides below the lateral line are silvery and the belly is silvery to white. Black spots occur on the back and top of the head, upper sides and on all fins, including the tail. The lower gum line is black. Breeding chinook salmon are an overall olive-brown to purple color with males darker than females (Scott and Crossman 1973).

Young chinook salmon have 6 to 12 parr marks, each longer and wider than other Pacific salmon. The adipose fin has color at the edge and is clear in the center and front areas. There are no spots on the dorsal fin. The first ray of the anal fin is elongated and white (Scott and Crossman 1973).

Distinguishing characteristics of chinook salmon are its large size, small black spots on both lobes of the tail fin, and black pigment along the base of the teeth. Chinook salmon also differ from the other salmon species by their variable flesh color, from white through various shades of pink to red (Healey 1991).

Distribution

Chinook salmon are found along the Pacific coast from the Ventura River in southern California to Point Hope, Alaska. They are also found in northeast Asia, from the Anadyr River south to Hokkaido, Japan (Wydoski and Whitney 1979). Chinook salmon were introduced into streams from Maine to South Carolina, as well as in Georgia, Louisiana, and Mississippi. They were also introduced in Mexico, Argentina, Chile, Nicaragua, England, Ireland, Holland, France, Germany, Italy, Hawaii, Australia, Tasmania, and New Zealand (Davidson and Hutchinson 1938).

Landlocked populations of chinook salmon have been established in Chile (Lindbergh 1982). Chinook salmon introduced into the Great Lakes thrived initially, but failed to maintain spawning populations in many areas (Scott and Crossman 1973). Recently, naturally spawning populations have become established in the Laurentian Great Lakes (Carl 1982). Naturally produced chinook salmon are now a valuable component of the sport fisheries in Lake Michigan and its tributary streams (Healey 1991).

Life History

Life histories of chinook salmon are composed of traits such as age at maturity, age at downstream and upstream migration, time of migration, age at maturity, and size and growth. Life history traits are directly related to reproduction and survival and, therefore, are an important link to survival of the species (Mobrand et al. 1996). Life history traits may change as a result of changes in environmental condition or natural development (Smith-Gill 1883)

There is plasticity in the different life history pathways of chinook salmon, and this plasticity appears to be a consequence of genetics and environmental conditions. Despite the biological and ecological plasticity of the species, chinook salmon populations are specifically adapted to local conditions. Many life history pathways serve to spread the risk of mortality and help the race avoid extinction (Healey 1991).

Chinook salmon have evolved two basic race characteristics, “stream-type” and “ocean-type” (Healey 1983, Merrell 1981, Gilbert 1913), as well as a variety of juvenile and adult behavior patterns (Stearns 1976, Real 1980). The stream-type and ocean-type races are distinguished by ecological differences in (1) geographic distribution, (2) duration in freshwater as juveniles and as adults prior to spawning, (3) ocean distribution and dispersal, and (4) timing of their spawning migration. Healey (1991) provides several explanations as to how chinook salmon may have diverged into two separate races, but he provides little insight into possible evolutionary reasons for the development of the two races.

Chinook salmon return to the mouth of their natal river at almost any month of the year (Snyder 1931, Rich 1942, Hallock et al. 1957). There are generally one to three peaks of migratory activity, and the timing and the number of migratory peaks varies among river systems (Fraser et al. 1982, Rich 1942, Snyder 1931). These runs tend to occur progressively later in southern streams. Rich (1925) and Ball and Godfrey (1968a, 1968b) describe racial composition of spawning runs of chinook salmon in the Fraser and Columbia rivers. These data demonstrate alternation in run timing of different races. Generally, the fish that appear earliest at the river mouth migrate farthest (Scott and Crossman 1973). Healey (1991) describes survival advantages associated with different run timing.

Despite the wide variation in run timing within most rivers, spawning times in a river system tend to be similar among runs, but individual populations may spawn at different times (Healey 1991). The trend throughout the range of chinook is for earlier spawning as one moves north, with northern populations tending to spawn from July to September and southern populations tending to spawn from November to January. Early-run fish normally delay spawning and spawn in the early-fall. Late-run fish tend to spawn in late-fall. Between river systems, the time that chinook spawn is quite variable, ranging from May and June for some northern populations and for the winter run in the Sacramento River (Hallock et al. 1957, Slater 1963) to December/January for fall-run chinook in the Sixes and Elk rivers, Oregon (Reimers 1971, Burck and Reimers 1978).

Spawning beds chosen by chinook salmon vary in physical characteristics. Chinook will spawn in water a few inches deep (Burner 1951, Vronskiy 1972) to many feet deep (Chapman 1943, Chapman et al. 1986). They spawn in small tributaries (Vronskiy 1972) and in the main stem of large rivers like the Columbia and Sacramento (Chapman 1943, Hallock et al. 1957).

Males and females are aggressive on the spawning ground (Scott and Crossman 1973). The female digs the redd by lying on her side and thrashing her tail up and down. Gravel and sand thrown out of the depression accumulates in a mound at the downstream margin of the depression (Healey 1991). Overall redd size varies (Chapman 1943, Burner 1951, Briggs 1953, Vronskiy 1972, Collings et al. 1972, Smith 1973, Bovee 1978, and Chapman et al. 1986). The redd can be as much as 12 feet long and 1 foot deep. Each female is attended by a large, dominant male and often by several smaller males. At spawning, the female and the dominant male swim into the redd, the two fish side-by-side, their mouths open, they vibrate, and eggs and sperm are released at the same time. Smaller males may dart into the redd and release sperm (Scott and Crossman 1973). The female deposits a group of eggs in the redd and then covers them with gravel. Over the course of one to several days, the female deposits four or five such groups of eggs in a line running upstream, enlarging the redd in an upstream direction in the process (Healey 1991). A female may dig more than one redd and spawn with more than one male (Scott and Crossman 1973).

There is considerable variation in numbers of eggs per female within each chinook salmon population and even larger difference among different chinook populations (McGregor 1922, 1923). Generally, chinook females lay about 5,000 eggs, but fecundity ranges from fewer than 2,200 eggs to more than 7,750 eggs (Wydoski and Whitney 1979). Fecundity is correlated with female size, but size explains only 50 percent or less of the variation in fecundity between individuals within a population (Healey 1991). Fecundity also varies somewhat according to color of flesh (Godfrey 1968). Age apparently contributes nothing to variations in fecundity beyond that predicted by the corresponding differences in size (Healey and Heard 1984). Fecundity within a population fluctuates on an annual basis (Godfrey 1968). Healey and Heard (1984) speculate that fecundity is an uncertain trade-off between egg size and egg number in the overall fitness of chinook populations.

Egg size increases with female size (Nicholas and Hankin 1988), while a general trend in fecundity increases from south to north (Healey and Heard 1984, Nicholas and Hankin 1988). Egg quality can also depend on genetic characteristics of the parents (Healey 1991).

Females that die unspawned on the spawning grounds, or that do not spawn all their eggs represent a potential loss in fish production. However, this loss is seldom large (Chapman et al. 1986). Egg loss also can occur if eggs are swept out of the redd during spawning, are not fertilized, are not buried deeply enough, or die because of floods, siltation, freezing or disease (Healey 1991). In addition, poor gravel percolation or poor water quality can cause mortality of eggs. Conversely, survival rates for eggs are good if there is good water percolation in the gravel (Shelton 1955, Gangmark and Bakkala 1960). Water temperature has seldom been implicated in any significant loss of eggs during incubation (Healey 1991), although warm-water temperatures (Thompson and Haas 1960) and decreasing water temperatures may restrict areas where chinook spawn. Thompson and Haas (1960) and Gangmark and Broad (1956) describe high water flow conditions that could result in complete dislodgement of salmon eggs and embryos.

Chinook begin spawning when water temperatures are decreasing and less than 61ºF, the upper temperature limit for 50 percent egg mortality (Alderdice and Velsen 1978). Eggs are usually not exposed to warm temperatures for long (Healey 1991). Piper et al. (1982) reported that chinook salmon eggs require 1,600 temperature units to develop into free-feeding fry (a temperature unit is one degree F above 32ºF for 24 hours). Egg development can vary greatly depending upon the date of fertilization and subsequent water temperatures. Neeley et al. (1993) project that in the Imnaha River, Oregon, eggs fertilized August 1 would be free-feeding fry in 97 days, whereas eggs fertilized September 15 would be free-feeding fry in 272 days.

Hatched fry spend 2 to 3 weeks in the nest while the yolk is absorbed before struggling up through the gravel to become free-swimming fry (Scott and Crossman 1973). Upon emergence, some fry are immediately displaced downstream. Thomas et al. (1969) found that fall chinook fry go through a period of reduced swimming ability just before the yoke is completely absorbed. Thomas et al. (1996) hypothesized that reduced swimming ability was the cause for downstream migration. Downstream movement of fry occurs mainly at night (Reimers 1971, Lister et al. 1971, Mains and Smith 1964).

After emergence, some fry proceed almost directly to the estuary (ocean-type), while others remain in fresh water for a year (stream-type) (Scott and Crossman 1973). What determines whether fry will hold and rear in the river, or migrate downstream to the estuary is unknown. Reimers (1968) and Lister and Walker (1966) speculate that social interaction or density-dependent mechanisms (total number of fish in a given space) may cause fry to be displaced downstream. Lister and Walker (1966) and Major and Mighell (1969) concluded that the size of the available freshwater rearing area limited the number of fry that could reside in the river, and that the rest were displaced downstream. Whether fry move to the estuary, move downstream because of limited freshwater habitat, or remain in the natal area is probably caused by a combination of factors including environmental condition and genetic adaptation (Lichatowich and Mobrand 1995).

Downstream movement of chinook fry has been observed at almost all times of year (Kjelson et al. 1981, Slater 1963, Reimers and Loeffel 1967, Northcote 1976, Lister and Walker 1966, Healey 1991). Downstream movement of chinook fry between February and May is typical of most stream-type populations (Lister and Walker 1966, Bjornn 1971, Reimers 1971, Healey 1980, Kjelson et al. 1981). Later in the spring, there appears to be a second dispersal that carries some fry to the estuary (ocean-type populations) or simply redistributes the fry within the river system (stream-type populations). June is a month of very active downstream migration for fry, but the timing of fry migration varies and tends to be earlier in the southernmost parts of the range (Kjelson et al. 1981). For those populations that remain a year in fresh water there is a third, late-fall redistribution, usually from the tributaries to the main stem. Bjornn (1971) observed downstream movement of chinook fingerling during fall months, and he proposed that this migration represented a redistribution of fish to more suitable wintering habitat.

Factors stimulating the timing of downstream movement of sub-yearling ocean-type chinook are not known. Reimers and Loeffel (1967) suggested that body size is an important variable in determining when fish move downstream. However, downstream migrant chinook salmon fingerling vary in size, both within and among rivers, so some factor other than size must play a role in stimulating downstream movement (Healey 1991).

Ocean-type chinook fry rear in estuaries for some period of time (Rich, 1920; Kjelson et al. 1981, 1982; Congleton et al. 1981; Dunford 1975; Goodman 1975; Levy and Northcote 1981, 1982; Levings 1982; Gordon and Levings 1984; Healey 1980, 1982; Levings et al. 1986; Birtwell 1978). Chinook fry are able to survive moderate to high levels of salinity (Healey 1991). Chinook fry remain in the estuary until they are about 3 inches, then migrate to sea. The average length of stay of fry in the estuary is about 20 to 25 days (Healey 1980). In some river systems, fry leave the estuary about the time that stream-type smolts arrive (Reimers 1971, Reimers et al. 1979, Myers 1980, Myers and Horton 1982).

Stream-type chinook do not migrate to seas during their first year of life but delay migration until the spring following their emergence from the gravel. Yearling smolts in stream-type populations normally migrate seaward in the early spring, sometimes ahead of the downstream dispersals of fry and fingerlings and sometimes intermixed with them (Bell 1958, Major and Mighell 1969, Meehan and Siniff 1962, Waite 1979, Healey 1991). Yearling chinook migrate faster than sub-yearling chinook (Cramer and Lichatowich 1978). The rate of downstream migration also is correlated with stream discharge, although rates of travel through free-flowing and impounded sections of river can be similar (Raymond 1968). Chinook that migrate to sea as yearling smolts often spend some time in the estuary, but not all migrant yearlings remain in the estuary, and those that do stay for only a short period (Healey 1980, 1983; Leavy and Northcote 1981).

Yearling smolts vary greatly in size (Major and Mighell 1969). In some rivers, there appears to be two distinct size groups of smolts in the same run. This fact suggests that, in these rivers, there may be important differences in microhabitat affecting chinook growth (Healey 1991). Major and Mighell (1969) observed that larger fish migrate first, while Bell (1958) observed that the larger fish migrated last. Mains and Smith (1964) observed change in the size of migrating smolt as the migration season progressed. The observed changes in smolt size over the duration of the migration season may simply reflect the differences in growth rates of different stocks, rather than indicating any direct correlation between body size and timing of migration (Healey 1991).

All types of chinook disperse seaward in their first ocean year, with stream-type chinook moving offshore earlier and ocean-type chinook remaining longer in sheltered coastal waters. Wahle and Vreeland (1977) and Wahle et al. (1981) describe the ocean distribution of ocean-type and stream-type chinook from various Columbia River hatcheries. Ocean-type chinook, in general, were recaptured mainly in British Columbia and Washington fisheries, while stream-type chinook, in general, had a wider distribution. This information suggests that ocean-type chinook do not migrate far offshore compared to stream-type chinook, which appear to be dispersed over a much broader area (Healey 1991). Despite much study, however, understanding of the ocean migratory and distribution patterns of chinook is sketchy.

Most chinook spend 2 or 3 years in the ocean, although some chinook may spend up to 9 years at sea before migrating back to the natal stream to spawn (Pritchard 1940). Some males (jacks) spend only 1 year at sea (Scott and Crossman 1973). Chinook grow larger than other Pacific salmon. A larger fish may be 38 inches long and 30 to 40 pounds (Scott and Crossman 1973). Fish make up the bulk of food of chinook in the ocean, but invertebrates such as squid, shrimps and crab larvae are also eaten (Pritchard and Tester 1944, Scott and Crossman 1973, Healey 1991).

Age at maturity for chinook varies between races, among different populations, and between sexes. Most populations are dominated by a few age classes. Males mature at a younger average age than females regardless of race (Healey 1991). Healey (1991) provides information regarding age at maturity for stream-type and ocean-type chinook from several rivers.

Chinook salmon have developed strong homing behavior for returning to their natal stream to spawn. Homing appears to be guided by long-term memory of specific odors and, to a lesser degree, by vision. Imprinting to the home stream appears to occur very early in life. Younger chinook home better than older chinook, and males that have spent only one summer at sea have the highest homing rate (Healey 1991). Higher stray rates occur during years with poor overall returns (Quinn and Fresh 1984).

HABITAT REQUIREMENTS

Habitat requirements of chinook salmon throughout their life are complex and depend on many variables (FEMAT 1993). There are four basic principles to assess when considering habitat requirements of chinook salmon. These are: (1) all watershed and streams are different; (2) fish populations that inhabit a particular body of water have adapted to the natural environmental fluctuations that they experience; (3) specific habitat requirements change with season, life stage, and the presence of other fish; and (4) ecosystems change over evolutionary time (Spence et al. 1996). Karr (1991) identified five classes of environmental factors that affect the aquatic ecosystem: (1) food source, (2) water quality, (3) habitat structure, (4) flow regimes, and (5) biotic interactions.

Adult migrating chinook salmon need holding or resting sites and suitable flow and water quality (Spence et al. 1996). Some runs of chinook salmon arrive at spawning sites several months before spawning. Large woody debris, boulders, and other structure provides stream conditions that serve as resting areas for adult fish as they migrate upstream to spawn.

Streamflow during the adult migration must be sufficient to allow passage over barriers. Spring and summer chinook runs occur during periods of high flows that allow them to reach spawning tributaries in headwater reaches, while fall runs, which typically spawn in lower reaches, may enter streams during periods of relatively low flow (Healey 1991). The minimum stream depths that will allow passage of chinook salmon is about 10 inches (Bjornn and Reiser 1991); however, substantially greater depths may be needed to negotiate larger barriers. Pool depth must exceed barrier height by approximately 25 percent to allow fish to reach swimming velocities necessary to leap barriers (Stuart 1962). Pool configuration also influences passage. Water plunging over a steep falls forms a standing wave that allows chinook salmon to attain maximum heights (Bjornn and Reiser 1991). Less severe inclines, like cascades, may be more difficult to pass if pool depths are inadequate and velocities are high (Spence et al. 1996).

Adult chinook salmon migrate at different water temperatures, depending upon race. Early-run chinook salmon migrate when water temperature are between 38 and 56ºF. Summer-run chinook salmon migrate when water temperatures are between 57 and 68ºF. Fall-run chinook salmon migrate when water temperatures are between 51 and 67ºF (Bell 1986). Overly high or low temperatures may delay migration (Major and Mighell 1966, Hallock et al. 1970, Monam et al. 1975). High temperatures may cause outbreaks of disease (Spence et al. 1996). Migrating adult chinook salmon also need adequate concentrations of dissolved oxygen. Swimming performance is impaired when dissolved oxygen levels drop below 100 percent saturation. Low dissolved oxygen levels impairs swimming performance (Spence et al. 1996). High, muddy water may delay or divert spawning runs, and in some instances under these conditions, migrating fish may go to another stream to spawn (Smith 1939, Servizi et al. 1969, Mortensen et al. 1976). In most cases, turbid stream conditions may delay migration, but they do not seem to affect homing ability (Murphy 1995).

Spawning adults select spawning sites based on gravel size, channel gradient and configuration, water depth and velocity, dissolved oxygen, water temperature, and porosity of the gravel (Bjornn and Reiser 1991). Chinook salmon generally spawn in gravel ranging from 0.5 to 4 inches in diameter (Bjornn and Reiser 1991). However, the particle size of usable spawning gravel is proportional to adult size, with larger individuals spawning in larger gravel (Marcus et al. 1990). Subgravel flow seems to be important in the area chosen by chinook to spawn (Vronskiy 1972). Surface water velocity in areas selected by chinook salmon for spawning varies from 1.4 (Smith 1973) to 3.2 feet per second (fps) (Chapman et al 1986). Eggs are buried about 8 to 14 inches deep (Briggs 1953). Nawa and Frissel (1993) found that eggs deposited too shallow are likely to wash downstream. Streams with good bank stability, large woody structure, and intact watersheds and riparian zones are generally not affected by high flows that cause scouring and displacement of eggs (Naiman et al. 1992).

Chinook salmon require gravels for spawning that have low concentrations of sediments and organic material. Sediments and organic materials settle over spawning redds, affecting the intragravel water flow (Spence et al. 1996). Fine sediments may also act as a physical barrier to fry emergence (Cooper 1959, 1965; Wickett 1958; McNeil and Ahnell 1964; Koski 1972; Everest et al. 1987). Eggs deposited in small gravel or gravel with fine sediments have lower survival to emergence (Harrison 1923, Hobbs 1937, Shapovalov and Berrian 1940, Shaw and Maga 1943, Koski 1966). In addition, organic material that enters the substrate uses oxygen as it decomposes, causing a reduction in dissolved oxygen (Bjornn and Reiser 1991).

Water depth and velocity affect redd construction, egg deposition, and incubation (Bjornn and Reiser 1991). Chinook salmon may spawn in water 2 inches (Burner 1951, Healey 1991) to 24 feet deep (Vronskiy 1972) with water velocities ranging from 0.5 (Healey 1991) to 6 fps (Chapman et al. 1986). Larger fish tend to spawn at greater depths and in faster water velocities than smaller fish (Spence et al. 1996).

Chinook salmon spawn in water temperatures between 42 and 57ºF (Bell 1986). Seymour (1956) studied effects of temperature on chinook eggs and sac fry, and he found that egg defects and mortality increased when water temperatures dropped below 40ºF or increased over 58ºF.

Bjornn and Reiser (1991) summarized dissolved oxygen level needs and determined that pre-eyed eggs required the lowest levels of oxygen, while eggs about to hatch needed the highest levels of oxygen. Low levels of dissolved oxygen at these later stages causes abnormalities and delays or advances in egg hatching (Alderdice et al. 1958, Spence et al. 1996).

The abundance of juvenile chinook salmon is influenced by the quantity and quality of suitable habitat. Habitat selection by juveniles is influenced by life stage, time of year, food availability, year-to-year variation in environmental conditions, and presence of other salmonids (Everest et al. 1985, Bjornn and Reiser 1991). Shortly following emergence, fry occupy shallow habitats along the margins of streams, moving into deeper and faster waters as they increase in size (Spence 1995). Large woody debris, boulders and undercut banks with overhanging vegetation serve as cover for juvenile chinook salmon (Spence et al. 1996). During winter, juvenile chinook will seek refuge in spaces between rocks and in pools (Chapman and Bjornn 1969, Bustard and Narver 1975, Campbell and Neuner 1985, Hillman et al. 1989). During summer months, juvenile chinook select holding positions at moderate velocities but immediately adjacent to faster waters (Chapman and Bjornn 1969, Jenkins 1969, Everest and Chapman 1972).

Juvenile chinook salmon tend to use faster waters than other species of salmon, although chinook do use pool habitats when available (Spence 1995). Periodic turbidity caused by storms and snowmelt seems to have little effect on juvenile chinook (Sorenson et al. 1977). Prolonged turbidity, however, can influence feeding behavior and thus reduce growth rates (Sigler et al. 1984, Lloyd et al. 1987).

Bjornn and Reiser (1991) identified preferred, lower lethal and upper lethal water temperatures for juvenile chinook. The preferred water temperature for juvenile chinook salmon is 54 to 57ºF. The lower lethal water temperature is 33ºF, and the upper lethal water temperature is 80ºF (Brett 1952). The ability of fish to tolerate temperatures extremes depends on their recent thermal history. Fish acclimated to low temperatures, for example, have lower temperature thresholds than those acclimated to warmer temperatures (Spence et al. 1996).

Water temperature affects migration timing by influencing the rate of growth and responsiveness of fish to environmental stimuli (Grott 1982). Healey (1991) found that ocean-type fall chinook migrate when temperatures are 40 to 60ºF, whereas stream-type spring chinook smolts tend to migrate when water temperatures were cooler.

Streamflow is important in facilitating downstream movement (Grott 1982, Dorn 1989) and determining the rate at which smolts move downstream (Bjornn and Reiser 1991). Spence (1995) found that short-term increases in streamflow is an important stimulus for smolt migration.

In larger rivers, chinook migrate near the shore and out-of the high velocity water near the center of the channel. When the river is deeper than about 10 feet, chinook prefer to migrate near the surface (Mains and Smith 1964, Healey and Jordan 1982).

Juvenile chinook salmon are strong, active swimmers and require highly oxygenated water. Swimming performance, growth rates, and food-conversion drops off when dissolved oxygen levels drop (Spence et al. 1996). Supersaturation of dissolved gasses (usually caused as water flows over spillways at dams) however, causes gas bubble disease in migrating chinook (Ebel and Raymond 1976). The full impact of dams is beyond the scope of this review. A thorough discussion of effects of dams can be found in the recovery plan for Snake River salmon (Bevan et al. 1994).

Migrating fish are vulnerable to predation (Larsson 1985). Undercut banks and large woody debris provide escape areas and cover from predators (Spence et al. 1996).

INTER/INTRASPECIFIC INTERACTIONS

Predators are commonly implicated as the principal natural agent of mortality in chinook salmon fry and fingerling (Foerster and Ricker 1941, Hunter 1959). Young chinook salmon in fresh water are preyed on by rainbow and cutthroat trout, bull trout, coho salmon smolts, northern pikeminnow, sculpins, mergansers, kingfishers, and other diving birds (Scott and Crossman 1973; Clemens and Munro 1934; Thompson 1959a, 1959b). Patten (1971) found that the most important predators were the prickly sculpin and the torrent sculpin.

Lister and Genoe (1970), Chapman and Bjornn (1969), Murphy et al. (1989) and Everest and Chapman (1972) reported habitat segregation among juvenile chinook and juvenile coho and steelhead. Chinook salmon of the same brood year were larger than coho and steelhead because they emerged earlier than coho and steelhead and they often chose habitats with higher water velocities. The basic diet of young chinook salmon is similar to that of coho, steelhead, and other stream-dwelling salmonids (Mundie 1969, Chapman and Bjornn 1969). Factors other than predation and competition usually govern numbers of chinook, however (Scott and Crossman 1973).

Fry and smolts in the ocean are eaten by other fishes and birds. Ricker (1976) concluded that ocean mortality rate of chinook is impossible to estimate. The mortality rate probably declines with age in chinook, most likely dropping markedly after the first year or two in the ocean (Healey 1991, Parker 1962). Adult chinook at sea are preyed on by large mammals and possibly the Pacific lamprey, and are targeted in commercial and recreational fisheries. Spawning adults are eaten by bears, other mammals, and larger flesh-eating birds (Scott and Crossman 1973).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Lower Crooked River

Historic game-fish populations in the Deschutes River Basin included spring chinook salmon in the Crooked River. The chinook and other anadromous fish runs were lost because of irrigation diversions, hydroelectric dam construction, and habitat degradation caused by a combination of land and water management practices (Stuart et al. 1996). Reports conflict as to when the chinook population was lost in the Crooked River (Nehlsen 1995).

Metolius River Basin

Historically, the Metolius River Basin annually produced several hundred spawning spring chinook salmon (Wallis 1960). These fish migrated as far as the headwaters and into Lake Creek to spawn and rear (Fies et al. 1996a). Spring chinook salmon were eliminated from the Metolius River Basin with construction of the Pelton Dam in 1956 and Round Butte Dam in 1964 (Fulton 1970). Attempts to pass juvenile chinook salmon around these dams failed (Nehlsen 1995, Fies et al. 1996a). The presence of spring chinook salmon in the Metolius River was last documented in spawning ground counts taken in 1987 (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Spring chinook salmon were indigenous in the Deschutes River and its tributaries upstream to Big Falls, which was a natural barrier to further migration. Historically, spring chinook salmon spawned in lower Squaw Creek (Fies et al. 1996b). A small number of spring chinook were trapped at Steelhead Falls in 1953. (Montgomery 1953, Nehlsen 1995). Chinook salmon adults and juveniles have periodically been observed in recent years below Steelhead Falls to Lake Billy Chinook. The origin of these chinook is unknown (Fies et al. 1996b: Stuart et al. 1996).

Lake Billy Chinook

Construction of Round Butte Dam in 1964 inundated spring chinook salmon spawning and rearing habitat. Population size, distribution, and production levels of chinook salmon were never determined for the affected area prior to inundation. However, chinook likely spawned and reared in the Lake Billy Chinook area (ODFW 1997).

A remnant population of spring chinook salmon is believed to exist in Lake Billy Chinook. A single 8-inch chinook salmon was captured in trap nets set below the mouth of the Metolius River in 1994 (Stuart et al. 1996). Each year, creel surveyors report anglers catching chinook salmon, but Stuart et al. (1996) suspect that these fish are misidentified by the surveyors.

Lake Simtustus

Historically, stream-type spring chinook salmon spawned and reared in the area presently inundated by Pelton Dam (ODFW 1997). Construction of Pelton Dam in 1958 inundated spring chinook salmon spawning and rearing habitats. Stuart et al. (1996) do not identify chinook salmon among the species currently present in Lake Simtustus.

Lower Deschutes River

Stream-type wild spring chinook salmon are present in the lower Deschutes River, Warm Springs River, and Shitike Creek. The run size of adult wild spring chinook salmon in the lower Deschutes River from 1977 to 1995 averaged 1,913 and ranged from 214 to 3,895. The average spawning escapement into Shitike Creek from 1982 to 1995 was 49 adults (Confederated Tribes of the Warm Springs Reservation of Oregon, unpublished data in ODFW 1997). The average run size of adult wild chinook salmon in the Warm Springs River from 1977 to 1995 was 1,270, with a range of 160 to 2,564. During the same period, about 18 percent of the run was kept for brood stock in the Warm Springs National Fish Hatchery (ODFW 1997).

In addition to the wild spring chinook run in the lower Deschutes River, there are two hatchery runs, from the Round Butte Hatchery and Warm Springs National Fish Hatchery. The return to the Round Butte Hatchery from 1977 to 1995 averaged 1,033 adult chinook. The range of returns during that period was 14 to 2,241. The average return to the Warm Springs National Fish Hatchery from 1981 to 1995 was 752 adult chinook salmon, with a range of 52 to 2,538 (ODFW 1997).

Stream-type wild chinook salmon adults enter the Deschutes River in April and May. Spawning begins the last week of August and peaks by the second week of September. Spawning is completed by the last week of September (ODFW 1997, Lindsay et al. 1989). Emergence of spring chinook fry begins in February or March (Lindsay et al. 1989). Juvenile spring chinook migrate in two peaks, a fall migration from September through December, and a spring migration from February through May (Lindsay et al. 1989). The fish migrating in the fall are less that 1 year of age, range in size from 3.1 to 4.3 inches, and do not have the appearance of smolts. Spring migrants are age 1 fish, range in size from 3.5 to 5.1 inches and have the bright silver coloration characteristic of smolts. Wild spring chinook salmon that migrate from the Warm Springs River as age-0 fish appear to rear over the winter in the Deschutes or Columbia rivers before entering the ocean the following spring at age 1 (Lindsay et al. 1989).

Ocean-type fall chinook salmon are found throughout the mainstem Deschutes River below the Pelton Round Butte Project. All production of fall chinook is from wild stock. The run size of fall chinook salmon from 1977 through 1995 averaged 9,465 fish annually. Total numbers of spawning fall chinook in the Deschutes River during that period ranged from 4,061 to 19,808 fish (ODFW 1997).

It is uncertain if the lower Deschutes River fall chinook run is composed of one or two populations — one spawning above Sherars Falls and one spawning below Sherars Falls (Beaty 1995). Trapping at Sherars Falls indicates there are two peaks in adult migration of fall chinook, one in June through August and one in late September and early October. Fall chinook begin spawning in late September and peak spawning occurs in November. Spawning is completed in

December (Jonasson and Lindsay 1988). Fry emerge from the gravel beginning in January or February, and emergence is completed by April or May (Jonasson and Lindsay 1988). Most juvenile fall chinook salmon leave the lower Deschutes River between May and July of their first year, in accordance with the typical ocean-type chinook behavior described by Healey (1991). Emigration through the Columbia River occurs from April to August, with the peak in June and July (ODFW 1997).

FISHERIES

Recreational and tribal harvest of spring chinook salmon in the Deschutes River averaged about 1,739 fish annually from 1977 through 1993. During that period, an average of approximately 1,002 of the chinook caught each year were of hatchery origin and 737 were of wild origin. Most of the annual harvest occurred in a 3-mile section from Sherars Falls downstream. The harvest period extends from early April to mid-June. In years when the hatchery returns are greater than brood stock requirements, spring chinook are recycled through the recreational and tribal fisheries at Sherars Falls (ODFW 1997).

Recreational and tribal harvest of fall chinook salmon in the Deschutes River from 1977 through 1995 was about 2,682 fish annually. The harvest ranges from 11 to 3,533 fish during that period. The fall chinook harvest occurs primarily in a 3-mile section from Sherars Falls downstream, and the fishery occurs from early July to late October (ODFW 1997).

LIMITING FACTORS

Wild spring chinook salmon are currently produced only in the Warm Springs River and Shitike Creek. The optimum escapement goal for the Warm Springs River above the hatchery is 1,300 adult spring chinook salmon. This goal has been met in 12 of the last 17 years. Factors controlling natural production of spring chinook salmon in the Warm Spring River are high temperature, high sediment loads, gravel quality, stream bank degradation, stream gradient, and instream cover. Factors controlling natural production in Shitike Creek are channelization, high temperatures, stream bank degradation, flash flooding, and passage problems (ODFW 1997).

Loss of access to spawning and rearing habitat upstream of the Pelton Round Butte Project constrains natural production potential in the Deschutes River Basin. In addition, there are out-of-basin factors that constrain natural production, including juvenile and adult passage at Columbia River dams (Beaty 1995), natural variations in estuary and ocean productivity, and ocean fisheries (ODFW 1997).

All fall chinook salmon production in the Deschutes River Basin occurs in the mainstem lower Deschutes River. Spawning distribution appears to have shifted from above Sherars Falls to below Sherars Falls. The mainstem Deschutes River is capable of maintaining an average adult spawning escapement of approximately 4,000 adult fall chinook. Spawning escapement at this level should provide for an average annual harvest of approximately 1,300 adult fish (ODFW 1997).

Major habitat constraints on fall chinook salmon production in the reach of the lower Deschutes River from its mouth to White River are gravel quality and quantity, streambank degradation, sedimentation, and in-stream cover. Habitat constraints in the reach from White River to the Pelton Round Butte Project are gravel quality and quantity, pool-to-riffle ratio, streambank degradation, and in-stream cover (ODFW and Confederated Tribes of the Warm Springs Reservation of Oregon 1990). Aney et al. (1967) and Huntington (1985) note that the hydroelectric complex interrupts the recruitment of gravel in downstream reaches, particularly the 3-mile reach immediately downstream from the dams. The dams have also affected large woody material recruitment to some degree (Minear 1998).

ODFW (1997) suggests that reducing fine sediment load in the river can be accomplished by riparian habitat enhancement projects and by releasing flushing flows from the Pelton Round Butte Project. Grant et al. (1999) determined that the Deschutes River below the Project is extremely stable because of a hydrologically uniform flow regime and low rates of sediment supply. Grant et al. (1999) determined that the dams have not substantially altered the geomorphic characteristics of the lower Deschutes River. Periodic introduction of suitable spawning gravel and large woody debris would aid in island and gravel bar formation and provide habitat diversity for fall chinook salmon (ODFW 1997). The need to introduce gravel and large woody debris into the lower Deschutes River has been discussed, but methods to accomplish those objectives have not been developed.

The disease Ceratomyxosis may impact chinook salmon production by killing some of the emigrating smolts (ODFW 1997). Impacts of Ceratomyxosis on the Deschutes River Basin chinook salmon population have not been determined.

Harvest of Deschutes River Basin fall chinook occurs in the ocean and Columbia River, as well as within the basin. Jonasson and Lindsay (1988) determined that 74 percent of the harvest of Deschutes River Basin fall chinook occurred outside the basin, with ocean fisheries accounting for 64 percent of the harvest and Columbia River fisheries accounting for 10 percent of the total harvest. Beaty (1995) concluded that ocean harvest of lower Deschutes River fall chinook has likely changed little from that measured from 1977 through 1979. ODFW (1997), however, suggests that current ocean harvest of Deschutes River Basin fall chinook may be lower because of efforts to reduce harvest of federally listed chinook stocks.

In-basin harvest is hampered by the inherent uncertainty in predicting either preseason or mid-season fall chinook run strength. Managers presently use trends in runs in the Columbia River and at Sherars Falls to estimate escapement and population strength. There appears to be a shift of spawning distribution to below Sherars Falls, which has led to the development since 1991 of regulations that emphasize protection of fall chinook spawning above Sherars Falls (ODFW 1997).

Ecological Role

Chinook salmon were native to the Deschutes River Basin, and they provided an important food source for region’s native peoples. Unlike present runs, historic runs of chinook salmon probably extended from April through November. Harvest management and habitat alterations within and outside of the basin have decreased run size and probably have changed historic run timing.

Chinook salmon provide an important predator/prey relationship with other fish and wildlife in the Deschutes River Basin. Because chinook salmon are such voracious fish eaters, managers have suggested that they be used to control undesirable species (Scott and Crossman 1973).

Scientists are presently examining potential ecological impacts associated with the reintroduction of chinook salmon above the Pelton Round Butte Project. Emphasis is being placed on disease transmission associated with various reintroduction plans, although concerns also have been expressed about interspecific interactions with resident fish. Disease transmission and interspecific interactions can be very difficult to predict. Models are helpful in understanding potential impacts of the reintroduction program, but actual impacts will be known only if the reintroduction program is implemented. Most likely, subtle changes in ecological conditions will result from reintroduction. For example, the carcasses of spawned-out chinook salmon could be an important source of nutrients for the aquatic food chain. On the other hand, juvenile chinook salmon could displace resident fish, which are important to the economic health of the Metolius River area. Identification and management of high risk concerns should reduce major ecological and economic impacts associated with salmon reintroduction.

SOCKEYE SALMON

Onchorhnchus nerka

Other common names: Blueback salmon, red salmon (Scott and Crossman 1973)

General

APPEARANCE

Sockeye salmon have a streamlined body shape and are laterally compressed. The head is cone-shaped and tapers to a rather pointed snout. The mouth is on the end of the snout and is slightly turned up. Compared to other salmon species, the teeth and eyes of sockeye are rather small. The maxillaries extend to the back side of the eye. At maturity, sockeye salmon are usually about 24 inches in length (Scott and Crossman 1973).

Sockeye salmon have one dorsal fin located in the center of the back. The dorsal fin is almost square with 11 to 13 soft rays. There is a rather small adipose fin located behind the dorsal fin. The tail is broad and moderately forked and has pointed tips. The anal fin has a long base with 11 to 16 soft rays. The pelvic fins have rounded tips, axillary processes, and 9 to 11 rays. The pectoral fins are moderately long and have rounded points and 11 to 21 rays. The scales are round and small (Scott and Crossman 1973).

The top part of the body is steel-blue to green-blue in color with no distinct black spots. The bottom of the fish is white to silver. The dorsal fin may have a few dark marks, but the other fins are clear to dusky color. Juvenile sockeye have vertical parr marks along the lateral line, with the width of the parr marks greater than the light areas. The fins in juveniles have no color.

In breeding males, the body becomes bright red to dirty red-grey in color, while the head turns bright green to olive color. The snout and lower jaw turn white to grey, the dorsal and anal fins turn red, and the pectoral, pelvic and caudal fins turn green to almost black. Spawning coloration in the female is similar, but the body is a darker grey-red color (Scott and Crossman 1973, Carl et al. 1959, Wydoski and Whitney 1979). Variation in spawning coloration occurs among sockeye populations. In some populations, for example, the belly may be a black rather than white (Burgner 1991).

DISTRIBUTION

Spawning populations of sockeye are found from the Sacramento River in California (Hallock and Fry 1967) to the Sea of Okhotsk in Eastern Russia (Burgner 1991). The distribution of sockeye is associated with freshwater lakes, where the juveniles rear before they migrate to sea, and rivers that provide a transportation corridor between the freshwater lakes and the ocean. The two largest spawning populations of sockeye salmon in the North Pacific are found in Bristol Bay, Alaska and in the Fraser River in British Columbia (Rogers 1986, Burgner 1991). Other important production areas in North America are the Skeena, Nass, and Somass rivers in British Columbia and the Chignik, Karluk, and Copper rivers in Alaska (Burgner 1991).

Most runs of sockeye salmon in the Columbia River Basin are now extinct because dams have blocked access to 96 percent of the lake surface rearing areas (Mullan 1986). Sockeye populations of Washington are found in Quinault Lake, Baker Lake, Lake Washington, Lake Sammamish, Osoyoos Lake, Banks Lake, Loon Lake, and Lake Wenatchee (Wydoski and Whitney 1979). Historic populations of sockeye salmon in Idaho spawned in Payette Lake, Stanley Lake, Redfish Lake, and Alturas lakes (Simpson and Wallace 1978). A very small remnant run of sockeye salmon is present in Redfish Lake (Brannon et al. 1994). Natural populations of sockeye salmon in Oregon were historically found in Wallowa Lake (Cramer and Witty 1997) and Suttle Lake (Nehlsen 1995). The sockeye populations in Wallowa and Suttle lakes are extinct, but a small percentage of kokanee (the resident form of this species) in Lake Billy Chinook still exhibit anadromous behavior (Ratliff et al. 1996).

LIFE HISTORY

Sockeye salmon exhibit a greater variety of life history patterns than do other salmon (Burgner 1991). Typically, juvenile sockeye rear in lakes for 1 to 3 years before they migrate to sea. A very small percentage of sockeye salmon do not rear in lakes but instead migrate to sea as fry soon after emerging from the gravel (Burgner 1991). Sockeye spend from 1 to 4 years in the ocean before returning to fresh water to spawn and die in late summer and fall (Burgner 1991). Accordingly, the age of spawning in sockeye salmon varies among races and from year to year more than in other Pacific salmon species (Healey 1987).

The timing of adult sockeye runs is triggered by changes in specific environmental conditions, including water flow and temperature (Miller and Brannon 1982). Sockeye salmon spawn in late summer and fall, with different stocks exhibiting different migration rates and spawning at different times within this period (Royce 1965; Mundy 1979; Burgner 1980, 1991; Marriott 1964; Demory et al. 1964; Gilbert 1968).

Spawning behavior has been studied by Kuznetsov (1928), Mathisen (1962), Hanson and Smith (1967), and McCart (1969, 1970). The female selects a site, digs a depression, deposits the eggs, which are simultaneously fertilized by the male, and covers the nest. She also guards the nest until she is nearly dead. Several nests are made within one redd. Each females uses about 3 square feet of space to spawn. Larger males are more successful in mating than small males, but small body size does not seem to hinder females from breeding. The length of time that a female spends on the spawning ground varies from 1 to 19 days depending upon the race of sockeye. In areas where bears are abundant, salmon remain in the lake until they are ready to spawn. The ripe fish makes one or more daytime trips into the stream, spawns, and returns to the lake to spend the night, which is the time when bears are most active. After the sockeye are spawned out, they are more easily caught by bears (Merrell 1964, Gard 1971).

The number of eggs per female is determined by size of the female and number of years spent in the ocean (Rounsefell 1957). Number of eggs per female range from 2,000 to 5,000 (Foerster 1968). The length of time spent by the female in the ocean also correlates with the number of eggs she carries (Rousefell 1957). A relatively large run of sockeye salmon in the Okanagan River of Washington includes females that have spent 1 and 2 years, respectively, in the ocean. The females that spend 2 years in the ocean are on average 70 percent heavier and have 50 percent more eggs than the females that spend 1 year in the ocean; however, the number of eggs per pound of fish is higher for the females that spend 1 year in the ocean (Fulton 1970). The number of eggs per female varies most among stocks from different river systems (West and Mason 1987).

Sockeye salmon eggs are differentiated from eggs of other salmon by their darker orange-red color and smaller size (Hanamura 1966). Robertson (1922) noted that egg size differs among sockeye stocks. However, large eggs tends to be associated with large females (Healey 1987).

The rate of sockeye salmon egg development is controlled by water temperature. The incubation period varies from 92 days at a constant 55ºF to 337 days at a constant 33ºF (Brannon 1987). Given the same water temperature conditions, the incubation period is longer for sockeye salmon eggs than for eggs of other salmon species. Sockeye salmon eggs can survive under reduced oxygen levels because the eggs are small, have high carotenoid pigmentation, and have a dense network of capillaries, all of which assist in oxygen transfer from the water to the egg (Smirnov 1950; Soin 1956, 1964).

Sockeye salmon fry emerge from the gravel when the yolk has been absorbed (Bams 1969). Yolk absorption takes about 97 days when the water temperature is 54ºF. Sockeye salmon embryos have a longer incubation period than the other species of Pacific salmon and use up a higher percentage of their yolk sac material before hatching (Smirnov 1958, 1964). The fry emerge at night during complete darkness (McDonald 1960, Hartman et al. 1962) and swim downstream (McDonald 1960) or, in lake outlets, swim laterally to reach river banks and avoid being swept downstream (McCart 1967, Brannon 1972, Clarke and Smith 1972). Sockeye salmon fry exhibit directional preferences specific to their particular river-lake system (Brannon 1972, Brannon et al. 1981). In general, the fry seem to disperse rapidly away from the stream after entering the lake. In some lakes, fry migrate near the shore (Goodlad et al. 1974), but in other lakes, fry migrate to open water (McDonald 1969, McDonald and Hume 1984, Woodey 1972, Dawson 1972).

Sockeye fry attain neutral buoyancy to swim and feed freely by gulping air at the surface (Bams 1969). Repeated cruises to the surface, alternating with resting periods, are necessary for the fry to achieve neutral buoyancy. This activity is conducted during dark hours to avoid predators (Bams 1969).

The diet of sockeye salmon fry varies, depending upon available food. In most cases, plankton are the mainstay (McCart 1969). Sockeye locate their food by sight, so most feeding occurs during the day (Brett and Groot 1963; Doble and Eggers 1978; Eggers 1977,1978,1982; Eggers et al. 1978). However, fry feeding during the day are vulnerable to predators. As a result, juvenile sockeye salmon in lakes exhibit complicated seasonal and daily feeding behavior characterized by vertical migration patterns. Food visibility, food availability and predator avoidance are forces that control vertical migration behavior. Light and temperature stimuli cause vertical migration to continue at night and throughout the summer season (Burgner 1991). Vertical migration behavior in juveniles sockeye salmon differs from lake to lake (Burgner 1991).

Growth of lake-rearing sockeye salmon fry varies among different individuals, different populations, and different lake systems. Growth rates are determined by available food, water temperature, thermal stratification, turbidity of the lake, length of daylight hours and of the growing season, intra- and interspecific competition, disease, and energy expended avoiding predators and seeking food (Burgner 1991). Depending on the above factors, typical growth for juvenile sockeye is up to lengths of 3 to 5 inches by age 1, and 4 to 8 inches by age 2 (Burgner 1991).

Juvenile sockeye salmon start a preparatory phase for migration to the sea as daily light and temperatures increase, triggering hormonal changes. Changing from parr to smolt involves changes in behavior, coloration, body shape, and tolerance to sea water (Hoar 1965, 1976; Wedemeyer et al. 1980; Groot 1982). The urge to migrate toward the sea is related to the size and growth rate of juveniles. Older sockeye salmon juveniles tend to migrate first in the spring, and the smaller, younger fish tend to remain an additional year or more in the lake before migrating seaward (Barnaby 1944; Krogius and Krokhin 1948; Burgner 1962).

Differing ideas have been proposed to explain how smolts find the lake outlet to begin seaward migration (Foerster 1968). Groot (1965, 1972) determined that sockeye smolts use sun-based direction-finding compasses and polarized light cues to find the outlet, but Foerster (1968) suggests that smolts follow the shoreline to the outlet. Hoar (1976) determined that sockeye have the most highly developed navigation capabilities of all salmonids. Sockeye salmon smolts travel in schools during their in-lake and seaward migration (Burgner 1991), and the exodus can occur in a few days. Hartman et al. (1967) found that smolt migration begins when water temperatures rise above 40ºF and ends by the time water temperature reaches 50ºF. Smolts swim faster than the current, and when they encounter obstacles they turn and pass downstream tail first (Barnaby 1944; Hartman et al. 1967; Foerster 1968).

Sockeye salmon smolts entering marine water show a wide variety of adaptative behavior traits (Burgner 1991). Straty and Jaenicke (1980) state that the complexity of simultaneously changing physical, chemical, and biological processes makes it difficult to predict cause-and-effect relationships or to describe the niche of juvenile salmon in the marine environment.

Sockeye salmon may travel over 2,300 miles in the ocean, and they appear to be continuous travelers (Royce et al. 1968). Ocean distribution varies between stocks, but most North American sockeye rear east of the 175°E longitude line. Ocean distribution of sockeye is related to major physical features of the oceanic environment, including current (Favorite and Hanavan 1963), temperature (Manzer et al. 1965, Fujii 1975), and salinity (French et al. 1976, Fujii 1975). Sockeye salmon rear near the surface in the upper 30 feet (French et al. 1976, Manzer 1964, Machidori 1966).

Ocean survival also seems to be determined by changes in water surface temperature during winter months. Different temperatures result in different winter distribution patterns of sockeye, which in turn affect their vulnerability to predators, particularly marine mammals (Rogers 1984).

Sockeye salmon in the ocean feed primarily on large zooplankton, but they also feed on fish and squid (Wing 1977, McAllister et al. 1969). They follow food availability and abundance as it varies with season and location (Burgner 1991). Growth in individuals continues throughout the year, although it slows during winter months (French et al. 1976). Growth rates vary year to year (Lander and Tanonaka 1964, Rogers 1973). Nevertheless, the size of sockeye salmon of a given race is quite uniform for a given length of stay in the ocean (Burgner 1991). There is substantial variation among races in size of individuals at a given age (Healey 1987).

The means by which sockeye salmon return to their home stream and do so at a particular time are not understood. In fact, the remarkable navigational ability of salmon remains one of the most intriguing mysteries in the animal world (Burgner 1991). Quinn (1980) proposes that salmon navigate by the location of the sun, length of day, and the earth's magnetic field, imprinting to the natal stream by the local magnetic field before migrating to sea. Evidence also suggests that sockeye salmon in particular home to the natal stream by acute sense of smell (Hasler et al. 1978). The sockeye's ability to migrate through lake environments also requires precise homing characteristics (Burgner 1991).

Some populations of sockeye are noted for extreme cyclic variations in size (i.e. large numbers one year followed by low numbers the following year). Cycles create harvest and marketing problems, and managers have attempted to level these runs. Each population of sockeye salmon seem to have a different cause for the cyclic nature of run size. Cycles may be related to fisheries (Walters and Staley 1987, Eggers and Rogers 1987), predation (Ward and Larkin 1964, McIntyre 1980), migration barriers, (Ricker 1950), interspecific competition (Ward and Larkin 1964, Larkin 1971, Peterson 1982), age compensation (Mathisen and Poe 1981, Eggers and Rogers 1987, Barnaby 1944), lake temperature (Rogers and Poe 1984), marine survival (McDonald and Hume 1984), genetic impacts (Bilton 1971, Peterman 1982), and parasites (Ricker and Smith 1975). Evidence does not suggest that annual differences in productivity originates in lakes (McDonald and Hume 1984).

Habitat Requirements

Sockeye salmon have adapted to many different spawning, rearing and migration habitats (Burgner 1991), and under all conditions they are highly sensitive to and synchronized with specific environmental conditions (Miller and Brannon 1982). However, it is difficult, in many cases, to find connections between environmental conditions and population abundance (Selifonov 1987).

The migration of sockeye salmon from the ocean to their natal stream requires habitat with resting sites, suitable flow, and good water quality. Streamflow must be sufficient to allow passage over barriers. Preferred water temperature for adult migration is 45 to 60ºF (Bjornn and Reiser 1991). Excessively high or low water temperatures may delay migration (Major and Mighell 1966, Hallock et al. 1970, Monan et al. 1975). Fish and Hanavan (1948) report that Columbia River runs of sockeye salmon congregate in cold water creeks when temperatures in the mainstem river corridor exceed 70ºF. Major and Mighell (1966) report that sockeye salmon migration does not resume until the water temperature falls below 70ºF. The lethal temperature for adult sockeye salmon is 72ºF (McCullough 1993). High energy expenditures by migrating salmon require adequate dissolved oxygen, and adult swimming performance may be reduced when dissolved oxygen is below 100 percent saturation (Davis et al. 1963).

Dams in migration corridors adversely affect migration of adult sockeye salmon. Spilling large volumes of water at dams causes gas supersaturation (Meekin and Allen 1976). The minimum level of gas supersaturation lethal to sockeye is unknown, but dissolved gas concentrations of 123 to 143 percent of saturation have been documented to kill adult salmon (Ebel et al. 1975). High water temperatures exacerbated the risk posed by elevated dissolved gas levels alone (Bouck et al. 1970). The presence of dams also impedes upstream passage of adult sockeye salmon, causing delay and fallback. Passage delay results from fish having difficulty finding entrances to fish passage facilities. Fallback occurs when adults pass downstream through spillways, juvenile fish passage facilities or turbines. Conversion rates (the number of fish passing an upper dam compared to number of fish passing a lower dam) for sockeye salmon passing Columbia River dams are highly variable from year to year, but the ratios range from 0.8 to 1.5. Documented fallback rates for sockeye salmon range from 22.2 percent at Bonneville Dam in 1982 (Ross 1983) and McNary Dam in 1985 (Shew et al. 1985) to 4.2 percent at John Day Dam in 1985 (Shew et al. 1985).

High concentrations of suspended sediments in the water may delay or divert spawning runs (Smith 1939, Servizi et al. 1969, Mortensen et al. 1976). Bell (1986) found that salmon did not migrate when sediment levels were high.

Sockeye salmon spawn in areas adjacent to lakes, including tributary creeks, streams connecting lakes, outlet streams, and groundwater spring areas along lake shores. The importance of each type of spawning area varies among lake systems (Burgner 1991). Sockeye salmon select spawning sites based on gravel size, cover, and water quality and quantity. Egg survival depends on conditions within the gravel, including water flow, dissolved oxygen, water temperature, and open space between the rocks (Bjornn and Reiser 1991). Spawning gravel varies from coarse granitic sand (Olsen 1968) to large angular rock too large to be moved by salmon (Kerns and Donaldson 1968, Olsen 1968). Generally, however, spawning gravel is small enough to be dislodged by normal digging action (Burgner 1991).

Water depth in spawning areas can vary from 0.5 to 10 feet (Krokhin and Krogius 1937, Bjornn and Reiser 1991, Bovee 1978, Stober and Graybill 1974, Clay 1961). Water velocity can vary from 0.7 to 3.3 feet per second (Bjornn and Reiser 1991, Bovee 1978, Stober and Graybill 1974, Clay 1961). Water temperatures that support spawning vary from 34 to 68ºF. (Bjornn and Reiser 1991). Optimal egg incubation temperatures for sockeye eggs range from 40 to 58ºF (Bell 1986, Combs 1965), although 50 percent of sockeye eggs survive at temperatures of 34ºF and 59ºF (Murphy and McPhail 1988, Beacham and Murray 1990). The sac fry stage is less sensitive to temperature (Beacham and Murray 1990).

Sockeye salmon eggs and sac fry need high levels of dissolved oxygen to survive (Shirazi and Seim 1981). In addition, oxygen levels below saturation can result in delayed hatching and decreased size of sac fry (Doudoroff and Warren 1965). Brannon (1965) found that oxygen levels and size of sockeye salmon sac fry were directly related. Fine-grained sediments and organic material in gravels impede water flow through the gravel, reducing available oxygen and creating a physical barrier to fry emergence (Cooper 1959, 1965; Wickett 1958; McNeil and Ahnell 1964; Koski 1972; Everest et al. 1987). McHenry et al. (1994) determined that spawning gravel containing 13 percent or more of fine-grained sediment increased mortality of sockeye salmon eggs.

Sockeye salmon select rearing habitats in lakes according to their life stage, the time of year, food availability, year-to-year variation in conditions, and presence of other fish (Everest et al. 1985, Bjornn and Reiser 1991). Sockeye salmon fry may use shore habitat for a month or more before moving offshore (Burgner 1991) and find shelter among riparian vegetation and woody debris during this phase of their life. The preferred range of lake water temperature for sockeye salmon rearing is 54 to 57ºF (Brett 1952). High levels of dissolved oxygen in lakes enhances swimming and feeding activities (Davis et al. 1963) and growth rates in sockeye salmon fry (Alabaster et al. 1979). Turbidity in lakes influences feeding behavior by reducing the distance that juvenile sockeye can see food.

Once sockeye begin their seaward migration, streamflow is important in determining speed of migration (Bjornn and Reiser 1991). Sufficient streamflow and adequate water temperature are important factors for smolt survival during migration (Groot 1982, Dorn 1989, Spence 1995). Other conditions, including the presence or absence of both shelter areas and dams, affect smolt survival. Migrating smolts are particularly vulnerable to predation (Larsson 1985). Undercut banks and woody structure provide refugia and resting areas for sockeye smolts. Dams in the migration corridor create conditions that (1) kill and injure smolts, (2) delay migration, (3) increase predation, (4) increase pathogens, (5) alter seasonal and daily flows, (6) reduce water velocities, and (7) change natural temperature and gas regimes in the water (Spence et al. 1996).

Sockeye salmon do not spend much time in estuaries. Levy and Northcote (1982) found only a few sockeye in estuaries in spring, indicating that sockeye may not use estuaries for rearing. Chapman and Witty (1993) state that sockeye salmon smolts appear to move rapidly through the Columbia River estuary.

Survival of juvenile sockeye salmon in the ocean is most precarious during their first few months in the marine environment (Pearcy 1991). Hartt (1980) discusses various ecological factors affecting survival rates of juvenile sockeye in the first summer of ocean life, including the following:

•The concentration of juvenile sockeye salmon. Greater concentrations make them more vulnerable to predation and disease.

•The presence of larger salmon. Distribution of the juveniles among larger fish may minimize their exposure to large predators.

•Competition with other sockeye stock and other fish species. Large numbers of juvenile sockeye migrate continuously along narrow coastal belts, resulting in competition among overlapping populations for the same food supply.

Mathews (1984) evaluated the cause of mortality in the first few months of ocean life as elusive, variable from year-to-year, and dependent on complex ecological interactions. Pearcy (1992) noted a need for research on specific processes that affect marine survival of sockeye salmon.

INTER/INTRASPECIFIC INTERACTIONS

Competitive interactions among sockeye salmon may occur throughout most of the life stages. Large numbers of sockeye salmon often spawn in the same area, and competition for spawning sites is probably substantial; however the superimposition of redds (the spawning of one female on top of another female nest) is minimized by territorial defense of the redd by the female following egg deposition (Mathisen 1962, Kerns and Donaldson 1968).

Lake rearing generally does not require the territorial behavior displayed by fish that rear in streams (Burgner 1991). Nevertheless, competition for food or space during the period when young sockeye are rearing in a lake may occur when the number of young sockeye is large, when there are two or more age classes using the same food resources, or when other species are using the same food resources (Birch 1957). If food is in short supply, juvenile sockeye grow more slowly (Nilsson 1965). However, predation, rather than starvation, is the primary source of mortality of juvenile sockeye in lakes (Burgner 1991).

There is also potential for intraspecific competition in lakes where both kokanee and sockeye are present. As a result of the close genetic relationship between these two varieties of Onchorhnchus nerka, kokanee and sockeye are more likely to compete with each other than with other species for food and spawning areas. The potential for this type of competition is greatest during the period when kokanee and sockeye fry are using shore habitat (Burgner 1991). However, kokanee and sockeye have coexisted in lakes naturally populated with these stocks.

Rieman and Meyers (1990) and Cramer and Witty (1997) examined kokanee/sockeye relationships and found age-dependent density-growth correlations in kokanee that suggested competition with sockeye ceases after the first year of life, when sockeye migrate from the lake. Interestingly, there is a strong correlation of density vs. growth for sockeye (Koenings and Burkett 1987, Burgner 1987, Goodlad et al. 1974, Kyle et al. 1988). Rieman and Meyers (1990) suggest that the difference between kokanee and sockeye population dynamics is that kokanee populations are regulated by the number of eggs per female. The number of eggs per female is directly related to body size. By contrast, most sockeye salmon are about the same size at maturity, so the females have the same number of eggs. Cramer and Witty (1997) provide a detailed description of the intraspecific relationship between sockeye and kokanee.

Interactions between sockeye salmon and other species begin when sockeye are at egg stage. Fishes and birds feed on sockeye eggs during spawning (Morton 1982, Ward and Larkin 1964). Physical factors such as freezing, siltation, reduced flow, and shifting gravel, however, are more important factors affecting sockeye salmon egg survival than is predation (Burgner 1991).

Sockeye fry are vulnerable to predation by fish and birds during the emergence and migration periods as well. Mortality during this period can be as high as 91 percent (Foerster 1968, Stober and Hamalainen 1980). Because sockeye salmon fry feed during the day, they are highly vulnerable to predators. Predators of sockeye salmon fry in freshwater environments include coho salmon, trout, char, sculpin, northern pike, northern pikeminnow, gulls, mergansers, and water ouzels (Foerster 1968, Ward and Larkin 1964, Morton 1982, Foerster 1968, Semko 1954, Stober and Hamalainen 1980, Nelson 1966, Moriarity 1977, Hartman and Burgner 1972, Poe et al. 1991, Vigg et al. 1991, Rogers et al. 1972).

The most intensive predation of sockeye occurs during smolt migration (Burgner 1991). Predators often congregate to take advantage of the feeding opportunity provided by migrating sockeye salmon smolts (Hartman and Burgner 1972, Krebs 1978, Glasser 1979, Vigg 1988, Rieman et al. 1991, Beamesderfer and Rieman 1991). A short period of high migration appears to have a survival advantage over extended migration, and night migration has further advantage over day migration for sockeye salmon smolts (Ruggerone and Rogers 1984, Burgner 1991, Meacham and Clark 1979). Poe et al. (1991) and Vigg et al. (1991) state that northern pikeminnow are the principal predator of migrating smolts in the Columbia River migration corridor. Northern pikeminnow congregate at hydroelectric project bypass facilities on the Snake and Columbia rivers (Ledgerwood et al. 1990). Predator control programs may reduce predator concentrations in and near dam tailraces (Chapman and Witty 1993).

American shad also have the potential for negative interactions with sockeye salmon in the Columbia River migration corridor. The number of shad in this system has increased from 250,000 in 1967 to 2,500,000 in 1992 (Chapman and Witty 1993). Competition between the two species may arise because juvenile sockeye salmon and juvenile shad eat the same foods (McCabe et al. 1983). On the other hand, sockeye salmon move rapidly through the migration corridor, so interactions with shad may not significantly affect them (Chapman and Witty 1993).

Kaeriyama (1989) notes that fish culture programs have increased the numbers of salmon rearing in the ocean, which in turn has resulted in the decline in mean size of adult salmon. Reduced size of fish makes them more subject to predation (Parker 1971). It is possible that hatchery programs may have exceeded the ocean carrying capacity for salmon (Kaeriyama 1989). In 1990, the total annual hatchery smolt production plus wild production of all anadromous species was approximately 347.7 million smolts in the Columbia River (Chapman and Witty 1993). The historic smolt abundance of all anadromous species was about 264.5 million (Kaczynski and Palmisano 1992).

Predators of sockeye salmon in the ocean include lamprey, seals, sea lions and sharks (Hartt 1980). Large numbers of hatchery fish have been shown to attract seals and sea lions to the extent that an overabundance of marine mammals results (Park 1993). This type of situation is confounding sockeye recovery in the Columbia River (Park 1993). Also, variations in ocean conditions and marine predator populations undoubtedly have affected marine survival of sockeye salmon populations, but these effects are poorly understood (Burgner 1991).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Historically, Suttle Lake, located in the Metolius River subbasin of the Deschutes River Basin, supported sockeye salmon (Fies and Robart 1988, Fulton 1970, Nehlsen 1995, USGS 1914, Holloway et al. 1938, Newcomb 1941, Frey 1942, Haas and Warren 1961, Fies et al. 1996). Information about the historical abundance of sockeye salmon in Suttle Lake is sparse (Nehlsen 1995). Sockeye salmon runs to Suttle Lake were reported extinct by 1940 (Frey 1942).

A hatchery program for sockeye salmon was initiated in 1947 at the Metolius Hatchery on Spring Creek (Nehlsen 1995). Brood stock for the sockeye salmon hatchery program originated from Bonneville, Winthrop, and Leavenworth hatcheries (Wallis 1960). Nearly 100,000 sockeye fingerlings were released annually into Suttle and Blue lakes and into Spring Creek (Wallis 1960). The numbers of smolts released ranged from 27,438 in 1958 to 198,160 in 1952 (Wallis 1960). In 1955, at least 348 adult sockeye salmon were counted in the Metolius River and tributaries (Montgomery 1955). These adults originated from a release of 101,800 fingerlings in 1951 (Wallis 1960). In 1956, only 11 sockeye salmon were counted in the Metolius River (Montgomery 1956). Approximately 350 to 600 adult sockeye salmon originating from 1953, 1954, and 1955 broods escaped fisheries and returned past Bonneville Dam in spawning runs in

1957, 1958, and 1959 (Wallis 1960). The last sizable run of sockeye in the Metolius River was reported in 1955 (Nehlsen 1995).

Lower Crooked River

Historically, populations of sockeye salmon were not found in the Crooked River. The feasibility of introducing sockeye salmon into the Crooked River Basin has not been studied. The potential to produce sockeye salmon in the Crooked River above Lake Billy Chinook for rearing in Lake Billy Chinook also has not been explored.

Metolius River Basin

Historically, there were two native runs of sockeye salmon in Oregon; the Suttle Lake stock and the Wallowa Lake stock (Cramer and Witty 1997). The Suttle Lake sockeye salmon stock migrated up the Columbia River, Deschutes River, Metolius River, and Lake Creek to spawning areas at Suttle Lake and Link Creek (Nehlsen 1995). They entered the Deschutes River from June to September, and their peak migration timing at the Pelton Project from 1956 through 1961 (prior to construction of Round Butte Dam) was August. Spawning occurred from mid-September to November. Juveniles reared in Suttle Lake 1 to 2 years. Gunsolus and Eicher (1962) recorded out-migration of hatchery-produced smolts occurring from March to July and peaking in April.

The factors contributing to the demise of sockeye salmon in the Metolius River have not been throughly examined (Nehlsen 1995). Frey (1942) attributes the loss of the historic runs to the dam at Suttle Lake and dams at Lake Creek Lodge, which began blocking migration in 1940. An examination of chronological events affecting reaches of the Metolius River and its tributaries historically inhabited by sockeye salmon could provide additional insight into their demise.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Historically, sockeye salmon were not found in the Deschutes River above Lake Billy Chinook. The potential to produce sockeye salmon in the Deschutes River above Lake Billy Chinook for rearing in Lake Billy Chinook has not been explored.

Lake Billy Chinook

Historic runs of sockeye salmon migrated through the area of the Deschutes River presently inundated by Lake Billy Chinook. Some kokanee that rear in Lake Billy Chinook (which are assumed to have originated from the historic sockeye runs) move downstream past the Pelton Round Butte Project and develop anadromous traits.

Kokanee in Lake Billy Chinook that develop migratory instincts and survive downstream passage and ocean conditions may return to the Pelton Fish Trap as sockeye salmon (ODFW 1995, Kostow 1996, Wy-Kan-Ush-Mi Wa-Kish-Wit 1995). The trap is located directly downstream of the Reregulating Dam.

Zimmerman and Reeves (1998) examined the genetic origin of 37 sockeye salmon collected at the Pelton Fish Trap in 1997 and determined that two sockeye had kokanee parents and 34 had sockeye salmon parents. Zimmerman and Reeves (1998) did not determine geographic origin of sockeye collected at the trap in 1997. The sockeye could have been strays or native Deschutes sockeye. Genetic analyses comparing returning sockeye salmon and Lake Billy Chinook kokanee have not been able to establish a definite relationship between the two groups (M. Powell, University of Idaho, in letter to K. Witty, April 30, 1998).

Lake Simtustus

As with Lake Billy Chinook, historic runs of sockeye salmon migrated through the area of the Deschutes River presently inundated by Lake Simtustus. Similarly, kokanee that rear in Lake Simtustus could move downstream to the lower Deschutes River and return as adult sockeye salmon to the Pelton Fish Trap (Stuart et al. 1996). However, the population of kokanee in Lake Simtustus is small compared to the size of the kokanee population in Lake Billy Chinook (Stuart et al. 1996). Therefore, the frequency of kokanee produced in Lake Simtustus returning as sockeye salmon is undoubtedly quite low.

Lower Deschutes River

Historically, the lower Deschutes River provided a migration corridor for juvenile and adult sockeye salmon. Historic runs of sockeye salmon entered the Deschutes River from June to September (Stuart et al. 1996). The size of the historic runs is unknown (Nehlsen 1995), but counts of returning adult sockeye salmon at the Pelton Fish Trap from 1957 to 1962 ranged from 30 to 330 fish (Stuart et al. 1996).

Sockeye salmon from remnants of the historic runs continue to occur at extremely low levels in the Deschutes River (Kostow 1995). Small numbers of juvenile sockeye/kokanee in the Deschutes River have been noted downstream of the Pelton Round Butte Project (S. Pribyl, ODFW, personal communication, April 8, 1998). Electrofishing surveys conducted in early-spring in four sections of the Deschutes River during recent years have documented small numbers of juvenile sockeye/kokanee in the Trout Creek reach of the Deschutes River. The number of sockeye/kokanee caught in the survey has varied from 0 to 3 (S. Pribyl, ODFW, personal communication, April 8, 1998). The number of sockeye caught in the Pelton Fish Trap between 1988 and 1997 varied from 0 to 60, and was 37 in 1997. Of 213 sockeye captured at the trap during the period from 1988 through 1997, 55 percent were collected in August (S. Pribyl, ODFW, personal communication, April 8, 1998). The number of kokanee below the Pelton Round Butte Project, including any component that originated as migratory kokanee, probably varies greatly year-to-year depending upon the amount of spill at Round Butte Dam.

FISHERIES

Sport fisheries of sockeye salmon is prohibited in the Deschutes River, but a limited commercial fishery exists for sockeye salmon in the Columbia River below the mouth of the Deschutes River. Wild Deschutes sockeye salmon are not marked, so harvest levels of these fish are unknown. Sockeye salmon production is quite low in the Deschutes River system, however, so the number of Deschutes-origin sockeye salmon harvested in commercial fisheries is, undoubtedly, also very small.

LIMITING FACTORS

The demise of sockeye salmon in the Deschutes River Basin is attributed to blockage of the spawning run by dams on Lake Creek and Suttle Lake, and by the completion of Pelton and Round Butte dams (Stuart et al. 1996). Passage problems in the Columbia River migration corridor and commercial fisheries have also undoubtedly affected sockeye salmon runs into the Deschutes River Basin. Biologists are exploring the feasibility of reintroducing sockeye into the Metolius River. Questions regarding the feasibility of reintroducing sockeye salmon into the Deschutes River Basin include those related to limiting factors for this species, such as natural smolt production potential, susceptibility to disease, potential inter/intraspecific interactions, and juvenile and adult passage.

ECOLOGICAL ROLE

Sockeye salmon are open-water feeders and feed primarily on zooplankton. There are considered a prey rather than a predator species. In some areas, intraspecific interactions occur between sockeye and kokanee. Such interactions affect sockeye salmon less than kokanee because sockeye salmon gain most of their growth at sea.

Historically, sockeye salmon and resident kokanee were well integrated into the Deschutes River and Suttle Lake fish community. Studies are ongoing to evaluate opportunities and issues associated with the potential reintroduction of sockeye salmon above the Pelton Round Butte Project. Unlike historic conditions where adult sockeye spawned above Suttle Lake and reared in Suttle Lake, the proposed plan provides for adult sockeye salmon spawning above Lake Billy Chinook in the Metolius River system and juvenile sockeye salmon rearing in Lake Billy Chinook. Sockeye salmon and resident kokanee have not co-existed in Lake Billy Chinook, so there is not a historic record to help guide a sockeye salmon reintroduction project. Also, Lake Billy Chinook is a reservoir with fish management programs designed for specific objectives and beneficial uses. The reintroduction of sockeye salmon above the Pelton Round Butte Project area will require new fish management strategies.

Factors that should be considered when planning for the reintroduction of sockeye above the Pelton Round Butte Project include physical, biological, social, and economic values. Physical habitat values include spawning, rearing and migration corridor habitat conditions. Biological values include availability of food for fish, potential interactions with existing fish species, and the availability of a potential donor stock. The presence of sockeye salmon would add social and economic values to the Project area.

Anglers may be concerned about the potential risk for intraspecific interactions between sockeye and residual kokanee in the Metolius River and in Lake Billy Chinook. Intraspecific competition may occur between adult sockeye salmon and resident kokanee for spawning sites in the Metolius River system and between juvenile sockeye salmon and resident kokanee for food in Lake Billy Chinook. Intraspecific competition for food, if it occurs, will likely be between age 0 sockeye and age 0 kokanee.

The proposal for the reintroduction of sockeye salmon above the Pelton Round Butte Project includes construction and operation of new fish passage facilities around the Pelton

Round Butte Project area. Reintroduction of other species of anadromous fish species is also being considered.

Sockeye salmon have a high stray rate in the Columbia River. The cause of straying is unknown, although some people suspect that barging smolts increases the incidents of adult straying. PGE has proposed that only sockeye salmon collected at the Pelton Fish Trap be used for brood stock should the decision be made to reintroduce sockeye salmon above the Pelton Round Butte Project area. At present, the origin of sockeye salmon collected at the trap remains unclear.

Sockeye salmon are a major food source for other animals including fish, birds and mammals. Sockeye salmon are a highly prized commercial fish, and they are traditionally used by Native Americans for food, trade, and ceremonial purposes.

KOKANEE SALMON

Oncorhynchus nerka

Other common names: Kennerly's salmon, silver trout, little redfish, kickininee (Scott and Crossman 1973), yank (Cramer and Witty 1997)

General

APPEARANCE

The body of kokanee is streamlined and laterally compressed. The head is cone shaped. The end of the snout is slightly turned up. The teeth and eyes are rather small. The maxillaries extend to the back side of the eye (Scott and Crossman 1973).

Kokanee have one dorsal fin located in the center of the back. The dorsal fin is almost square and has 11 to 13 soft rays. There is a rather small adipose fin located behind the dorsal fin. The tail is broad and moderately forked with pointed tips. The anal fin has a long base with 11 to 16 soft rays. The pelvic fins have rounded tips, 9 to 11 rays, and there are axillary processes at their base. The pectoral fins are moderately long with rounded points. There are 11 to 21 rays in the pectoral fins. The scales are round and small (Scott and Crossman 1973).

The top of the body is a steel-blue to green-blue color. Most kokanee do not have distinct black spots on their backs (Scott and Crossman 1973), but kokanee in Lake Billy Chinook do have such spots (S. Lewis, PGE, personal communication, September 1998). The belly of the fish is white to silver. The dorsal fin may have a few dark marks, but the other fins are clear to dusky in color (Scott and Crossman 1973).

Juvenile kokanee have vertical parr marks along the lateral line with the width of the parr marks greater than the light areas between them. The fins have no color. In breeding males, most of the body becomes bright red to dirty red-grey while the head to lower jaw turns bright green to olive in color. The snout and lower jaw turn white to grey, the dorsal and anal fins turn red, and the pectoral, pelvic, and caudal fins turn green to almost black. Coloration in the breeding female is similar, but the body is a darker grey-red color (Scott and Crossman 1973, Carl et al. 1959).

Distinguishing characteristics of kokanee are the lack of distinct dark spots on their backs and tail (except locally, such as in Lake Billy Chinook) and the distinctive green heads and bright reddish bodies in spawning adults (Wydoski and Whitney 1979).

DISTRIBUTION

Kokanee are native to Japan, Russia, Alaska, Yukon Territory, British Columbia, Washington, Idaho, and Oregon (Nelson 1968). They occur naturally in lakes where anadromous sockeye salmon are found, as well as in many lakes and reservoirs to which anadromous sockeye salmon no longer have access. Kokanee have been introduced widely in North America including in Maine, California, Montana, Colorado, Connecticut, New York, Pennsylvania, Vermont, North Dakota, Nevada, Oregon, Washington, Idaho, Utah, Alberta, Saskatchewan, Manitoba, and

Ontario. They have also been introduced into the Great Lakes (Scott and Crossman 1973). Kokanee were native to the Deschutes River Basin, where they were found in Suttle Lake (Nehlsen 1995).

LIFE HISTORY

The evolution of kokanee is not clear (Burgner 1991). The different forms of O. nerka are characterized by the anadromous "sockeye" and the smaller resident "kokanee." Offspring of kokanee are usually resident fish, although kokanee are capable of producing anadromous adults (Foerster 1947, Brannon et al. 1994). Kokanee may move into new areas, but those that do typically originate from spawning anadromous sockeye (Burgner 1991).

Offspring of anadromous sockeye often include a relatively small number of residuals that remain in the lake and complete their life cycle entirely in freshwater. Some progeny of residuals may develop anadromous life history patterns (Brannon et al. 1994). Kokanee and sockeye have shown a close genetic relationship, and the spawning stock can be genetically the same (Foote et al. 1989). However, some stocks of kokanee and sockeye have demonstrated genetic separation (Brannon et al. 1992, Foote et al. 1989).

Genetic separation between sockeye and kokanee is a condition consistent with their differing life histories. Kokanee will evolve characteristics favorable for total freshwater life while sockeye will evolve characteristics favorable for an anadromous life history (Brannon et al. 1992). Genetic separation between sockeye and kokanee can occur because of the location and timing of spawning. Kokanee that spawn in lakes spawn later than kokanee and sockeye that spawn in streams, and kokanee in general spawn earlier than sockeye (Ricker 1940). Kokanee show a reduced migratory tendency, but their capacity to develop anadromous forms continues to be demonstrated (Kaeriyama et al. 1992, Foote et al. 1994). Mating between sockeye and kokanee produce some offspring that are anadromous and others that are residual (McCart 1970, Foote and Larkin 1988). LaRiviere (1993) crossed kokanee eggs with sockeye sperm and produced a stock with characteristics of both sockeye and kokanee.

Distinct populations of kokanee may develop within a single lake (Vernon 1957, Chernenko and Kurenkov 1980), as each population evolves characteristics to fit its particular environment. Kokanee and sockeye also may coexist in the same lake. Fish size, spawning sites, fecundity, and fry size (Williams 1975, Moyle and Cech 1988) favor the competitive success of sockeye over kokanee.

Kokanee spawn from early August to February in water temperatures ranging from 41 to 51ºF and in water depths of less than 1 foot to 30 feet deep. The male is usually the aggressor. In the stream environment, the female prepares a nest in pea-sized gravel by lying on her side and beating her tail violently up and down. Kokanee also spawn in lakes, where their is little or no current. Here the female uses a side-to-side action of the tail to prepare a nest. The male and female swim into the nest, and as the spawning act begins their mouths open as their bodies vibrate, and the eggs and sperm are deposited. The nest is covered by the female. The spawning adults die a few days to several weeks later. The number of eggs per female varies from approximately 370 to 1,800, depending on the size of the female. Fry hatch after 48 to 140 days depending upon water temperature (Fallis 1970, Lindsey 1958). Fry hatch in December of

January and emergence occurs during the period of March through May (Scott and Crossman 1973).

Kokanee fry that hatch in streams move quickly to the lake environment. Growth of fry is rapid during the first year. Growth is limited by food supply and competition with other kokanee. By using open water, juvenile kokanee tend to avoid many potential predators (Scott and Crossman 1973). Kokanee exhibit schooling behavior as juveniles and adults (Scott and Crossman 1973).

Generally, kokanee mature, spawn, and die at age 4, but fish age 2 to 8 may be in the spawning run. Spawning fish may be as small as 6.3 inches to as large as 21 inches. The homing instinct of mature adults is highly developed (Vernon 1957)

HABITAT REQUIREMENTS

Kokanee spawn in tributaries and outlets to lakes or in shoreline gravels in lakes. Spawning gravel ranges from less than 0.5 inch to 4 inches in diameter. The velocity of water can be less than 2.0 feet per second where kokanee spawn. Lake spawning usually occurs over spring seepage (Jeppson 1956, Kimsey 1951). Cramer and Witty (1997) describe a condition where channelization of the spawning area played a role in the reduction of a kokanee population.

Egg incubation occurs in water temperatures from 32 to 55ºF, although green eggs in water less than 38ºF die (Seeley and McCammon 1966). Eggs may hatch in water as warm as 55ºF, but egg mortality above that temperature threshold is high (Scott and Crossman 1973).

Kokanee may live in any part of a lake during spring and fall, but they are usually associated with open water and depths below the thermocline (a layer of water where the temperature change is greater than that of the warmer layer above and the colder layer below) during summer. They move into deeper water in summer when temperatures increase. Kokanee prefer temperatures that range from 50 to 59ºF (Scott and Crossman 1973).

Kokanee feed mainly on plant and animal plankton, terrestrial insects, and water mites (Northcote and Lorz 1966). Platts (1958) observed kokanee fry eating insects in streams, but after fry enter a lake they switch to eating plankton. Growth and size of kokanee depends on plankton abundance and on competition with other kokanee and with other species for available food. Most growth in kokanee juveniles occurs in summer and fall (Seeley and McCammon 1966).

INTER/INTRASPECIFIC INTERACTIONS

Kokanee are not generally known to prey on other fishes, but they may prey on small sculpin (Scott and Crossman 1973). Young kokanee are consumed by a wide variety of predator fishes including rainbow, bull trout, and lake trout, smallmouth bass, and northern pikeminnow (Scott and Crossman 1973).

The open water feeding habits of kokanee may limit their competition with other fishes in some lakes (Scott and Crossman 1973). However, Seeley and McCammon (1966) state that kokanee may inhibit trout production in some lakes because of competition for food. Interactions of rainbow trout and kokanee were described by Swartzman and Beauchamp (1990). They found that small rainbow trout and kokanee eat the same food. Whitefish also feed on the same food as kokanee (McMahon 1948).

There is considerable intraspecific competition for food and space among kokanee. Rieman and Meyers (1990) found that competition for food is more important within age classes, rather than among age classes, because there are differences in food preference among age groups of kokanee. Kokanee and sockeye that coexist in the same lake also may compete for food (Rieman and Myers 1992).

Rieman (1981) found that the growth of age 0 and age 1 kokanee was related to the amount of preferred prey and not related to the number of kokanee, and Rieman and Meyers (1992) found that kokanee in these age classes did not seem to reach densities at which growth was affected. In contrast, growth of age 2 and 3 kokanee was found to be related to the total number of kokanee in the population (Rieman 1981). Rieman and Meyers (1990) speculate that dense, maturing kokanee populations resulted in reduced growth, smaller females, and fewer eggs. Overall, factors such as the number of eggs per female, egg size, and fry mortality are primary factors limiting numbers of young kokanee (Collins 1971, Taylor 1980, Bradford and Peterman 1987, Murray et al. 1989).

Rieman and Meyers (1990) suggest that the reproductive difference between kokanee and sockeye is that kokanee populations are regulated by the number of eggs per female (directly related to body size), whereas most sockeye salmon are about the same size at maturity, so the females have about the same number of eggs. Juvenile sockeye salmon typically migrate from a lake at age 1 or 2 at lengths less than 6 inches and, consequently, are not adversely affected by increased numbers of adult kokanee (Rieman and Myers 1992).

Pelton Round Butte Project Area

Population Distribution and Size

Historically, Suttle and Blue lakes supported kokanee as well as sockeye salmon (Fies and Robart 1988, Fulton 1970, Nehlsen 1995, Fies et al. 1996). Information about the historical abundance of sockeye and kokanee salmon in Suttle and Blue lakes is sparse (Nehlsen 1995). Sockeye salmon runs in the upper Metolius River Basin were reported extinct by 1940 (Frey 1942). Attempts to re-establish sockeye salmon runs in the basin using hatchery fish were initiated in the late 1940s. The Metolius Hatchery on Spring Creek began releasing sockeye juveniles in 1948, and releases continued until 1961. The 1947 brood (released in 1948) originated from Bonneville Hatchery, and the 1949 brood originated from Winthrop Hatchery, located in Washington State; all other releases were stocks from the Leavenworth Hatchery in Washington State (Wallis 1960). Escapement of sockeye salmon back to the Metolius River ranged from 345 to 618 adults per year (Wallis 1960). Some of the kokanee now present in Lake Billy Chinook and the Metolius River Basin probably originated from the hatchery-stock sockeye released into the area.

Hatchery kokanee were also introduced into Suttle and Blue lakes in 1954, when 22,291 fingerling were released into Suttle Lake and 14,972 fingerling were released into Blue Lake. Kokanee releases into Suttle Lake continued through the 1960s and early 1970s. Numbers of kokanee release each year ranged from 10,125 to 93,272 (Fies et al. 1996). The origin of kokanee stock released into Suttle Lake is unknown (S. Marks, ODFW, personal communication, April 9, 1998). Currently, natural reproduction is maintaining the kokanee population in Suttle Lake (Fies et al. 1996). It is unknown if the indigenous form of kokanee is still present in Suttle Lake (Fies et al. 1996).

Metolius River Basin

A run of several thousand kokanee annually migrate upstream from Lake Billy Chinook to spawn in the Metolius River Basin (Fies et al. 1996). High concentrations of spawning kokanee are observed in the Metolius River and in Jefferson, Candle, Canyon, and Spring creeks (Stuart et al. 1996, Thiesfeld et al. 1998).

Kokanee spawning index surveys in the Metolius River Basin were started in 1994. Figure 7 depicts numbers of spawning kokanee observed in the index areas from 1994 through 1997. The total number of kokanee spawning in the basin is much larger than numbers for the index areas alone. Spawning escapement is calculated by marking and recapturing spawning kokanee, and this information provides an estimate of total spawners. The number of spawners is used to estimate numbers of eggs deposited and predict annual fry production (Thiesfeld et al. 1998).

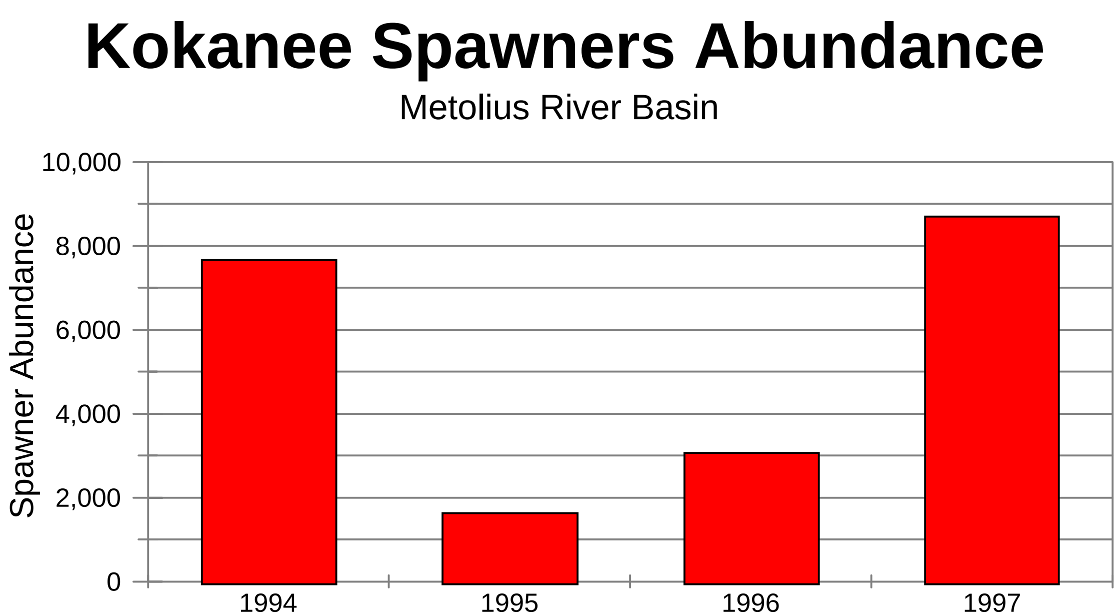

Figure 7. Numbers of kokanee spawning in index survey areas, Metolius River Basin, 1994–1997. (Note: The total number of kokanee spawning in the basin is much larger.)

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Kokanee migrate upstream to Steelhead Falls and into Squaw Creek to spawn. The number of kokanee that spawn in these reaches is unknown (Fies et al 1996b, Stuart et al. 1996). Theisfeld et al. (1998) observed substantial numbers of kokanee in the Deschutes River during 1998. However, no kokanee were observed in Squaw Creek. Thiesfeld et al. (1998) determined that a 4-foot falls approximately 500 yards upstream of the mouth was a barrier to the upstream passage of kokanee in most, but not all, years.

Lower Crooked River

Kokanee are present and spawn in the Crooked River below Opal Springs Dam. Kokanee have been observed attempting to spawn in small lower Crooked River tributaries during the fall. The contribution of these streams to the kokanee population in Lake Billy Chinook is probably minimal (Stuart et al. 1996).

Lake Billy Chinook

Lake Billy Chinook kokanee appear to have originated from Suttle Lake or from the Metolius Hatchery (Stuart et al. 1996). By 1968, kokanee made up 67 percent of the total fish harvest in Lake Billy Chinook, even though kokanee were not stocked in the reservoir until 1970 (Stuart et al. 1996). The Oregon Game Commission released kokanee fingerling into Lake Billy Chinook in 1970 and 1971 (Stuart et al. 1996). Lake Billy Chinook currently supports a self-sustaining population of kokanee, and management plans provide for the maintenance and harvest of naturally produced fish (Stuart et al. 1996).

ODFW is presently involved in a study to determine the factors that control kokanee recruitment, growth, and survival in Lake Billy Chinook (Thiesfeld and Dale 1998). Creel surveys are conducted to determine kokanee harvest by anglers. Acoustic, trawl, and curtain net surveys are conducted to estimate the kokanee population by year class in the reservoir, spawning kokanee are tagged to determine total spawning escapement, and screw traps are operated to estimate numbers of kokanee fry entering Lake Billy Chinook.

Sampling problems have limited success in determining abundance of kokanee fry entering the reservoir (Thiesfeld and Dale 1998). The screw trap fishing at the mouth of the Metolius River has had varying rates of efficiency, and trapping success has generally been low. However, the information obtained to date from the screw traps indicates that millions of kokanee fry are produced annually in the Metolius River Basin (Thiesfeld et al. 1998). Based on a fry survival rate of 5.27 percent, Thiesfeld et al. (1998) estimate that as many as 3.5 million fry were produced in the basin in 1998.

Acoustics, curtain nets, trawl nets, and creel surveys have provided good estimates of kokanee population size in the reservoir (Thiesfeld et al. 1998). Thiesfeld and Dale (1998) and Thiesfeld et al. (1998) have found that the information indicates high wintertime loss of kokanee that may be caused by disease, predation, natural mortality, turbine passage, or spillway passage. Studies are ongoing to determine kokanee losses caused by disease (Banner et al. 1992, Engelking and Kaufman 1994), predation by birds (Concannon 1996) and bull trout (Beauchamp 1997, 1998), and turbine and spillway passage Schulz and Ratliff 1996, 1997).

Lake Billy Chinook kokanee spawn mostly in the Metolius River and its tributaries, including Heising Spring, Spring Creek, Jefferson Creek, Candle Creek, Canyon Creek, Link Creek and Lake Creek (Thiesfeld and Chilcote 1997). These kokanee also spawn to a lesser extent in the Crooked River upstream to Opal Springs, and in the Deschutes River upstream to Steelhead Falls (Thiesfeld and Dale 1998). The kokanee migrate downstream, entering Lake Billy Chinook from mid-March through May (Thiesfeld et al. 1998).

Numbers of kokanee fry in Lake Billy Chinook are considered low compared to numbers in other lakes (Reiman and Myers 1992, Thiesfeld et al. 1998). Because of low numbers, growth rates are good for age 0 and age 1 kokanee in Lake Billy Chinook. Growth slows as kokanee reach age 2, and age 3 fish in the reservoir show little growth (Thiesfeld et al. 1998).

While the number of kokanee fry are relatively low in Lake Billy Chinook, Thiesfeld et al. (1998) found that the number of age 0 kokanee affected growth in 1998. This observation contradicts findings by Rieman and Myers (1992) that numbers of age 0 kokanee does not affect growth of age 0 kokanee. However, some findings of Thiesfeld et al. (1998) are consistent with findings by Reiman and Myers (1992). Both studies determined that the survival of eggs and fry during their first year controls the abundance of that year class, and survival during the first year plays a major role that determines available of kokanee for harvest and spawning in coming years.

Lake Simtustus

Kokanee are present in Lake Simtustus when they pass into the reservoir through the power intake system from Lake Billy Chinook upstream (Schulz and Ratliff 1996, 1997, 1998). Most of these fish are severely injured by air bladder expansion (Schulz and Ratliff 1998). Kokanee in Lake Simtustus are generally low in abundance, but they exhibit good growth rates and usually outgrow those in Lake Billy Chinook. Kokanee measuring up to 20 inches are occasionally caught by anglers in Lake Simtustus (Stuart et al. 1996).

Lower Deschutes River

ODFW reports the presence of small numbers of juvenile sockeye/kokanee in the Deschutes River downstream of the Pelton Round Butte Project (S. Pribyl, ODFW, personal communication, April 8, 1998). Electrofishing conducted annually in early spring in four sections of the Deschutes River has produced small numbers of juvenile sockeye/kokanee in the Trout Creek reach of the Deschutes River. The number of sockeye/kokanee caught each year varies from 0 to 3 (S. Pribyl, ODFW, personal communication, April 8, 1998).

ODFW (1995), Kostow (1996), and Wy-Kan-Ush-Mi Wa-Kish-Wit (1995) suggest that outmigrating smolts of “kokanee sized” fish that escape the Pelton Round Butte Project may return as sockeye salmon to the Pelton Fish Trap, located directly below the Reregulating Dam. Zimmerman and Reeves (1998) examined the genetic origin of 37 sockeye salmon collected at the Pelton Fish Trap in 1997 and determined that two sockeye had kokanee parents and 34 had sockeye salmon parents. Zimmerman and Reeves (1998) did not determine the geographic origin of the sockeye. The sockeye could have been strays or native Deschutes stock.

Fisheries

Lake Billy Chinook

Estimated boat angler hours of effort for kokanee at Lake Billy Chinook in 1990 through 1998 ranged from approximately 95,000 to 136,000 (data provided by S. Thiesfeld, ODFW). A typical angler at Lake Billy Chinook spends about 4.5 hours of effort fishing the reservoir (Theisfeld and Chilcote 1997). Approximately 61 to 92 percent of the angling effort at Lake Billy Chinook from 1990 through 1998 was for kokanee (data provided by S. Thiesfeld, ODFW). The catch rate varies from 0.004 to 1.4 fish per hour (data provided by S. Thiesfeld, ODFW). Most kokanee caught are kept. The greatest catch occurs in June and July, but some of the best fishing occurs in September and October (Theisfeld and Chilcote 1997).

Lake Simtustus

Both wild and hatchery kokanee are present in Lake Simtustus. They are generally low in abundance. The wild kokanee in the reservoir enter by turbine or spillway passage at the upstream Round Butte Dam. Kokanee cannot successfully reproduce in Lake Simtustus. After completion of Pelton Dam, hatchery kokanee were stocked into Lake Simtustus on an occasional basis by the by the Oregon Game Commission (Stuart et al. 1996). Creel information indicates that approximately 1,000 to 4,000 kokanee are caught in Lake Simtustus each year at a catch rate of 0.15 kokanee per hour. This catch rate does not provide an adequate fishery. ODFW stocks approximately 75,000 fingerling hatchery kokanee during July of each year into Lake Simtustus (Stuart et al. 1996). An analysis of the kokanee stocking program has been initiated (Stuart et al. 1996).

Limiting Factors

A study was initiated in 1996 to determine factors that control kokanee recruitment, growth, and survival to assess potential ecological relationships between kokanee and other fish species, and to evaluate the role these factors play in associated fisheries in Lake Billy Chinook (Chilcote 1996). The study is ongoing, but some general observations have been noted. These are:

- Several thousand adult kokanee spawn in the Metolius River Basin.
- Kokanee spawn at age 1, 2, and 3.
- Age of spawners varies year-to-year.
- Numbers of newly recruited fry vary greatly year-to-year.
- Newly recruited kokanee fry spent most of their time in the Metolius River Arm until May.
- Most age 0 kokanee remain in the Metolius River Arm.
- Growth rates of kokanee are consistently higher than would be predicted.

- Age 0 and 1 kokanee have exceptional growth rates, but growth rates decrease thereafter.
- Age 0 fry have high mortality rates.
- Kokanee enter the fishery as early as age 1.
- Factors controlling growth of kokanee are not understood at this time.

There is a tradeoff between size and number of kokanee available in a fishery (Boisclair and Leggett 1989). Growth of kokanee is influenced by the productivity of the water (Rieman and Myers 1990, Lewis 1971). As kokanee become older, there is greater competition between them for food (Rieman and Myers 1990). High densities of older kokanee result in declines in growth rates (stunting) (Rieman and Bowler 1980). The number of older kokanee in the population may also regulate the population size (Rieman and Myers 1990). Because of this density-size tradeoff, managers tend to push for larger numbers of kokanee, which in turn reduces the size of fish in the fishery. On the other hand, with lower population numbers of fish, bulk harvest can still be high because fish are larger (Lewis 1973); however, the risk of population collapse is greatest when there is a small population of large kokanee. Attempts to manage for large kokanee can result in collapse of the population due to over-fishing, predation, and catastrophic events (Rieman and Myers 1990). Managers should be cautious when kokanee size approaches 12 inches (Rieman and Myers 1990). High kokanee densities also should be a concern in fishery management. High densities of kokanee, especially older age groups, will result in slow growth and poor catch rates (Reiman and Myers 1990).

Age-at-maturity (the age of a fish when it is sexually mature) also has an influence on a kokanee fishery. Faster growing kokanee reach maturity at a younger age than do slower growing kokanee. Generally, kokanee enter fisheries the summer that they are maturing. Age-at-maturity may be influenced by environment, genotype, genetic, population density, and growth rates at different ages (Kato 1980, Graynoth 1987, Lewis 1971). Management of factors affecting age-at-maturity could have substantial benefits in some kokanee fisheries, but managers do not fully understand how these factors interrelate (Reiman and Myers 1990).

At Lake Billy Chinook, outmigration of kokanee occurs during periods of major floods when spill occurs at Round Butte Dam (Schulz and Ratliff 1996). Many age 1 kokanee left the lake during a major flood in February 1996. Thiesfeld and Chilcote (1997) speculate that this event provided exceptional growth of Age 0 kokanee in 1996. However, the review of literature presented above suggests that the exceptional growth of age 0 kokanee in 1996 was not directly related to outmigration of age 1 kokanee.

Ecological Role

Kokanee live in open water and feed there on plankton that may not be available to shore-dwelling species of fish. In turn, kokanee become prey for shore-dwelling fish and other animals when they spawn. There is potential for intraspecific competition in lakes where both sockeye and kokanee are present. Since sockeye leave the lake environment at a relatively small size, most competition for available food occurs between the resident kokanee. Sockeye have a reproductive advantage over kokanee because sockeye salmon females have more eggs than kokanee females, and sockeye juveniles leave the fresh-water environment when competition for food becomes a factor.

There are currently two kokanee populations above Lake Billy Chinook — one population that lives in Suttle Lake and spawns in Link Creek, and a second population that lives in Lake Billy Chinook and spawns in the upper Metolius River. Both populations have the same physical characteristics (ODFW 1995). Waples et al. (1997) analyzed kokanee from Lake Billy Chinook and Link Creek above Suttle Lake to determine genetic make-up. Samples of kokanee from these two locations did not differ significantly and were most closely related to kokanee from Okanogan Lake in Washington. Genetic relationships to other stocks were quite distant (Waples et al. 1997).

STEELHEAD TROUT

Oncorhynchus mykiss

Other common names: Steelhead, coast rainbow trout, silver trout (Scott and Crossman 1973), ironheads

General

SCIENTIFIC NAME

Oncorhynchus mykiss. Until recently, steelhead trout were known by the scientific name Salmo gairdneri. Scientists now have evidence of a close genetic link between Pacific trout and salmon. Consequently, trout native to streams that drain to the Pacific Ocean have been classified together with Pacific Ocean salmon under the single genus Oncorhynchus (Smith and Stearly 1989).

APPEARANCE

Steelhead exhibit a considerable variety of body shapes among individuals in different habitats and stocks (Mottley 1936a, Needham and Gard 1959, Bidgood and Berst 1967, MacCrimmon and Kwain 1969). In general, however, steelhead have a body shape that is elongated (Scott and Crossman 1973) and laterally compressed. Steelhead reach lengths of 20 to 30 inches or more. The head in juveniles and females is about 20 percent of the total body length, but the heads of males become somewhat longer with sexual maturity. The eyes are moderate in size, usually about 20 percent of the head length. The snout is rounded and is slightly longer than the eye diameter except in breeding males, in which the snout is extended and the lower jaw is turned up. The mouth is located on the end of the snout and is rather large. The maxillary is long, usually extending past the eye. The teeth are well developed. The scales are rather small and generally round, although the shape varies somewhat among different stocks (Scott and Crossman 1973).

Steelhead have one dorsal fin, which is located midpoint on the back and has 10 to 12 soft rays. The edges of the dorsal fin are square. Steelhead have a fleshy adipose fin located behind the dorsal fin. The tail fin is broad but not long, and is moderately forked on smaller fish, and rather square on large fish. The anal fin has 8 to 12 soft rays and square edges, and is relatively small. The pelvic fins are located on the belly, are rather small, and have nine or ten soft rays and small axillary processes at the base. The pectoral fins are rather small, are rounded to pointed (depending upon the individual), and have 11 to 17 soft rays (Scott and Crossman 1973).

Steelhead have different coloration depending upon habitat, size, and sexual stage. Although the different colorations have resulted in different scientific and common names for steelhead, Needham and Gard (1959) suggest that there is no reason for subspecies names based on coloration. Generally, the back, top of the head, and upper sides of steelhead are either steel-blue or blue-green, to yellow-green. The sides are silvery, white, or pale yellow-green to grey. The belly is silvery, white or grey to yellowish. The cheeks and opercula are pink. The sides of the body have a pink stripe that, in some populations, may be a very distinctive red band. Spotting varies greatly among different individuals and different stocks, but generally there are a large number of rather small black spots on the body. The spots may be either mostly restricted above the lateral line or scattered over the whole side. The dorsal and tail fins have rows of black spots. The adipose fin has a black border and a few spots. The other fins have a few spots, but they may be dusky or clear colored. Spawning fish are very dark and display a very red lateral band (Scott and Crossman 1973).

Juvenile steelhead have five to ten dark marks on the back between the head and dorsal fin. They also have five to ten short, dark, oval parr marks widely spaced on the sides. These parr marks straddle the lateral line. The space between the parr marks is wider than the parr mark. The dorsal fin has a white to orange tip and a dark leading edge. The adipose fin is edged with black and the anal fin has an orange to white tip. There are few or no black spots on the tail fin (McPhail and Lindsey 1970).

Since there are so many stocks with different characteristics, steelhead have few distinguishing characteristics, except that they have a uniformly silvery overall color until they darken toward spawning time (Wydoski and Whitney 1979).

Distribution

The original range of the steelhead was the eastern Pacific Ocean and its freshwater tributaries west of the Rocky Mountains from northern Mexico to the Kuskokwim River in Alaska. Steelhead have been widely introduced in North America, New Zealand, Australia, South America, Africa, Japan, southern Asia, Europe, and Hawaii (MacCrimmon 1971).

Summer steelhead runs occur throughout the mainstem lower Deschutes River below the Reregulating Dam and in most tributaries below the dam. Historically, steelhead were also found in the Deschutes River upstream to Big Falls (RM 128), in Squaw Creek, and in the Crooked River (Nehlsen 1995). There is some question as to whether steelhead were present historically in the Metolius River (Nehlsen 1995). Because salmon were present in the Metolius River, however, it is likely that steelhead were also present.

Life History

Steelhead exhibit a wide range of life history traits depending upon their location and habitat. For example, some young steelhead may migrate to the ocean after spending 3 to 4 months in fresh water, while other young steelhead may not migrate to the ocean until they are age 2 or 3. Their length of stay in the ocean may vary from 1 to 4 years. Maher and Larkin (1955) and Withler (1966) provide extensive general life history information on anadromous steelhead. However, the life history traits of many individual steelhead stocks are not well described, and virtually nothing is known about steelhead migrations or habits in the ocean (Scott and Crossman 1973).

In Oregon, steelhead life history studies have been conducted in the Rogue River Basin in Southwest Oregon. In addition, steelhead life history studies are on-going in the Hood River and Grande Ronde basins (B. McPherson, ODFW, personal communication, September 1998).

Zimmerman and Reeves (1998) are investigating differences between steelhead and rainbow trout in the Deschutes River.

Wild steelhead originating in the Deschutes River Basin have a total of eight different life history pathways (Olsen et al. 1991). Life history pathways are developmental characteristics (i.e., age at maturity, time of adult migration, time of spawning, age as smolts, etc.), each having its own set of environmental requirements (Lestelle et al. 1996). Most Deschutes River steelhead are summer-run steelhead, entering the Columbia River in early summer and entering the Deschutes River in August and September. Fry (1942) describes a spring and fall run of steelhead entering the Deschutes, with the spring run entering the river in April and May and the considerably larger fall run entering in August and September. Counts of wild adult steelhead at Pelton Dam during 1957 through 1965 indicated that steelhead migrated past the dam throughout the year, with peak numbers in late fall and early spring (Gunsolus and Eicher 1962). Steelhead runs at the Pelton Fish Trap formed three size groups: (1) a group in late spring averaging 8 to12 pounds; (2) a group in the summer averaging 3 to 5 pounds; and (3) a group in the fall averaging 8 to 12 pounds in weight of individuals (Gunsolus and Eicher 1962).

Steelhead normally spawn in the Deschutes River Basin in the late winter and spring, from February to June, depending on water temperature and location. Spawning in the mainstem lower Deschutes River and its west-side tributaries usually begins in March and continues through June. Spawning in east-side tributaries of the lower Deschutes River occurs from January through mid-April (ODFW 1997).

Spawning occurs at water temperatures between 50 and 60ºF. Spawning behavior of steelhead is similar to that of salmon. Males are aggressive on the spawning grounds and drive other males away from a nest occupied by a female. The male courts the female by sliding along and crossing over her body, rubbing his snout against her tail area. The female digs a redd in the gravel by turning on her side and beating her tail up and down. In this way, she cleans the gravel and excavates a pit that is longer and deeper than her body. Nest building may take place at any time of day or night. The redd may cover up to 6.5 square yards, but most redds are smaller. During the act of spawning, the female and male drop their eggs and sperm at the same time. The eggs fall into spaces between the gravel (Scott and Crossman 1973). After the spawning act is complete, the eggs are covered with a layer of gravel several inches to a foot thick (Wydoski and Whitney 1979).

Not all steelhead die after spawning. Those steelhead that survive attempt to return to sea a short time after spawning (Wydoski and Whitney 1979). It is rare for steelhead to spawn more than twice before dying, and most steelhead that make a second spawning run are females (Federal Register March 10, 1998).

Zimmerman and Reeves (1998) have determined that steelhead and rainbow trout (the resident form of this species) spawn in different habitat and at different times in the Deschutes River, thus maintaining a genetic separation between anadromous and resident stocks.

The number of eggs per female steelhead varies and is dependent on the size of the female and the stock of fish. The number of eggs per female ranges from 2,000 to 5,000 for fish 22 to 31 inches in length (Ging 1973). Egg counts for wild steelhead in the Deschutes River have ranged from 3,093 to 10,480 eggs per female, with averages of 5,341 eggs per female for fish that have spent 1 year in the ocean and 5,930 eggs per female for fish that have spent 2 years in the ocean (Olsen et al. 1991). Eggs hatch in about 50 days when the water temperature is 50ºF. Egg survival rates vary among different habitats and stream conditions (Wydoski and Whitney 1979).

Fry emerge in spring or early summer depending on time of spawning and water temperature during egg incubation. In the Deschutes River, fry emerge in late May through June (Zimmerman and Reeves 1996). Fry commence feeding about 15 days after hatching. Fry remain in pools until they become large enough to swim in the current. They occupy riffle areas in summer and pools during the other seasons. Generally, they are associated with the stream bottom (Wydoski and Whitney 1979). Growth rates of steelhead fry very with location, habitat, life history traits, and quantity and type of food (Scott and Crossman 1973).

Juvenile steelhead begin migrating seaward from natal streams in spring. Some steelhead may begin the migration during their first year, but others wait until subsequent years, up to their fourth year of life. Most stay in fresh water for 2 years. In the Deschutes River, many of the juveniles that migrate from the tributaries continue to rear in the mainstem lower Deschutes River before smolting (ODFW 1997). Migratory behavior appears to be hereditary. Some stocks have few or no individuals that migrate to sea (Wydoski and Whitney 1979).

The timing of the final portion of seaward migration depends on such factors as fish size and time of year. Smolts usually move to the sea during April through June, with a peak in about mid-April. Deschutes River steelhead smolts migrate through the lower Deschutes and Columbia rivers from March through June (ODFW 1997). Throughout the geographic range of steelhead, however, juvenile steelhead migrate to sea during each month of the year. Smolts are about 5 to 8 inches in length when they migrate to sea (Wydoski and Whitney 1979).

Steelhead will spend 1 to 4 years at sea. Wild summer steelhead originating in the Deschutes River typically return after 1 or 2 years in the Pacific Ocean (ODFW 1997). Typical of other summer steelhead stocks, very few steelhead return to spawn a second time in the lower Deschutes River (ODFW 1997). Steelhead may live up to age 9 or 10 (Wydoski and Whitney 1979).

Steelhead have well-developed homing behavior that allows them to find their way back to the natal stream to spawn. Homing appears to be guided by long-term memory of specific odors and to a lesser degree by vision. Imprinting to the home stream appears to occur very early in life (Spence et al. 1996).

HABITAT REQUIREMENTS

Steelhead require access to and from spawning and rearing areas; clean gravel for spawning; low sediment levels when eggs are in the gravel and when parr are feeding; food; cool, flowing waters free of pollutants; and high dissolved oxygen concentrations in rearing and incubation habitats (Everest et al. 1985). Steelhead prefer water temperatures lower than 70ºF, although they can survive water temperatures from 32ºF up to 80ºF (Spence et al. 1996).

Adult steelhead also need holding or resting sites and suitable flow and water quality for upstream migration (Spence et al. 1996). Summer steelhead may hold in mainstream rivers for several weeks or months prior to moving into their natal streams to spawn (Bjornn and Reiser

1991). Large woody debris, boulders, and other structures provide hydraulic complexity and pool habitats that serve as resting stations for fish as they migrate upstream to spawn. Such structure may also provide isolated pockets of cool water. In shallow reaches, riparian vegetation and large wood also provide cover from predators (Spence et al. 1996).

Steelhead migrate far upstream into headwaters to spawn. Streamflow during the spawning migration must be sufficient to allow passage over barriers. Minimum depths that will allow passage of steelhead are approximately 5 inches (Bjornn and Reiser 1991). Greater depths may be needed to negotiate larger barriers. Steelhead are capable of leaping about 11 feet if the pool depths exceed barrier height by approximately 25 percent (Stuart 1962).

Adult steelhead migrate when temperatures are less than 57ºF. Excessively high or low temperatures may delay migration (Major and Mighell 1966, Hallock et al. 1970, Monan et al. 1975), and excessively high temperatures during migration may cause outbreaks of disease (Spence et al. 1996). Adult steelhead that move from the ocean into river systems in the summer and fall may overwinter in larger rivers, delaying entry into smaller spawning tributaries until the streams are free of ice in the spring (Spence et al. 1996). Adult steelhead expend high energy swimming upstream to natal areas. Reduced dissolved oxygen levels greatly impair migration performance (Davis et al. 1963, Hallock et al. 1970).

At spawning sites, adequate areas of stable, appropriately sized gravel are required for successful spawning (Spence et al. 1996). Spawning gravel for steelhead is proportional to adult size (Marcus et al. 1990). Steelhead generally spawn in gravel less than 0.5 inch to as large as 4 inches in diameter (Bjornn and Reiser 1991). Steelhead spawn in water ranging from 5 to 35 inches deep and with velocities ranging from 1.3 to 3.6 feet per second (Smith 1973, Bjornn and Reiser 1991, Hunter 1973, Graybill et al. 1979). Steelhead spawn in temperatures from 40 to 57ºF. Eggs deposited in small gravel or gravel with a high percentage of fine sediments have low survival rates (Harrison 1923, Hobbs 1937, Shapovalov and Berrian 1940, Shaw and Maga 1943, Koski 1966). McHenry et al. (1994) found steelhead egg mortality excessive if fine material, which he considered to be the lowest 13 percent of the material by size distribution, was less than 1/3 inch in diameter. Steelhead avoid spawning in areas with high percentages of sand, silt, and clay (Burner 1951, Stuart 1953).

Steelhead parr typically prefer riffle habitats during summer (Everest et al. 1985) but shift to pool habitats in winter (Bjornn and Reiser 1991. Large woody debris interacts with natural channel-forming features such as boulders to create different types of pool habitats. Undercut banks and overhanging vegetation also serve as cover for juveniles. Boulders may provide isolation and cover from predators. In winter, steelhead parr have been observed in areas between rocks. Gravel, cobbles and boulders provide better areas for hiding than sand or silt (Chapman and Bjornn 1969, Bustard and Narver 1975, Campbell and Neuner 1985, Hillman et al. 1989a).

Numerous studies have been done to determine stream depth and velocity preferred by steelhead parr. Within stream environments, parr select habitats where water depth and velocity are within specific ranges. Preferences for water depth and velocity change by season and with life stage. Parr prefer to live in water 12 to 20 inches deep (Sheppard and Johnson 1985, Thompson 1972) and in water flowing 0.2 to 1 foot per second (Everest and Chapman 1972, Moyle and Baltz 1985, Thompson 1972). During summer months, parr select areas of moderate water velocities adjacent to faster waters (Chapman and Bjornn 1969, Jenkins 1969, Everest and

Chapman 1972). This position provides the greatest amount of food in proportion to water velocity (Wankawski and Thorpe 1979, Smith and Li 1983). During winter months, food requirements and swimming ability decrease (Brett 1971, Dickson and Kramer 1971, Griffiths and Alderdice 1972). At this time of year, parr tend to select slower water velocities, moving to off-channel habitats, or seeking refuge in interstices between rocks (Bustard and Narver 1975, Tschaplinski and Hartman 1983, Campbell and Neuner 1985, Johnson and Kucera 1985, Sheppard and Johnson 1985).

Steelhead parr can withstand temperatures between freezing and 75ºF, but they prefer temperatures between 50 and 55ºF (Lee and Rinne 1980, Charlon et al. 1970). Muddy water for short periods of time seems to have little affect on parr (Sorenson et al. 1977), but if present for extended periods, turbidity affects growth (Sigler et al. 1984) and will eventually cause parr to more to other areas (Bisson and Bilby 1982).

Migrating steelhead smolts require unobstructed access, cover, and sufficient flows to move downstream (Spence et al. 1996). Changes in temperature or streamflow trigger downstream movement once fish are ready to migrate (Groot 1982). Spence (1995) found that short-term flow fluctuations also stimulate smolt movement. Conditions that increase water temperature, such as removal of riparian habitat, induce earlier migration (Holtby 1988). If temperatures exceed threshold levels, smolts will revert to a presmolt condition and remain within the stream (Spence et al. 1996).

Supersaturation of dissolved gasses in water within the migration corridor have adverse affects on migrant smolts (Ebel and Raymond 1976). Steelhead smolts appear to be more susceptible than salmon smolts to supersaturation of dissolved gasses, and there is some evidence that steelhead smolts can sense and avoid areas with high levels of dissolved gasses (Stevens et al. 1980).

The impact of turbid waters in the migration corridor is unknown. Smolts tend to migrate during the evening hours (Burgner 1991) presumably to avoid predators (Spence et al. 1996). Turbid water may serve the same purpose as darkness to obscure visibility of predators and provide safe passage for smolts.

INTER/INTRASPECIFIC INTERACTIONS

Fish, mammals, and diving birds are the primary natural predators of juvenile steelhead (Chapman et al. 1994). Fish species that prey on steelhead include other trout, char, salmon, northern pikeminnow, bass, walleye and any other fish that eat eggs or small fish.

Young steelhead are primarily bottom feeders, but rise to the surface to feed on insects, a habit well known by anglers. The diet of young steelhead includes plankton, insects and insect larvae, snails, leeches, and fish eggs. Shapovalov and Taft (1954) found that as steelhead grow their diet changes from small aquatic organisms to larger foods such as worms and insects, although Peven (1990) found that as juvenile steelhead grow they continue to consume food primarily associated with the stream bottom.

Chapman et al. (1994) speculate that the most likely form of interspecific competition affecting steelhead is between juvenile steelhead and juvenile chinook salmon. However, Hillman et al. (1989a, 1989b) found that steelhead and chinook juveniles used different areas of daytime and nighttime habitat throughout the year. During the daytime in summer and fall, juvenile steelhead selected shallower and slower water than chinook. Steelhead primarily occupied areas near cobble and boulder cover, while chinook selected areas associated with brush and woody debris for cover. Hillman et al. (1989b) found that in daytime during winter months, steelhead and chinook used similar habitat and similar water velocities, but steelhead selected much shallower water than chinook. Everest and Chapman (1972) found that steelhead and chinook also maintained segregated spawning habitats by spawning at different times of the year.

Interspecific interaction may also occur between juvenile steelhead and redside shiners. Reeves et al. (1987) noted that in cool water, steelhead competed more successfully for food than did redside shiners; in warm water, however, redside shiners were more active and responded to food more quickly than did trout. On the other hand, Hillman (1989) and Griffith and Hillman (1986) noted that juvenile steelhead and redside shiners are usually not observed together.

Intraspecific interaction may occur between juvenile steelhead and hatchery rainbow trout. Hillman and Chapman (1989b) found that when both juvenile steelhead and hatchery rainbow trout inhabited the same waters, overlap in habitat use was minimal. Hatchery trout remain in pools where they were released, while steelhead were found in riffles, rapids, and cascades. Hillman and Chapman (1989) and Pollard and Bjornn (1988) observed no difference in steelhead habitat use before and after release of hatchery fish.

Juvenile steelhead may interact with brook trout, bull trout, and cutthroat trout if they occur together (Chapman et al. 1994). Hanson (1977) found that young steelhead displaced young cutthroat.

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Steelhead are not currently found in the Metolius River. Fulton (1970) states that steelhead were native to the Metolius River, but elders from the Confederated Tribes of Warm Springs Reservation of Oregon do not believe that steelhead were native to the Metolius River (Fies et al. 1996). ODFW records do not indicate the presence of steelhead in the Metolius River. Steelhead were probably historically present in the Metolius River, but in small numbers (Fies et al. 1996).

Middle Deschutes River — Steelhead Falls to Billy Chinook

Most of the historic spawning and rearing of steelhead in the Deschutes River above Lake Billy Chinook occurred in Squaw Creek, although some steelhead spawning and rearing apparently occurred in the upper mainstem Deschutes River. When the Oregon State Game Commission began surveys in 1951, no steelhead were observed spawning in the upper mainstem Deschutes River, but a few steelhead were trapped at Steelhead Falls in 1953, 1954, and 1955, suggesting the potential for steelhead spawning up to Big Falls. Counts of adult steelhead at the

Pelton fish trap and counts in index spawning survey areas indicate that many steelhead were spawning in areas other than Squaw Creek, including the mainstem Deschutes River above Lake Billy Chinook (Nehlsen 1995).

Squaw Creek was the primary steelhead spawning and rearing tributary in the reach of the Deschutes River above Lake Billy Chinook. In the 1950s, the number of steelhead counted annually in Squaw Creek (trapped at a weir located 16 miles upstream of the mouth and in the 16 miles below the weir) ranged from 62 to 619. Counts in this reach dwindled in the 1960s (Nehlsen 1995). Several factors affected the accuracy of the counts, including problems keeping the weir functional, effects of the weir on upstream migrants, and poaching (King 1966). All counts were considered as index counts rather than estimates of total abundance (Nehlsen 1995). Termination of fish passage at the Pelton Round Butte Project in 1968 eliminated summer steelhead from Squaw Creek.

Lower Crooked River

Although not currently found in these waters, steelhead were historically present throughout much of the Crooked River Basin, including the area downstream of Prineville Reservoir. Steelhead spawning and distribution were not systematically documented until after the construction of Bowman, Pelton, and Round Butte dams. By then, turbid stream conditions and poor access made observation difficult, and frequently unsuccessful (Stuart et al. 1996). Steelhead were documented in Beaver, Twelvemile, Drake, Newsome, Horseheaven, Ochoco, and McKay creeks and in the lower North Fork Crooked River (OSGC 1950-1973). The numbers of fish located were small (Montgomery 1952, 1953, 1954). Irrigation dams, irrigation withdrawals, low flows and high summer temperatures made steelhead production unsuitable in much of the middle portion of the basin (Stuart et al. 1996). Fish passage was terminated at the Pelton Round Butte Project in 1968, eliminating summer steelhead from the lower Crooked River (Stuart et al. 1996).

Lake Billy Chinook

Steelhead are not currently found in Lake Billy Chinook. Historic population size, distribution, and production levels of steelhead for the area inundated by the construction of Round Butte Dam are not known. However, steelhead likely spawned and reared in the area inundated by water with the construction of Round Butte Dam because the number of adult steelhead counted passing the Pelton Fish Trap from 1957 to 1965 was far greater than could be accounted for in index spawning surveys upstream of the affected area (Nehlsen 1995).

Between 1957 and 1965, the years when the Pelton Round Butte Project was under construction, numbers of adult steelhead caught in the upstream migrant trap ranged from 274 to 1,619. The freshwater survival rate of juveniles per upstream migrant adult was 7 in 1960, 5 in 1961, and 15 in 1962. The low rates of survival of both adult and juvenile steelhead after construction of the Project was insufficient to perpetuate the run (Gunsolus and Eicher 1962).

Gunsolus and Eicher (1962) and Korn et al. (1967) found that several thousand steelhead smolts were taken by sport fishing in Lake Billy Chinook after the reservoir filled, and that interspecific interactions, primarily in the form of predation, caused further significant mortality of juvenile steelhead.

Efforts to perpetuate the naturally spawning runs above Round Butte Dam were abandoned, and hatchery compensation was initiated in 1968. Considerable debate ensued about mitigation levels (Eicher 1965, 1969; Mathisen and Schneider 1965; McKean and Schoning 1969, 1970). Proposed steelhead mitigation levels were based on the Squaw Creek and Pelton Fish Trap counts; historical anecdotes; pre-Pelton Dam fish and redd counts; and potential runs of steelhead represented by the existing stream flows, amount of spawning gravel, and other favorable habitat factors in Squaw Creek and the upper Deschutes River below Big Falls (Nehlsen 1995). The parties eventually agreed on a mitigation level of 1,800 adult steelhead. At the present time, steelhead are not passed into Lake Billy Chinook.

Lake Simtustus

Steelhead do not now occur in Lake Simtustus. Historically, however, steelhead used the area presently inundated by Pelton Dam as a migration corridor and rearing area, and perhaps also for spawning. Efforts to document steelhead spawning and distribution were not conducted until the 1950s, when plans were well underway for the construction of dams. By that time, turbid stream conditions, poor access, and a lack of effort to find spawning steelhead all resulted in little documentation of spawning steelhead. Consequently, little is know about the historical population size and distribution of steelhead in the Lake Simtustus area (Stuart et al. 1996). The steelhead mitigation discussed for Lake Billy Chinook (above) included Lake Simtustus.

Lower Deschutes River

Summer steelhead occur throughout the mainstem lower Deschutes River and in most of its tributaries. Lower Deschutes River summer-run steelhead are classified as a wild population under Oregon's Wild Fish Management Policy [ORS 635-07-529(3)]. Wild summer-run steelhead spawn in the lower Deschutes River, the Warm Springs River system, White River, Shitike Creek, Wapinitia Creek, Eagle Creek, Nena Creek, the Trout Creek system, the Bakeoven Creek system, the Buck Hollow Creek system, and other small tributaries. Spawning in White River is limited to the 2 miles below White River Falls. The upstream distance of spawning in Nena Creek is limited by a natural barrier. Spawning in the mainstem lower Deschutes River accounts for 30 to 60 percent of the Deschutes River Basin natural production of steelhead (ODFW 1987,1997). The Warm Springs River system contributes a large portion of the tributary production area.

The number of wild steelhead entering the Deschutes River is unknown. All estimates of summer steelhead escapement in the Deschutes River are based on numbers documented in runs over Sherars Falls. The estimated number of returning adult wild summer steelhead migrating over Sherars Falls has ranged from a low of 480 in the 1994 run year to a high of 9,600 in the 1985 run year. The average spawning run over Sherars Falls is 4,900 (ODFW 1997). Based on available habitat, habitat condition, average fecundity, and egg-to-smolt survival rates, the lower Deschutes River and tributaries is capable of producing approximately 147,700 steelhead smolts per year and an annual adult spawning population of approximately 6,600 (ODFW 1987).

FISHERIES

Angling and harvest of summer steelhead in the lower Deschutes River has been an important recreational and tribal fishery. Recreational fishing occurs throughout the lower Deschutes River and is restricted by angling methods, season lengths, and bag limits. Currently, the bag limit is restricted to the harvest of hatchery-origin steelhead (ODFW 1997); all wild steelhead caught in the recreational fishery must be released.

Tribal fisheries occur primarily with dipnets in the area immediately below Sherars Falls. The fishery is regulated through time and area closures. Currently, wild steelhead caught in the tribal fishery are released (ODFW 1997).

Based on habitat availability, average fecundity of female steelhead, and an assumed egg-to-smolt survival rate of 0.75 percent, the maximum steelhead production capacity of the lower Deschutes River is approximately 147,700 smolts, with an adult spawning population of approximately 6,575 adults. The estimated adult return from a spawner escapement of 6,575 is 9,089 adults, assuming a 6 percent wild smolt-to-adult survival rate (ODFW 1987). Based on calculations of 6,575 adult steelhead escapement to spawn and a 6 percent wild smolt-to-adult survival rate (ODFW 1987), approximately 2,500 adult steelhead should be available for harvest each year (ODFW 1997).

Currently, no specific harvest goals or allocations have been established for wild summer steelhead in the lower Deschutes River Basin. ODFW has proposed a tiered escapement at Sherars Falls (ODFW 1997). The tiered escapement proposal provides the following:

1.If wild steelhead escapement over Sherars Falls exceeds 6,575 fish for five consecutive years, a consumptive harvest, not to exceed 2,500 wild steelhead, will be proposed.

2. At escapement levels between 1,000 and 6,575 over Sherars Falls, harvest of wild steelhead will not be considered.

3.If wild steelhead escapement over Sherars Falls is less than 1,000 adults for three consecutive years, special regulations will be recommended.

4.If the run drops to less than 300 adults, further special regulations will be recommended.

LIMITING FACTOR

Constraints to natural production of steelhead in the Deschutes River Basin include channelization, lack of in-stream cover, flash flooding, low flow, low gravel quantity, high gradient, ice, poor pool-to-riffle ratio, stream bank degradation, sedimentation, and high temperatures. The Pelton Round Butte Project is an upstream passage barrier to steelhead. Natural barriers on tributaries to the lower Deschutes River include the falls on White River and Nena Creek. Several unscreened irrigation diversions in the Trout Creek system contribute to losses of juvenile steelhead. Past recreational and tribal harvest of wild steelhead may have had a constraining effect on the population size (ODFW 1997).

Schroeder and Smith (1989) speculate that interactions with rainbow trout also may have a potential for limiting steelhead numbers. The effects of competitive interactions with resident species on wild steelhead are still unclear but is currently being evaluated (Zimmerman and Reeves 1996, 1998).

Passage conditions for both juvenile and adult steelhead at mainstem Columbia River dams has contributed to the declines in Deschutes River Basin wild steelhead. Passage through turbines, delay in passage caused by dams, longer travel time caused by reservoirs behind dams, increased water temperatures in the reservoir environment, and increased predation near mainstem dams all contribute to increased losses of juvenile and adult steelhead (ODFW 1997). Harvest of wild steelhead in the mainstem Columbia River and natural events outside the Deschutes River Basin further constrain natural production in the basin (ODFW 1997).

The Deschutes River receives large numbers of stray (from other basins) steelhead of both wild and hatchery origin (ODFW 1997). This phenomenon has the potential to introduce genetic material that is mal-adapted to wild steelhead survival in the lower Deschutes River Basin (ODFW 1997). Wild lower Deschutes River steelhead populations may have declined, and the decline may be due in part to the mating of and competition between native and non-native wild and hatchery steelhead in the Deschutes River Basin (ODFW 1997).

Infectious disease is one of many factors that can influence adult and juvenile steelhead survival. Steelhead are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and marine environments. Specific diseases such as bacterial kidney disease, ceratomyxosis, columnaris, Furunculosis, infectious hematopoietic necrosis, redmouth, black spot disease, and Erythrocytic Inclusion Body Syndrome are present in the Deschutes River Basin and are known to affect steelhead (Rucker et al. 1953, Wood 1979, Leek 1987). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. However, studies have shown that native fish tend to be less susceptible to pathogens than hatchery-reared fish (Buchanon et al. 1983, Sanders et al. 1992).

ECOLOGICAL ROLE

Historically, steelhead and the resident rainbow probably developed many different life history pathways to support the preservation of the species. Steelhead and rainbow trout are a major species of fish in north Pacific streams and lakes because of their ability to adapt to different and changing habitat conditions. This adaptability depicts a survival resilience that surpasses that of many other species of fish. Their ecological role may be as simple as filling vacant habitat niches.

Steelhead and resident rainbow are well integrated into the lower Deschutes River fish community. Presently, studies are on-going to evaluate opportunities and issues associated with the potential reintroduction of steelhead above the Pelton Round Butte Project. There is some question as to whether steelhead were native in the Metolius River Basin. However, they were fairly abundant in Squaw Creek and in the Crooked River Basin. Steelhead and resident rainbow trout co-existed in these areas. Habitat conditions for fish have deteriorated in Squaw Creek and the Crooked River Basin, which will restrict steelhead reintroduction options. The reintroduction of steelhead above the Pelton Round Butte Project area will require new fish management strategies with emphasis placed on fish habitat rehabilitation.

Steelhead trout are both predators and prey in the lower Deschutes River Basin. Bisson et al. (1988) describe interactions of steelhead with other species as well as physical characteristics of steelhead that allows them to use specific types of habitat. Because steelhead trout are so widespread in the lower Deschutes River Basin, their physical characteristics must fit available habitat conditions. Steelhead trout have an advantage over resident forms in that when population densities of fish become high, steelhead leave for the ocean. Interactions between resident fish and steelhead may be one of many biological factors creating conditions that allow steelhead to reach the right size at the right time for migration.

RAINBOW TROUT

Oncorhynchus mykiss

Other common names: Redband trout, golden trout, redsides, Kamloops trout, coast rainbow trout, silver trout (Scott and Crossman 1973). In recent years, scientists have referred to resident, inland Oncorhynchus mykiss as redband trout. However, angling regulations continue to refer to O. mykiss as rainbow trout.

General

SCIENTIFIC NAME

Oncorhynchus mykiss. Until recently, redband/rainbow trout were known by the scientific name Salmo gairdneri. Scientists now have evidence of a close genetic link between Pacific trout and salmon (McKay et al. 1996). Consequently, trout native to streams that drain to the Pacific Ocean have been classified together with Pacific salmon under the single genus Oncorhynchus (Smith and Stearly 1989).

APPEARANCE

External characteristics of rainbow trout vary greatly over their range (McAfee 1966). Rainbow trout populations are often called different names to describe these different physical characteristics. In the past, scientists have described subspecies based on physical characteristics, geographic location, and behavior (Richardson 1838; Gibbons 1855; Jordan 1892; Evermann and Clark 1931; Jordan et al. 1930; La Rivers 1962; Rutter 1908; Mottley 1934, 1936a; Miller 1950a, 1950b; Hartman 1956; Behnke 1966; Northcote et al. 1970). Needham and Gard (1959), however, suggest that there is little need to classify subspecies. Compounding identification problems is the fact that rainbow trout breed with other trout creating interesting and colorful hybrids, as described by Buss and Wright (1956).

There is a great variation in rainbow trout body shape that seems to change with environmental conditions (Mottley 1936b, Needham and Gard 1959, Bidgood and Berst 1967, MacCrimmon and Kwain 1969). In general, the body is laterally compressed, especially in larger fish. The head length is typically about 20 percent of the total body length. The diameter of the eye generally makes up about 20 percent of the head length. The snout is rounded with the length of the snout slightly greater than the eye diameter except in breeding males, in which the snout is extended and the lower jaw is turned up to form a kype. The mouth is located on the end of the head. The maxillaries are long, usually extending past the eye (Scott and Crossman 1973).

Fins include a dorsal, an adipose, two pectorals, two pelvic, one anal, and the tail or caudal fin. The dorsal fin is on the back midpoint of the body and has 10 to 12 soft rays. The adipose fin is located behind the dorsal fin. The tail is broad but not long, moderately forked and rather square in larger individuals. The anal fin has square edges and 8 to 12 principal soft rays. The pelvic fins are rather small, square to rounded in shape, and have nine or ten soft rays and small axillary processes. The pectorals are rounded to rather pointed with 11 to 17 soft rays. The scales tend to be round and rather small, although their size and shape is variable among different stocks (Scott and Crossman 1973).

The color of rainbow trout varies with habitat conditions and with size and sexual stage of the fish. Stream-dwelling and spawning rainbow trout are darker and have more distinct colors, while lake-dwelling rainbow trout are lighter and brighter colored with more silver on their bodies. Generally, the back, top of the head, and upper sides of the fish are steel-blue, blue-green, or yellow-green to almost brown. The sides are silvery, white or pale yellow-green to grey and are marked with a vague, pink blush or a wide rose-to red-colored band. There are a large number of rather small black spots that may be restricted to the area above the lateral line or may be scattered over the whole side of the fish. The belly is silvery, white, or grey to yellowish. The cheeks and opercula are pink The dorsal and caudal fins have rows of black spots. The adipose fin has a black border and a few spots. The other fins have few if any spots or borders. Rainbow trout that are about to spawn or that have already spawned are very dark with a bright red lateral band. Stream residents often retain parr marks as adults, making them appear quite different from lake residents of the same size (Scott and Crossman 1973).

Juvenile rainbow trout are blue to green on the dorsal surface, silver to white on the sides, and have white bellies. There are five to ten dark marks on the back between the head and dorsal fin. There are also five to ten short, dark, oval parr marks widely spaced on the sides and straddling the lateral line. The spaces between these marks are wider than the marks. There are some small dark spots above the lateral line. The dorsal fin has a white to orange tip and a dark leading edge, but in some fish there is a series of bars or spots on the dorsal fin. The adipose fin is edged with black, and the anal fin has an orange to white tip. There are few or no spots on the caudal fin (Scott and Crossman 1973, McPhail and Lindsey 1970).

DISTRIBUTION

The range of native rainbow trout is mainly west of the Rocky Mountains from northwest Mexico to the Kuskokwim River in Alaska (Needham and Gard 1959, Lindsey 1956, Scott and Crossman 1973). Scott and Crossman (1973) suggest that rainbow trout also may have been native to the Peace and Athabasca rivers east of the Rocky Mountains. Rainbow trout have been widely introduced in North America, where populations of this species continue to be sustained in numerous areas of suitable habitat (Scott and Crossman 1973). Rainbow trout also have been introduced into New Zealand, Australia, South America, Africa, Asia, Europe, Hawaii (MacCrimmon 1971), and Japan (Scott and Crossman 1973).

LIFE HISTORY

Life history traits of rainbow trout vary with location and type of habitat (Scott and Crossman 1973). There are two basic life history patterns for this species: anadromous (steelhead) and resident (rainbow). This section describes life history traits of rainbow trout.

Rainbow trout are primarily spring spawners that spawn in smaller tributaries from mid-April to late June (Lindsey et al. 1959, Hartman et al. 1962). However, in the Metolius River in the Deschutes River Basin, rainbow trout spawning occurs from November to July, with peak activity in December (Fies et al. 1996a). This local variation in normal spawning time may occur because the Metolius River is formed by warmer spring water, which provides an environment that may allow rainbow to mature earlier in the year.

Rainbow trout tend to move upstream into tributaries to spawn (McAfee 1966). They do not spawn successfully on beaches of lakes (Scott and Crossman 1973). Spawning typically occurs once per year, although Hume (1955) reports that rainbow trout may spawn twice a year in California. An individual fish may spawn several times during its life, but not always in successive years (McAfee 1966). Greeley (1933) observed individual females and males spawning during as many as three and four different years, respectively.

Spawning sites are generally located in small gravel in a riffle above a pool (Scott and Crossman 1973) or in a riffle of moderate gradient at the lower end of a pool (McAfee 1966). Males are aggressive on the spawning grounds and drive other males away from spawning females. A male courts a female by sliding his body along and over her body while rubbing against her body. He may have body vibrations during this activity. The female digs a redd in the gravel by turning on her side and beating her tail up and down. This action cleans the gravel and forms a pit that is longer and deeper than her body. The female may dig the redd at day or night. After the redd is dug, the female moves to the bottom of the pit, the male moves parallel to her, both fish arch their body, vibrate, and the eggs and milt are released at the same time. The fertilized eggs fall into spaces between the gravel, and the female begins digging gravel at the upstream edge of the nest. This gravel moves downstream and covers the eggs. A females may dig several nests during the spawning period and may spawn again with the same male or with other males. A female may lay from 200 to over 9,000 eggs each year (Mottley 1947, Needham 1938, Nicholls 1958, Simon 1946). The eggs are small (about 1/5 inch in diameter) and are pink to orange in color (Simon 1946, Briggs 1953, Greeley 1932, Needham and Taft 1934, Shapovalov and Taft 1954, Scott and Crossman 1973). Spawners lose weight during the spawning period. Rayner (1949) notes weight losses as high as a third of total body mass in females, and as high as nearly half of the body mass in males.

Eggs hatch in 4 to 7 weeks and fry emerge 3 to 7 days later depending upon water temperature, region, and habitat (Scott and Crossman 1973). The incubation period averages about 80 days at 40ºF and 19 days at 60ºF (Embody 1934). Eggs develop normally at temperatures as high as 56ºF, but egg losses may occur at temperatures below 42ºF. Eggs development is described by Wales (1941) and Knight (1963). Fry begin feeding about 15 days after hatching (Scott and Crossman 1973). Fry from April or May spawning emerge from the gravel in mid-June to mid-August (Scott and Crossman 1973). Lake-type rainbow trout fry may move up or down the spawning stream to the lake almost immediately after emergence, or they may spend 1 to 3 years in the stream (Scott and Crossman 1973). Stream-type rainbow trout generally remain in the streams (Scott and Crossman 1973).

Scott and Crossman (1973) describe growth of rainbow trout as “bewildering.” The growth of rainbow trout differs from one population to another and among individuals within a population. Size of rainbow trout with age depends upon environmental conditions, length of time spent as young in the spawning stream, length of time spent in a lake, and years before the first spawning.

The largest rainbow trout occur where forage fish are numerous (McAfee 1966). The weight of rainbow trout per inch of length varies greatly at lengths over 15 inches because of differences in feeding conditions and stage of maturity. Rainbow trout eat a wide variety of foods, as available. The most common foods eaten by rainbow trout are snails, leeches, aquatic insects, zooplankton, terrestrial insects, and fish. Algae, fish eggs, and earthworms are eaten less often (Burdick and Cooper 1956, Hazzard 1935, Idyll 1942, Metzelaar 1929, Needham 1934, Rawson and Elsey 1950). The rainbow trout's habit of rising to feed at the surface on emerging or egg-laying insects is well known to fly fishermen. Detailed analyses of the rainbow trout's feeding habits are presented in Neave and Bajkov (1929), Larken et al. (1950), and Crossman and Larken (1959). Rainbow trout are generally not considered upper-level predators, although large rainbow trout may feed extensively on other fish, including kokanee (Mottley 1947). The rainbow trout's digestion rate varies with temperature and food type (Reimers 1957).

Sexual maturity in rainbow trout can be achieved at age 1 in males to as late as age 6 in females; however, the average length of time to reach maturity is age 3 to 5, with males generally maturing a year sooner than females (Greeley 1933, Mottley 1947, Scott and Crossman 1973). Size at maturity, which reflects habitat conditions and competition with other fish, is extremely variable in rainbow trout, ranging from 5 inches in headwaters to over 10 pounds in some lakes (McAfee 1966). Maximum size at maturity also varies with area, type of rainbow trout, and habitat. Rainbow trout in the Great Lakes grow to about 36 inches, but rarely exceed 20 pounds. Lake-type rainbow trout in other areas usually do not exceed 6 to 8 pounds. However, a record rainbow trout was caught in Lake Pend Oreille, Idaho, in 1947 that was 40.5 long, 28 inches in girth, and 37 pounds in weight (Scott and Crossman 1973). Life expectancy varies from as low as age 3 to 4 to as high as to age 6 to 8 (Scott and Crossman 1973).

Habitat Requirements

Migration distances of rainbow trout may vary from a few hundred yards to several miles (Everest et al. 1985). During migration, rainbow trout need diverse habitats to accommodate their needs for resting sites, suitable flows, and prey. Large woody debris, boulders, and other structures provide hydraulic complexity and pool habitats that serve as resting stations. Such resting sties out of the main current also are used by resident species to wait for prey to drift by in adjacent, faster waters. Stream flow during the spawning migration must be sufficient to allow passage over barriers such as falls, cascades, or debris jams. Therefore, spawning migration may coincide with high flows to provide passage (Spence et al. 1996). The minimum water depth to allow passage of rainbow trout is approximately 5 inches (Bjornn and Reiser 1991). Maximum leaping ability of rainbow trout varies from 2.6 feet to 11 feet (Reiser and Peacock 1985), but pool depths must exceed barrier height by approximately 25 percent to allow the fish to reach swimming velocities necessary to leap the maximum heights (Stuart 1962).

Rainbow trout may hold at the mouths of spawning streams until temperatures warm to the preferred temperature range (Bjornn and Reiser 1991). High turbidity may delay or divert spawning runs (Smith 1939, Servizi et al. 1969, Mortensen et al. 1976).

Rainbow trout spawn in water at least 7 inches deep that is flowing 1.3 to 2.6 cfs (Smith 1973, Chambers et al. 1955, Li et al. 1979). Rainbow trout spawn in temperatures usually between 50 to 60ºF in small gravel (Scott and Crossman 1973). However, rainbow trout may spawn in temperatures as low as 36ºF to as high as 68ºF (Bell 1986). Everest et al. (1985) found rainbow trout spawning in temperatures of 40 to 55ºF. Rainbow trout require sufficient gravel within a specific size range for successful spawning. Usable gravel size generally is proportional to fish size; larger individuals spawn in larger gravel (Marcus et al. 1990). Rainbow trout spawn in gravel ranging in size from 0.2 to 4 inches in diameter (Bjornn and Reiser 1991). Zimmerman and Reeves (1998) observed rainbow spawning in gravel that averaged approximately 1 inch in diameter in the lower Deschutes River.

Rainbow trout also require spawning gravels that have a minimum amount of fine sediments and organic material. Fine sediments and organic material in redds negatively affect the environment of eggs and sac fry by diminishing intragravel flows, and they act as a physical barrier to fry emergence (Cooper 1959, Wickett 1958, McNeil and Ahnell 1964, Koski 1972, Everest et al. 1987). McHenry et al. (1994) determined that sediments and organic material in the gravel resulted in mortality of eggs and sac fry.

Most studies designed to determine preferred egg incubation temperatures for salmonids have been conducted for anadromous species. Nevertheless, information from these studies also adequately summarizes characteristics of rainbow trout egg incubation. Generally, water temperature correlates with egg mortality, with the number of abnormal fry, and with the length of incubation (Seymour 1956). Eggs hatch in about 50 days when the water temperature is 50ºF. Eggs and sac fry need high levels of oxygen to survive (Shirazi and Seim 1981). Phillips and Campbell (1961) suggest that dissolved oxygen content in the water must be fairly high for eggs and sac fry to survive. Doudoroff and Warren (1965) reported that dissolved oxygen concentrations below saturation resulted in increased incubation periods, while Silver et al. (1963) and Shumway et al. (1964) observed that trout reared in water with low or intermediate oxygen concentration were also smaller in size than those raised in waters with high dissolved oxygen contents.

The abundance of juvenile and adult rainbows trout is influenced by the quantity and quality of habitat, food availability, and interactions with other species, including predators and competitors (Bjornn and Reiser 1991). Bjornn and Reiser (1991) suggest that at any given time, environmental conditions may be better suited for some individuals or populations than for others. This observation suggests that there is no "optimal" habitat for all individuals at all life stages (Spence et al. 1996).

Rainbow trout prefer riffle habitats during summer (Everest et al. 1985) and often select positions at moderate velocities but immediately adjacent to faster waters (Chapman and Bjornn 1969, Jenkins 1969, Everest and Chapman 1972). During winter, swimming ability decreases because the water is colder (Brett 1971, Dickson and Kramer 1971, Griffiths and Alderdice 1972), and fish may be less able to maintain positions in fast waters. In these conditions, rainbow trout may move to slower water, to off-channel habitats, or may seek refuge in pools (Chapman and Bjornn 1969, Bustard and Narve 1975, Tschaplinski and Hartman 1983, Campbell and Neuner 1985, Johnson and Kucera 1985, Sheppard and Johnson 1985, Spence 1989, Hillman et al. 1989). During any season, smaller sized fish tend to select shallower, slower moving waters than do larger individuals (Chapman and Bjornn 1969, Everest and Chapman 1972, Moyle and Baltz 1985). Newly emerged fry may be vulnerable to downstream displacement by flow (Bjornn and Reiser 1991).

The preferred water temperature for rainbow trout is about 50 to 55ºF (Bell 1986). The upper lethal temperature is 77ºF (Charlon et al. 1970) to 85ºF (Lee and Rinne 1980). The lower lethal temperature is near 32ºF (Spence et al. 1996). The ability of rainbow trout to tolerate temperature extremes depends on the recent thermal history that the fish has experienced. Fish acclimated to low temperatures have lower temperature thresholds than those acclimated to warmer temperatures (Spence et al. 1996). Many rainbow trout habitats experience conditions that approach or exceed upper lethal temperature levels. Li et al. (1991) recorded resident rainbow trout selecting natural and artificially created coldwater seep habitats when main-channel temperatures exceeded 75ºF.

Turbid waters during storms and snowmelt do not generally affect rainbow trout (Sorenson et al. 1977). However, Lloyd et al. (1987) found that juveniles avoided streams that were chronically turbid. Turbidity influences feeding behavior of resident fish by reducing the distance over which they can locate prey (Spence et al. 1996).

In general, growth of rainbow trout is faster in lakes than in streams. Growth in lakes, where the primary food is zooplankton and insect larvae, is usually rapid. Rapid growth may continue if forage fish are available. Fish are eaten, particularly by larger rainbow trout, in many lakes. The food of rainbow trout in streams is mostly of bottom-living and terrestrial insects (Carlander 1969).

INTER/INTRASPECIFIC INTERACTIONS

Many fish including whitefish, suckers, minnows, sculpins, and other species of trout compete with rainbow trout for food and habitat (McAfee 1966). Young rainbow trout potentially compete with all other salmonids for food (Scott and Crossman 1973). The effect of competition on rainbow populations is difficult to assess, however, because interspecific relationships are not thoroughly understood (McAfee 1966).

The availability of other fish as food is often considered necessary for rainbow trout to attain large size (Scott and Crossman 1973). Rainbow trout grow well in some waters with large numbers of chubs, suckers, and other nongame fish (McAfee 1966). Hartman (1956) demonstrated a correlation between mouth size of young rainbow trout and the sizes of stonefly nymphs, caddis larvae, and trout fry eaten. However, large rainbow are not as predaceous as brown or lake trout of comparable size (McAfee 1966).

Generally, the territory used by lake-type rainbow trout is not large (Scott and Crossman 1973). Shields and Groves (1998) initiated a study to determine territory, movement, and mixing of rainbow trout populations in the three arms of Lake Billy Chinook. Groves and Shields (1998) have marked and recaptured rainbow trout to determine territory and movement patterns. Groves and Shield (1998) have also examined rainbow trout to determine if there are physical characteristics that would separation populations of rainbow trout in each of the three arms of Lake Billy Chinook. Groves and Shields (1998) have found some evidence of separation of rainbow trout populations in Lake Billy Chinook, but their findings are preliminary. Separation of rainbow trout populations in Lake Billy Chinook would support findings that the territory used by lake-type rainbow trout is not extensive.

Carlander (1969) found that in some locations, rainbow trout grow faster than brook trout, which may indicate that rainbow trout are a more successful competitor and more efficient user of plankton. In other locations under identical conditions, growth of brook and rainbow trout was about the same, but faster than that of brown trout (Carlander 1969).

Rainbow trout are eaten by other trout and by char, salmon, wading and diving birds, snakes, and a variety of mammals (McAfee 1966).

In recent years, biologists have become concerned that hatchery-reared rainbow trout that mate with wild rainbow/steelhead trout produce inferior progeny. Johnsson et al. (1993) found that domesticated rainbow trout mating with wild steelhead produced progeny that did not feed in winter. The feeding problem appeared to affect growth in both fresh and salt water. Campton et al. (1985) speculates that hatchery-reared rainbow trout mating with native steelhead has caused a major decline in the abundance of native steelhead in the upper Yakima River.

Schroeder and Smith (1989) speculate that rainbow and steelhead trout have a potential for interaction in the Deschutes River Basin. The effects of competitive interactions and cross-breeding between rainbow trout and steelhead are currently being evaluated (Zimmerman and Reeves 1996, 1998a). Preliminary data suggest that most of the steelhead and resident rainbow trout spawn in different habitat and at different times in the Deschutes River Basin, thus maintaining a separation between anadromous and resident stocks. However, Zimmerman and Reeves (1996, 1997) have found some cases of breeding between resident rainbow trout and steelhead in the Deschutes River Basin. Zimmerman and Reeves (1998b) are conducting a study that involves crossing steelhead and resident rainbow trout caught at the Pelton Fish Trap and rearing the fish at Round Butte Hatchery. Results of these crossing have not been completed. Zimmerman and Reeves (1998b) are also examining otoliths (small, round bone-like structure in the internal ear that develop annular marks similar to fish scales) to determine origin of adult rainbow trout and adult steelhead in the Deschutes River Basin. So far, all adult steelhead are of steelhead maternal origin, and all adult rainbow trout are of rainbow trout maternal origin (Zimmerman and Reeves 1998b).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Rainbow trout are native to the Deschutes River Basin, and there are different native stocks within the basin (ODFW 1997). Native stocks have been supplemented with hatchery rainbow trout since 1918 to meet harvest objectives (Stuart et al. 1996), and the basin has historically been subdivided into discrete management areas, often based on the use of hatchery rainbow trout (ODFW 1997). In some reaches of the Deschutes River and its tributaries, however, hatchery supplementation has been discontinued (ODFW 1997).

Ceratomyxa shasta, a parasite that kills rainbow trout, has received a lot of attention in the Deschutes River Basin (Ratliff 1981, 1983; Conrad and Decew 1966). Many of the management strategies in the Deschutes River Basin are based on presence/absence of C. shasta and use of stocks of rainbow resistant to C. shasta (ODFW 1997). Hosts that transmit C. shasta are present in some reaches and absent in other reaches of the system. Some stocks of rainbow trout are more resistant to C. shasta than other stocks. Native Deschutes River Basin rainbow trout stocks are resistant to C. shasta, which reflects the native stocks' unique genetic makeup (Stuart et al. 1996).

Genetic analysis of Deschutes River Basin rainbow trout show that some native populations have remained isolated while others show evidence of mating with non-native hatchery trout (ODFW 1997). No long-term studies have been conducted to determine the impact of hatchery rainbow mating with native rainbow in the Deschutes River Basin. However, studies conducted at Oak Springs Hatchery suggest that environment, rather than genetic factors, controls growth and maximum size of rainbow trout in the lower Deschutes River (ODFW 1997).

Rainbow trout are captured in the Pelton Fish Trap, indicating that some rainbow trout are trying to migrate upstream to spawn. Downstream passage of rainbow trout is limited to passage through the turbines and spill at the Pelton Round Butte Project. If passage of anadromous fish is provided at the hydroelectric complex, a method is needed to separate resident rainbow trout from anadromous steelhead (ODFW 1997). Zimmerman and Reeves (1998b) hope to develop techniques to separate resident rainbow trout from anadromous steelhead.

Metolius River Basin

Rainbow trout are native to the Metolius River Basin. Prior to the construction of the Pelton Round Butte Project, Metolius River rainbow trout were a part of the Deschutes River population (Fies et al. 1996a). Fies et al. (1996a) postulate that, historically, there was genetic interchange between the Metolius and Deschutes river rainbow trout populations.

Rainbow trout from Lake Billy Chinook spawn in tributaries and the mainstem Metolius River. Annual numbers of Lake Billy Chinook rainbow trout spawning in the Metolius River Basin is unknown (Fies et al. 1996). Spawning occurs from November to July, with peak activity in December (Fies et al. 1996a). Rainbow trout migrate from Lake Billy Chinook to the Metolius River system in April, May, and June, and may spawn in the system for a period spanning 9 to 11 months each year (Stuart et al. 1996). This extended spawning time period appears to be related to the spring-fed nature of the Metolius River system (Buchanan et al. 1990, Hemmingsen et al. 1992, Houslet and Riehle 1997).

Fies et al. (1996a) observed 86 percent of spawning rainbow in the Metolius River above Camp Sherman. They also found that hatchery fish are more abundant below Camp Sherman and comprise only about 10 percent of the spawning rainbow trout population above Camp Sherman (Fies et al. 1996a). Fies et al. (1996a) suggests that hatchery and wild rainbow have different areas where they spawn, but that there is some evidence of crossing between wild and hatchery rainbow trout. Fies et al. (1996a) reports that information is inconclusive regarding the degree of interbreeding between hatchery and wild rainbow trout in the Metolius River.

Houslet and Riehle (1997) observed that rainbow trout in the Metolius River system spawned in stream reaches where maximum water temperatures exceeded 45ºF. Spawning appeared to be triggered when water temperatures approached 44ºF. Most of the rainbow trout spawning activity during winter months occurred above the mouth of Lake Creek. As water temperatures warmed in lower reaches of the Metolius River, rainbow trout spawning activity increased in these reaches (Houslet and Riehle 1997).

Hatchery stocks of rainbow trout were first introduced into the Metolius River in the 1920s to meet sport fishing demands (Fies et al. 1996a). More than 40,000 legal-sized rainbow trout were stocked annually from 1959 through 1987. In 1988, the number of hatchery rainbow trouts stocked into the Metolius River was reduced to 17,500 legal sized fish annually (Kostow 1995). Because of the concern about hatchery and wild rainbow interbreeding, rainbow were not stocked after July or above Allingham Campground (Fies et al. 1996a). All rainbow trout stocking was discontinued in the Metolius River in 1996 (Fies et al. 1996a) after genetic analysis indicated genetic hybridization between hatchery and wild populations in the Deschutes River Basin (Currens 1987, Fies and Robart 1988, Phelps et al. 1996). The amount of genetic contribution from hatchery rainbow trout on wild rainbow trout ranged from 2.3 to 32.0 percent in selected tributaries of the Deschutes River Basin (Phelps et al. 1996).

There has been increasing concern about the population status of rainbow trout in the Metolius River. In 1992, the Oregon Department of Fish and Wildlife (ODFW) estimated the adult rainbow trout population to be only 430 individuals between the Metolius River headwater springs (RM 40.6) and Gorge Campground (RM 36.6) (Fies et al. 1996a). In 1997, Houslet and Riehle (1997) estimated 474 rainbow trout spawners in the same section. It is not clear how these numbers compare to historical numbers or to the current habitat potential (Fies et al. 1996a), but it is generally agreed by anglers (T. Derry, personal communication, November 1998) and by biologists (Fies et al. 1996a) that the number of rainbow trout in the Metolius River system is quite low. Monitoring of wild rainbow trout in specific reaches of the Metolius River suggests that rainbow trout are at risk and in a potential conservation crisis (Fies et al. 1996a). ODFW does not identify specific causes for the decline of rainbow trout in the Metolius River (Fies et al. 1996a), but factors such as the genetic hybridization between hatchery and wild rainbow trout, competition between hatchery and wild rainbow trout, high harvest rates, hooking mortality, and changing habitat conditions may have all contributed to the decline of wild rainbow trout in the Metolius River Basin.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Rainbow trout are indigenous to the Deschutes River above Lake Billy Chinook. They are also present in Squaw Creek. Rainbow trout compose approximately 75 percent of the fish in Squaw Creek. The rainbow population in the Deschutes River above Lake Billy Chinook to Big Falls is between 1,600 to 1,700 rainbow trout per mile (Fies et al. 1996b).

Lower Crooked River

Rainbow trout are native to the Crooked River Basin, and the populations found there are believed to be tolerant of high water temperatures. Historically, the river supported two rainbow trout populations, which were separated by a natural barrier in the North Fork of the Crooked River. Currently in this river basin, there are numerous smaller populations of rainbow trout that are isolated by artificial barriers such as reservoir impoundments, irrigation diversion systems, and road culverts (Stuart et al. 1996).

The abundance of rainbow trout populations in the Crooked River Basin varies by location. Rainbow trout are moderately abundant in headwater tributaries that contain good habitat, but populations levels are depressed in the mainstem river and in tributaries with poor fish habitat conditions (Stuart et al. 1996). Nevertheless, native rainbow trout spawn throughout the Crooked River from Bowman Dam to below the city of Prineville from late March into mid June.

Progeny of these spawning rainbow are observed the following April (A. Stuart, ODFW, personal communication, January 1999).

Rainbow trout have been stocked into Crooked River Basin since 1918. At the present time, rainbow trout are stocked in the South Fork, Antelope Flat Reservoir, Prineville Reservoir, Walton Lake, Ochoco Reservoir, and Haystack Reservoir. Hatchery rainbow trout genetic introgression is present in the lower Crooked River, and the lower river section has some of the higher genetic introgression rates in the Crooked River Basin. However, the genetic introgression of hatchery rainbow trout on wild rainbow trout in the lower Crooked River was relatively low compared to other populations of rainbow trout (Phelps et al. 1996).

Lake Billy Chinook

Rainbow trout in Lake Billy Chinook have an adfluvial life history, meaning that they rear in the reservoir and migrate to a stream to spawn. Adfluvial rainbow trout that rear in Lake Billy Chinook spawn in the Metolius River and its tributaries, in the Deschutes River upstream to Steelhead Falls, and in the Crooked River upstream to the Opal Springs Dam. In addition, rainbow trout populations from other areas, such as the Deschutes River above Steelhead Falls and the Crooked River above Opal Springs Dam, can drift into Lake Billy Chinook (Stuart et al. 1996).

Very few rainbow trout exceed a length of 10 inches in Lake Billy Chinook, suggesting that few individuals survive their initial spawning or that they stop growing after spawning. Groves and Shields (1998) found that rainbow trout grow slowly in Lake Billy Chinook.

Large numbers of rainbow trout were stocked into Lake Billy Chinook between 1964 and 1975, but a significant percentage of the fish stocked during this period were lost to the parasitic disease C. shasta. Discovery of disease led to the current management strategy, in which the rainbow trout population in Lake Billy Chinook is managed for natural production to protect genetic diversity and adaptiveness against C.shasta (Stuart et al. 1996).

The population of rainbow trout in Lake Billy Chinook is unknown, but a total of 1,600 rainbow trout were harvested from Lake Billy Chinook in 1990 (Thiesfeld et al. 1995). Merwin traps were set in upper reaches of each arm of Lake Billy Chinook in 1997 to estimate the rainbow trout populations in these areas. The catch of rainbow trout using the Merwin traps was 168 in the Crooked River Arm, 178 in the Deschutes River Arm, and 101 in the Metolius River Arm (Hiatt et al. 1997). Lewis (1999) also used Merwin traps to sample rainbow trout populations in Lake Billy Chinook in 1998. Lewis (1999) captured a total of 601 rainbow trout, of which 189 were caught in the Crooked River Arm, 157 were caught in the Deschutes River Arm, 90 were caught in the Metolius River Arm, and 165 were caught in the Round Butte Dam forebay. The 1997 and 1998 trapping results indicate that rainbow trout are present throughout the reservoir area.

A rainbow trout life history and population dynamics study was initiated in Lake Billy Chinook in 1997 (Shields et al. 1998). Since the study is in its initial phase, results should be considered very preliminary. Studies conducted in 1997 show no conclusive fish movement patterns, spawning locations and times, or growth differences between reservoir reaches. Shields et al. (1998) did find that small fish made up an insignificant part of the diet of larger rainbow.

Lake Simtustus

The Lake Simtustus rainbow trout population is believed to consist entirely of hatchery fish, although some natural production may occur in Willow and Seekseequa creeks (Stuart et al. 1996). Rainbow trout are found throughout the reservoir, but greater numbers are found in the upper end of the reservoir. Rainbow trout stocking in the reservoir has been limited in recent years because of concerns about migration of rainbow trout downstream into the Deschutes River, where they could breed and compete with wild rainbow trout. Abundance of rainbow trout in Lake Simtustus has likely declined since hatchery fingerling releases were discontinued. Under the present management strategy, 5,000 legal-size hatchery rainbow and 20,000 legal-size hatchery steelhead are released into Lake Simtustus each year (Stuart et al. 1996). Many of the steelhead will likely remain (residualize) in the reservoir, rather than become anadromous. Rainbow trout in Lake Simtustus probably number less than 10,000 (Stuart et al. 1996).

Lewis (1999) used a Merwin trap to sample fish populations in Lake Simtustus in 1998. Of 1,100 fish captured, only 4 percent were rainbow trout.

Lower Deschutes River

Rainbow trout are native to the lower Deschutes River Basin and are found in most of the tributaries to the lower Deschutes River. Native rainbow trout populations were supplemented with hatchery stock beginning in 1934 in the White River and beginning in the late 1940s in the mainstem Deschutes River. Hatchery supplementation has been discontinued in all streams except the Warm Springs River (ODFW 1997).

Rainbow trout larger than approximately 8 inches have been noted in specific areas of the lower Deschutes River. The density of rainbow trout above Sherars Falls ranges from 640 to 2,560 fish per mile. Generally, the most abundant population of rainbow trout is between the Reregulating Dam and Maupin. Rainbow trout populations are less abundant below Sherars Falls (ODFW 1997).

The relationship between resident (rainbow) and anadromous (steelhead) forms of O. mykiss has long confused biologists and anglers. A study has been initiated in the lower Deschutes River to help biologists and anglers understand this complex mystery regarding the different life histories of the two forms of this species (Zimmerman and Reeves 1998). Some early findings of the study show that rainbow trout spawn in different habitat and later than steelhead. Rainbow trout spawning occurs in shallower water of lower velocities and in smaller gravel than steelhead spawning. Rainbow trout spawn from late-March through August, while steelhead spawn from mid-March to late-May. Although there is some overlap, spawning location and timing tends to separate breeding populations of rainbow and steelhead trout in the lower Deschutes River (Zimmerman and Reeves 1998). These life history characteristics and habitat preferences probably tend to isolate anadromous and resident forms of O. mykiss populations during their reproductive period in the lower Deschutes River.

Fisheries

Metolius River Basin

At the present time, the Metolius River from Lake Creek upstream to the headwaters is closed to all angling. The mainstem Metolius River above Bridge 99 to Lake Creek is restricted to fly angling, and all wild fish must be released. There is a very restricted angling period for the area open to rainbow trout fishing, and many tributaries of the Metolius River are closed to all angling. Approximately 17,500 legal-sized hatchery rainbow are released for harvest. The number of wild rainbow trout caught and kept or killed by hooking is unknown. Monitoring harvest of hatchery rainbow trout from the Metolius River has not been conducted for nearly 20 years (Fies et al. 1996).

Middle Deschutes River - Steelhead Falls to Lake Billy Chinook

There is no comprehensive creel census data available for the Deschutes River upstream of Lake Billy Chinook to Steelhead Falls. Angling pressure in this reach is light because of the steep and rugged canyon. However, there are a few dedicated anglers who consistently fish the area. Few anglers fish Squaw Creek, so there have not been angling surveys conducted in this stream (Fies et al. 1996b).

Lower Crooked River

Angling regulations within the Crooked River Basin follow statewide regulations except that the mainstem Crooked River below Bowman Dam is open for winter angling, provided that all rainbow trout are released. The harvest of rainbow trout is unknown (Stuart et al. 1996). T. Derry, an angler from Camp Sherman (personal communication, November 1998), speaks highly of the rainbow trout fishery in the Crooked River below Prineville Reservoir.

Lake Billy Chinook

The Crooked River and Deschutes River arms of Lake Billy Chinook are open to angling year-round, and the Metolius River Arm is open from March through October. The daily trout limit is five per day, of which only one may be a bull trout. The Metolius River arm was closed to the harvest of all species of wild trout in 1983 to help protect bull trout (Stuart et al. 1996). Harvest records for 1990 through 1992 and 1996 through 1997 indicate that approximately 800 to 2,031 rainbow trout were harvested annually in Lake Billy Chinook during those periods. Most of the annual harvest occurs in the upper reaches of each arm of the reservoir. Rainbow trout documented in anglers surveys are not large, averaging 8 to 10 inches in length. The catch rate for rainbow trout is low, ranging from 0.009 to 0.013 caught per hour of angling effort (Thiesfeld et al. 1995; 1996 and 1997 data provided by S. Thiesfeld, ODFW).

Lake Simtustus

Lake Simtustus is open to rainbow trout fishing during the general trout season. The daily limit is five trout per day. The harvest of rainbow trout declined in Lake Simtustus after hatchery fingerling releases were terminated in 1992. At present, approximately 5,000 legal-sized rainbow trout and 20,000 legal-sized steelhead trout are stocked annually in Lake Simtustus. Most rainbow trout caught by anglers in Lake Simtustus are 8 to 10 inches long. Rainbow trout that survive a year in the reservoir generally measure 12 to 16 inches. The estimated harvest of rainbow trout from 1990 to 1992 varied from 790 to 2,794 (Thiesfeld et al. 1995).

When Lake Simtustus was created, there were many different and sometimes conflicting fishery management objectives (Stuart et al. 1996). In addition to providing passage and rearing habitat for anadromous species, there were also attempts to create a fishery for resident rainbow trout in the reservoir (Stuart et al. 1996). Fingerling and catchable-sized rainbow trout were stocked by the U.S. Fish and Wildlife Service, the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWS), and the Oregon Game Commission (now ODFW). From 1973 to 1986, excess grade-out steelhead from Round Butte Hatchery were stocked in the reservoir. Although these fish were intended to provide a fishery in the lake, some of these grade-out steelhead may have emigrated downstream as smolts and contributed to steelhead runs in the Deschutes River. Numbers of grade-out steelhead entering anglers' creels during this period were not estimated, but appeared to be low (Stuart et al. 1996). This program was discontinued in 1986 because the grade-out steelhead did not appear to be contributing to the Lake Simtustus rainbow trout catch.

Since 1997, 20,000 8-inch steelhead have been released in Lake Simtustus to improve rainbow trout fisheries in the reservoir. Deschutes-strain summer steelhead are used so that if they emigrate downstream into the Deschutes River they will not pose a genetic risk to native summer steelhead in the lower Deschutes River. Steelhead that do not migrate and remain in Lake Simtustus are expected to grow and look like rainbow trout when caught. Contribution of these fish to the resident rainbow trout fishery in Lake Simtustus and to the anadromous steelhead trout fishery in the lower Deschutes is unknown at the present time (A. Stuart, ODFW, personal communication, April 1998).

Lower Deschutes River

The lower Deschutes River supports a popular rainbow trout fishery. The character of this fishery has changed over the years as the number of anglers has increased. Angling regulations have become more restrictive, and the stocking of hatchery rainbow trout has been discontinued. Also, angling regulations have been adopted to protect juvenile steelhead and to increase certain size groups of wild rainbow trout (ODFW 1997). In general, changes in angling regulations for rainbow trout in the lower Deschutes River have been followed by decreases in the number of anglers and harvest of rainbow trout, and a catch and release fishery has replaced the historically more consumptive fishery (ODFW 1997). Current angling regulations allow the opportunity to keep two 10- to 13-inch trout per day.

Angling regulations on the portion of the lower Deschutes River bordering the Warm Springs Reservation are set by CTWS. At the present time, trout size and bag limits are the same as the State of Oregon regulations, and angling is allowed by tribal permit.

Historically, most of the rainbow trout angling in the lower Deschutes River occurred above Sherars Falls. Harvest of rainbow trout during the 1950s, 1960s and 1970s, when regulations were liberal and hatchery trout were stocked, ranged from about 22,000 to 133,000 annually from the Pelton Round Butte Project to Sherars Falls (ODFW 1997). Hatchery rainbow trout contributed significantly to the catch, and anglers caught approximately 62 percent of the hatchery rainbow trout stocked annually (Schroeder and Smith 1989). In recent years, rainbow trout harvest information is lacking for the area between the Pelton Round Butte Project and Sherars Falls, but estimates of rainbow trout harvest has been made from Sherars Falls to the mouth. Total catch of rainbow trout in this section of the lower Deschutes River, from 1989 through 1995, ranged from 4,700 to 8,800 (ODFW 1997). Anglers in the lower reach of the Deschutes River keep about 2 to 7 percent of all rainbow trout landed (ODFW 1997). The total number of anglers fishing this section of the lower Deschutes River ranged from approximately 1,500 to over 3,000 (ODFW 1997).

LIMITING FACTORS

Lower Crooked River

Rainbow trout populations in the Crooked River below Bowman Dam are in a depressed state, and populations could be declining. No hatchery rainbow trout are released in the Crooked River below Prineville Reservoir, but juvenile hatchery rainbow trout released into Prineville Reservoir appear to emigrate from the reservoir during drawdown or spill events. Surveys prior to 1993 determined that approximately 6 to 26 percent of the rainbow trout caught in the lower Crooked River are of hatchery origin, from releases into Prineville Reservoir (Stuart et al. 1996). However, surveys from 1993 to 1997 showed less than 1 percent of the rainbow trout to be of hatchery origin in the lower Crooked River (A. Stuart, ODFW, personal communication, January 1999).

Rainbow trout in the lower Crooked River are listed as Sensitive by ODFW and as a Category 2 Sensitive species by the U.S. Forest Service. Conditions restricting Crooked River rainbow trout populations are passage barriers, poor riparian habitat, low flows, high summer water temperatures, sedimentation, pesticides and other toxic chemicals, high organic loading, and unscreened irrigation withdrawals. Shoreline developments such as housing developments and recreational facilities have also negatively affected habitats of rainbow trout in the lower Crooked River (Stuart et al. 1996).

Metolius River Basin

Factors identified by Fies et al. (1996a) that seem to be responsible for limiting rainbow trout populations in the Metolius River are:

- competition with hatchery fish
- introduction of maladaptive genes in to the wild population from naturally spawning hatchery fish
- habitat limitations including the loss of woody debris in the stream
- catch-and-release hooking mortality
- illegal taking of wild fish

ODFW has discontinue the planting of hatchery rainbow trout into the Metolius River. Competition with hatchery fish is no longer a concern, and, with time, hatchery/wild hybrid rainbow trout with maladaptive genes will disappear from the population.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Factors limiting rainbow trout production in the Deschutes River above Lake Billy Chinook are irrigation diversions upstream that affect natural flow regimes, increased water temperatures caused by reduced flows as a result of irrigation withdrawals, and spawning habitat that may not be adequate to fully seed the river section (Fies et al. 1996b, Stuart et al. 1996).

Lake Billy Chinook

Factors limiting the size of rainbow trout populations in Lake Billy Chinook are competition, predation, and limited habitat quality and quantity. Kokanee, smallmouth bass, suckers, and brown trout compete with rainbow trout for food. Competition for food is intensified because of limited shoreline habitat for food production. Periodic drawdown of the reservoir may also affect food production (Stuart et al. 1996). The impact of drawdowns on fish food production is believed to be minimal because drawdowns occur mostly in winter months, when feeding is decreased because of cold water temperatures (D. Ratliff, PGE, personal communication, April 1998). Bull trout, brown trout, smallmouth bass, and northern pikeminnow consume rainbow trout in Lake Billy Chinook, but the level of this predation is not known (Stuart et al. 1996).

Lake Simtustus

Production constraints for rainbow trout in Lake Simtustus include competition with other fish, predation, poor habitat, and infections from the disease C. shasta. Shoreline habitat is limited, which intensifies competition for prey. Reservoir fluctuations further reduce fish habitat. Bull trout, brown trout and northern pikeminnow prey on rainbow trout. The disease C. shasta may be the most significant factor limiting population sizes of rainbow trout in Lake Simtustus (Stuart et al. 1996).

Lower Deschutes River

The Pelton Round Butte Project has changed the natural movement of gravel (Aney et al. 1967, O'Connor et al. 1998, ODFW 1997) and large woody materials (Minear 1998, ODFW 1997) in the lower Deschutes River below the Project. The loss of gravel and wood recruitment may affect fish habitat directly below the Project, but the overall effects on the rainbow trout population along the full length of the lower river are not understood (ODFW 1997). Water temperatures in the lower river have not been modified appreciably by the Pelton Round Butte Project (Beaty 1995). Alteration of natural flows of the lower Deschutes River downstream from the Project have been minor (Huntington 1985).

Rainbow trout production in the lower Deschutes River tributaries is believed to be at historically low levels because of degraded stream habitat conditions and drought. Other factors affecting rainbow trout are consumptive uses of surface water for irrigation, industrial and municipal uses, unscreened irrigation diversions, and sedimentation caused by agricultural and timber management activities (ODFW 1997).

Rainbow trout are less abundant downstream from Sherars Falls because of higher water temperatures that favor other species of fish, increasing competition for available resources. Potentially, there is lower quality and quantity of spawning gravel below the mouth of the White River as a result of glacial sediments entering the Deschutes River from White River (ODFW 1997).

There is evidence that genetic introgression has occurred between native and hatchery rainbow population in the lower White River, lower Tygh Creek, Jordan Creek, and Rock Creek (Currens et al. 1990). No expansion of the hatchery trout program is planned for the lower Deschutes River Basin (ODFW 1997).

Lower Deschutes River rainbow trout are resistant to infection by Ceratomyxa shasta, but non-native, hatchery stocks with low resistance to this parasite have been introduced into the lower Deschutes River Basin. Hatchery fish killed by ceratomyxosis resulted in an increase in the number of infective spores (Ratliff 1983), thus increasing the risk to native rainbow in the lower Deschutes River Basin. At present, only rainbow trout stocks resistant to C. shasta are released into Lake Billy Chinook and Lake Simtustus (ODFW 1997).

Hatchery rainbow trout released in past years increased angling pressure and thus resulted in the increased harvest of native fish. The net impact of hatchery trout releases and increased angling pressure may have kept wild rainbow trout populations low (ODFW 1997). Hooking mortality of rainbow trout caught and released in the lower Deschutes River is estimated to be approximately 7 percent (Taylor and White 1992).

At present, the population of rainbow trout in the lower Deschutes River appears to be fairly stable. However, natural mortality of adult rainbow trout spawners ranges from 45 to 69 percent for individuals over 12.2 inches long. This fact suggests that current angling regulations will not be successful in increasing the number of large rainbow trout in the lower Deschutes River (ODFW 1997).

ECOLOGICAL ROLE

Historically, resident rainbow trout probably developed to support life history traits important in the preservation of the species. For example, catastrophic events, such as landslides across the migration corridor, would prevent migration of O. mykiss, thus interrupting a major aspect in the life history of the anadromous forms of O. mykiss. The ecological role of resident forms of O. mykiss could originally have been to perpetuate migratory life history traits until such time as the migration corridor opened.

Alternatively, their ecological role may be as simple as filling vacant habitat niches. Rainbow trout are a major species of fish in northwest Pacific streams and lakes because of their ability to adapt to different and changing habitat conditions. This adaptability, as exemplified by successful production of this species in hatcheries, depicts a survival resilience that surpasses many other species of fish.

PACIFIC LAMPREY

Lampetra tridentatus

Other common names: Sea lamprey, three-toothed lamprey, tridentate lamprey (Scott and Crossman 1973)

General

APPEARANCE

The Pacific lamprey is long and has a nearly round cross section from the head to the dorsal fin. Beyond the dorsal fin, Pacific lamprey have a cross section that is progressively more laterally compressed toward the tail. Adults can reach a length of approximately 27 inches. Pacific lamprey do not have vertebrae, and the mouth does not have a jaw. Pacific lamprey have short heads with a large, circular mouth directly below the end of the snout. The mouth has several series of sharp teeth, and the tongue also has sharp, rasping teeth. The eyes are small and set high on the head. Pacific lamprey have one nostril located in the center of the head and ahead of the eyes. There are seven round gill openings on each side of the head and behind the eyes (Scott and Crossman 1973).

Pacific lamprey have two dorsal fins with the front dorsal fin flatter, smaller, and more rounded than the rear dorsal fin. The tail fin is rounded and shaped like a spade. The anal fin is inconspicuous. Pacific lamprey do not have pelvic or pectoral fins (Scott and Crossman 1973). Pacific lamprey do not have scales. The skin is smooth and leathery (Scott and Crossman 1973).

The overall color of adult pacific lamprey is blue-black to dark brown with a lighter color on the belly. The teeth are usually yellow to orange (Scott and Crossman 1973). The young of Pacific lamprey are pale brown with a fleshy, toothless, oral hood instead of a sucker disc mouth and have undeveloped eyes. Many of the Pacific lamprey's adult features develop while it is a juvenile living in the mud or sand and gravel (Scott and Crossman 1973).

DISTRIBUTION

Pacific lamprey are found on the Pacific coast and coastal islands of North American from the Aleutians Islands south to Baja California. They are also found in Asia as far south as Japan. They ascend all major rivers within their range, often to headwaters, including the Columbia River (Scott and Crossman 1973).

While Pacific lamprey can establish landlocked populations over their entire range and remain in freshwater throughout their adult life (Coots 1955), populations of Pacific lamprey above dams have generally become extinct (Wallace 1978, Beamish and Northcote 1989).

LIFE HISTORY

Spawning runs of adult Pacific lamprey usually enter freshwater from May to September. Migrating adult Pacific lamprey are weak swimmers (Bell 1990), but they are capable of clinging to rocks or concrete with their mouths (Scott and Crossman 1973). Although Pacific lamprey enter freshwater during summer, they do not spawn until the following March through July (Simpson and Wallace 1978, Pletcher 1963, Beamish 1980). In Oregon, Pacific lamprey spawn in May in water temperatures between 50 and 59 degrees F. (Close et al. 1995). Pacific lamprey do not feed during their spawning migration (Read 1968), and they may lose 20 percent of their body weight between the time they enter freshwater and the time that they spawn (Beamish 1980).

Males usually arrive on spawning grounds first; however, both sexes participate in building a nest in sand or small gravel using body vibrations or by moving rocks with their mouths. The nest is usually about 12 inches wide and 1 inch deep (Kan 1975). When the nest is ready, the female attaches to a rock and the male begins rubbing along the body of the female with slight contact of the mouth. When the male reaches the head of the female, he attaches to it, coils around the female and goes through various courting motions. At the proper time, eggs and sperm are emitted together and the fertilized eggs fall into the nest. The small, round eggs are adhesive for a short period and cling to stones in the nest. A female lamprey can deposit 100 to 500 eggs regularly every 2 to 5 minutes for 5 hours, and may produce a total of 34,000 to 106,000 eggs (Wydoski and Whitney 1979). Most eggs are laid over a period of 12 hours. Males may spawn with more than one female in different nests (Pletcher 1963, Russell et al. 1987, Kan 1975). The adults die within 3 to 36 days after spawning (Pletcher 1963). Eggs hatch in 2 to 3 weeks at 59ºF (Scott and Crossman 1973).

After hatching, the larvae, called ammocoetes, move downstream of the nest to live in mud for 5 or 6 years. Juvenile growth varies from 5 to 12 inches during the period that they remain in the mud (Scott and Crossman 1973, Richards 1980, Kan 1975, Pletcher 1963). Larvae feed on different types of algae (Simpson and Wallace 1978). The size of the larvae varies but ranges from 5 to 8 inches (Mallatt 1983). During the larval stage, the ammocoetes are blind, sedentary, and survive by filtering food particles including detritus and algae suspended above and within the mud (Moore and Mallatt 1980). The duration of larval life is difficult to estimate (Mallatt 1983).

The rate of development among a brood of Pacific lamprey varies greatly during the 5- to 6-year period they inhabit the mud; within a brood individuals can be found that resemble adults, while other continue to resemble ammocoetes (Applegate and Brynildson 1952). Transformation of Pacific lamprey from the larval to juvenile life stage occurs during summer (Richards and Beamish 1981, Hammond 1979). The process occurs over several weeks (Yousson and Potter 1979). The first change is the mouth, followed by eye development, and then the teeth and tongue develop (Richards 1980).

The most common life history pattern is for juveniles to move to the ocean or to a river estuary where, in the spring and summer following downward migration, they begin parasitic life (Scott and Crossman 1973). While waiting to migrate to the ocean, young adults burrow in cobble and boulder substrate (Pletcher 1963). Young adults may begin the downstream migration in late fall and spring (Close et al. 1995). The migration may take as long as 10 months (Beamish 1980). Juvenile migration occurs at night (Long 1968, Scott and Crossman 1973). Pacific lamprey rear 20 to 40 months off the Oregon coast (Kan 1975).

Migration is not always to the ocean, as there are landlocked populations over the whole of the range (Scott and Crossman 1973, Carl 1953). These landlocked forms remain in freshwater to prey on freshwater fishes throughout their adult life (Coots 1955). Dwarf populations also occur in certain rivers (Carl et al. 1967). There are also populations of landlocked, nonparasitic Pacific lamprey in Oregon and California (Hubbs and Miller 1948). Landlocked Pacific lamprey are considered to be mid-water fish associated with plankton layers (Beamish 1980).

As an external parasite, the Pacific lamprey lives on the blood and fluids of fish and other marine animals. Pacific lamprey attach to their hosts, generally on the belly near the pectoral fins (Roos et al. 1973, Beamish 1980), with their sucking mouth and sharp teeth. The sharp teeth on the tongue cut holes through the scales and skin of fish, and the fluids are consumed. This parasitic feeding is helped by the production of an anticoagulating agent that prevents the prey's blood from clotting (Scott and Crossman 1973). The extent of harm to the host by Pacific lamprey is not known (Simpson and Wallace 1978). Pacific lamprey locate their prey by smell, electrosensors, and vision (Bodznick and Preston 1983, Farmer 1980).

Researchers do not agree on whether adult lamprey return to their home streams. Hardesty and Potter (1973) stated there are no conclusive evidence lamprey home. However Beamish (1980) reported that it is probable that at least some Pacific lamprey return to their natal streams to spawn.

Habitat Requirements

Pacific lamprey spawn in low gradient streams in shallow gravel tailouts of pools and riffles (Pletcher 1963, Kan 1975). Spawning areas are a mix of pebbles and sand (Mattson 1949, Kan 1975).

Pacific lamprey ammocoetes burrow in mud, sand and small gravel in slow current areas (Pletcher 1963). Ammocoetes are usually found in coldwater but have been collected in water as warm as 77ºF (Mallatt 1983). Holmes and Lin (1994) determined that the larvae of Pacific lamprey preferred a summer temperature of 69ºF with a range of 64 to 71ºF.

Upstream migrant Pacific lamprey overwinter in deep pool habitat (Close et al. 1995).

Adult Pacific lamprey are not thought to be strong swimmers, and adult fallback occurs at dams on mainstem rivers. High flows over dams also cause delay, exhaustion, and possible death of Pacific lamprey. Long (1968) reported juvenile Pacific lamprey caught in turbines, Hammond (1979) reported juvenile Pacific lamprey impinged on submerged graveling screens used to bypass anadromous fish, and Starke and Dalen (1995) reported juvenile Pacific lamprey caught on extended bar screens at mainstem dams.

Inter/intraspecific Interactions

Lamprey, a natural component of the Columbia River Basin ecosystem, are a part of the predator/prey interactions in the river. Close et al. (1995) suspect that Pacific lamprey serve as a buffer for upstream migrating adult salmon from predation by marine mammals. Roffe and Mate (1984) and Starke and Dalen (1995) found that Pacific lamprey are an important food source for seals and sea lions.

Juvenile lamprey migrate at night (Hawkes et al. 1993, Klinge 1995), which may reduce predation during downstream migration (Hatch and Parker 1996). However, birds and predator fish prey on juvenile lamprey (Merrell 1959, Poe et al. 1991).

The importance of predation by lamprey on fish has not been evaluated, although some biologists suspect it might have a significant adverse impact on some fish populations, as observed in the Great Lakes, where large numbers of fish, especially lake trout, have been observed with lamprey scars. Compared to populations from the Great Lakes region, a smaller percentage of fish from the Pacific Ocean are observed to have lamprey scars (Wydoski and Whitney 1979). While a number of Pacific Ocean fish may show lamprey scars (Carl 1953, Williams and Gilhousen 1968, Pletcher 1963, Pike 1951, Birman 1950), the impact that Pacific lamprey have on fish in the open ocean is unknown (Scott and Crossman 1973).

Pelton Round Butte Project Area

Population Size and Distribution

Metolius River Basin

Fies et al. (1996a) did not identify the presence of Pacific lamprey in the Metolius River. Historically, Pacific lamprey may have spawned in Metolius River tributaries with low gradients and streambeds consisting of a mix of pebbles and sand.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) did not identify Pacific lamprey in the Deschutes River above Lake Billy Chinook. Historically, however, Pacific lamprey probably spawned in Squaw Creek. Pacific lamprey may have migrated upstream in the mainstem Deschutes River to upstream limits of salmon and steelhead passage; however, this idea is speculative.

Lower Crooked River

The Crooked River probably once supported a large population of Pacific lamprey. Nehlsen (1995) and Stuart et al. (1996) do not address the historical presence or absence of Pacific lamprey in the Crooked River Basin, but habitat conditions in the Crooked River were typical of conditions in other subbasins of the Columbia River that supported Pacific lamprey populations.

Lake Billy Chinook

Historically, the area now inundated by Lake Billy Chinook probably served as a migration corridor for Pacific lamprey. Construction of the Pelton Round Butte Project, however, resulted in the elimination of Pacific lamprey from the areas presently inundated by the Project. Stuart et al. (1996) did not identify Pacific lamprey in Lake Billy Chinook.

Lake Simtustus

Stuart et al. (1996) did not identify Pacific lamprey in Lake Simtustus. Historically, the area inundated by Lake Simtustus probably served as a migration corridor for Pacific lamprey.

Lower Deschutes River

Pacific lamprey are native to the lower Deschutes River. They are also found in Shitike Creek, Beaver Creek, Warm Springs River (ODFW 1997) and White River (Scott Lewis, PGE, personal communication, September 1998). The abundance of Pacific lamprey in the lower Deschutes River Basin has not been estimated, but appears to be relatively low (ODFW 1997).

FISHERIES

Pacific lamprey is an important traditional food source for members of the Confederated Tribes of the Warm Springs Reservation of Oregon. They are harvested annually from June through August in the fish ladder and surrounding area at Sherars Falls. Harvest techniques include hand, dip nets, and, most commonly, hooking. Approximately 1,000 lamprey are harvested each year (ODFW 1997). Lamprey do not provide sport or commercial fisheries in the Deschutes River.

LIMITING FACTORS

Close et al. (1995) suggest that factors affecting the decline of salmon and steelhead negatively affect Pacific lamprey as well. They identified several factors such as water withdrawals, increased sediment deposition, elevated stream temperatures, poor grazing practices, intensive logging, impediments to passage at dams, and changing ocean conditions as factors affecting Pacific lamprey populations. ODFW states that “environmental degradation and loss of spawning and rearing habitat throughout the Columbia River system has reduced the abundance of lamprey...” (ODFW 1997).

Specific factors limiting Pacific lamprey populations in the Deschutes River Basin are unknown. The Pelton Round Butte Project blocked passage of Pacific lamprey into the Crooked River Basin, which probably provided substantial spawning and early rearing habitat for juveniles. Water withdrawals, increased sediment deposition, elevated stream temperatures, and impediments to passage at mainstem Columbia River dams probably adversely affected the population of Pacific lamprey in the Crooked River Basin before the Pelton Round Butte Project was built.

ECOLOGICAL ROLE

Historically, all the tribes in the Columbia River Basin used Pacific lamprey for food, trade, ceremonial, and medicinal purposes. Pacific lamprey were collected at natural barriers such as waterfalls and rapids along the Columbia River and its tributaries. Pacific lamprey are presently harvested by the Nez Perce, Umatilla, Warms Springs, and Yakama tribes at Willamette

Falls (C. Fagan, Confederated Tribes of the Warm Springs Reservation of Oregon, personal communication, January 1999).

As adults, Pacific lamprey are high order predators that have had significant adverse impacts on the abundance of important food and sport fish in the Great Lakes. Unlike the Great Lakes, Pacific lamprey were a natural component of the Columbia River Basin ecosystem, and they played an important role in predator/prey interactions. However, that role was not always recognized as positive. In the past, actions were taken to stop upstream passage of adult Pacific lamprey by placing angle irons on the side walls of fish ladders in mainstem Columbia and Snake river dams (J. McMichael, U.S. Corps of Engineers, retired, personal communication, 1997). The angle irons were designed and located to stop the upstream migration of Pacific lamprey. However, the angle irons stopped the migration only of those Pacific lamprey that were not attached to adult upstream migrating salmon and steelhead. Over time, the angle irons contributed to the elimination of Pacific lamprey from many upper tributaries of the Columbia River Basin.

Predation may also be partially responsible for recent declines of Pacific lamprey. Roffe and Mate (1984) report that the principal food of seals and sea lion was Pacific lamprey. Poe and Rieman (1988) found juvenile Pacific lamprey in the stomach of northern pikeminnow, and Merrell (1959) found that gulls were feeding on juvenile Pacific lamprey.

The elimination of Pacific lamprey from the upper Columbia River Basin did not improve anadromous fish runs. Studies are currently ongoing in some Columbia River Basin tributaries to better understand habitat requirements, life history characteristics, inter/intraspecific interactions, and the ecological role of Pacific lamprey.

BULL TROUT

Salvelinus confluentus

Other common names: Dolly Varden, charr, red-spotted Rocky Mountain trout, red spotted char, Pacific or western brook char, brook trout (Scott and Crossman 1973).

General

Dolly Varden char in North America are separated into two species: Dolly Varden (Salvelinus malma) and bull trout (Salvelinus confluentus). The two species have distinct shapes and genetic characteristics (Haas and McPhail 1991, Leary and Allendorf 1997), but there is no single physical character that can be used to distinguish the species (Haas and McPhail 1991). The number of rays located on the bones that support the gills (branchiostegal rays) is the most reliable physical characteristic separating the two species. The two species may mate, producing hybrids (Phillips et al. 1994).

There are different stocks and races of Salvelimus confluentus, including anadromous as well as non-anadromous forms. Only non-anadromous bull trout are found in the Columbia River Basin. This report describes Deschutes River Basin bull trout.

APPEARANCE

Bull trout have a body shape that is laterally compressed, though rather rounded in cross section compared to other trout species. The body depth of the bull trout is greatest below the dorsal fin, where it is about 20 percent of the total body length. The head is rather long, about 15 to 28 percent of the total length, with the eye diameter measuring 20 to 22 percent of the head length. The snout is blunt and almost twice the length of the eye diameter. The mouth is located on the front end of the head and supports well developed teeth. Maxillaries above the mouth extend well past the eye (Scott and Crossman 1973).

The dorsal fin, located on the back at the middle of the body, has 10 to 12 major rays and 3 to 4 small rays. A slender, long adipose is present behind the dorsal fin. The tail is broad with a shallow fork and rounded tips. The anal fin has 9 to 11 major rays and 2 to 4 short rays. The pelvic fins are short and square with 9 to 11 rays. The pectoral fins are moderate in size and fairly square with 14 to 16 rays. The scales are small and round (Scott and Crossman 1973).

The color of bull trout varies with size, locality, and habitat. Some people confuse bull trout with brook trout because of color similarities. The main difference between bull trout and brook trout is that brook trout have wavy marks called vermiculations on the back near the dorsal fin, while bull trout lack these marks. The back and upper sides of bull trout are olive-green to brown, the lower sides are a pale red, and the belly is white or grey. The back and sides are marked with yellow, orange, or red spots that are nearly as large as the pupil of the eye. The pectoral, ventral, and anal fins are white or cream colored on the leading edge with a thin black line and a red line behind. Dorsal and tail fins are dusky to brownish in color, and they sometimes have a few pale spots that are hard to see (Scott and Crossman 1973).

Young bull trout have eight to ten dark parr marks, which may appear as dark blotches in fish less than 3 inches. They also have a fine dark speckling along the lower sides, with unspotted, dusky colored dorsal and adipose fins (Scott and Crossman 1973).

Spawning adults, especially males, turn reddish or orange on the belly and on the lower surface and tip of the snout. The lower jaw, gill covers or operculum, and parts of the head turn black, while the back and sides turn olive-brown. The spots become more vivid orange-red, and the pectoral, pelvic, and anal fins turn red to black with a white leading edge. The lower jaw turns up, especially on males. Spawning females change as males do, but do not become quite as brilliant (Carl et al. 1959, Scott and Crossman 1973, McAfree 1966).

DISTRIBUTION

Bull trout are found in rivers and lakes from northern California (McCloud River and Shasta Lake) to northwestern Alaska to Japan and Korea (McAfree 1966). In North America, they range inland to Alberta, Montana, Idaho, and northern Nevada (Delacy and Norton 1943, LaRivers 1962). There are both anadromous and non-anadromous populations from Washington north, but the populations in California, Nevada, Montana, Oregon, and Idaho are only freshwater populations (Scott and Crossman 1973).

LIFE HISTORY

Bull trout have complex life history traits (Rieman and McIntyre 1993) including multiple life-history forms, complex age structures, and complex maturation schedules. A particular life-history strategy may dominate under stable conditions, but another life-history may be favored with changing environment (Gross 1991, Northcote 1992, Sibly 1991). It is possible to have four or more year classes compose any spawning population and as many as 12 to 16 age combinations in any spawning year (Shepard et al. 1984).

Bull trout in Oregon have three life-history patterns represented by resident, fluvial, and adfluvial populations. Resident bull trout remain within their native stream. Fluvial bull trout migrate between smaller streams used for spawning and early juvenile rearing and larger rivers used for adult rearing. Adfluvial populations migrate between smaller streams used for spawning and juvenile rearing and lakes or reservoirs used for adult rearing. Fluvial populations can become adfluvial populations under some circumstances (Buchanan et al. 1997).

These three separate pathways of bull trout rearing occur in the Metolius River system: (1) resident populations of bull trout spend their entire lives in the tributary stream in which they hatch, (2) fluvial populations of bull trout leave the natal stream to rear in the Metolius River, and (3) adfluvial populations of bull trout leave the natal stream, enter the Metolius River, and rear in Lake Billy Chinook. Additional research is needed to fully understand bull trout life-history pathways in the Metolius/Lake Billy Chinook areas (Buchanan et al. 1997).

Bull trout are fall spawners, typically spawning from August to November depending upon the area (Bajkov 1927, Block 1955, Delacy and Morton 1943). River and lake populations spawn at about the same time (Scott and Crossman 1973). Spawning populations usually migrate to the spawning areas in August and September (Scott and Crossman 1973). Bull trout have a strong homing tendency, and in some areas, bull trout migrate great distances to natal spawning grounds. For example, bull trout migrate over 100 miles from Flathead Lake in Montana to natal spawning grounds (Carl et al. 1959).

Ratliff et al. (1996) identified some unique bull trout life history characteristics in the Deschutes River Basin. Spawning migration of adult bull trout from Lake Billy Chinook occurs as early as late July and typically lasts through the first week of October, with most spawning activity occurring between August 15 and October 1. The process of (1) migration into the spawning tributaries, (2) spawning, and (3) migration back to the Metolius River usually takes 2 weeks. Bull trout from the Deschutes River Basin exhibit the species' characteristically strong homing instinct (Ratliff et al. 1996).

Sexual maturity is reached in 4 to 9 years (Williams and Mullan 1992, Pratt 1991). Males often mature a year earlier than females (Scott and Crossman 1973). Sexual spawning characteristics in bull trout develop slowly (Scott and Crossman 1973). Spawning occurs at temperatures of 41 to 48ºF, and usually takes place in daytime hours (Scott and Crossman 1973). Males are aggressive during spawning activity. The redd is dug by the females. Pre-spawning courtship is done by body pressing and quivering (Needham and Vaughan 1952).

Egg numbers are high in females, ranging from 1,300 to 8,000. Eggs hatch in March and April depending upon water temperature, and fry emerge from the gravel in April to mid-May (Blackett 1968). Bull trout eggs require approximately 662 to 824 temperature units to hatch (Weaver and White 1984, Gould 1987, Pratt 1992). (A temperature unit is 1 degree Fahrenheit above 32ºF for 24 hours.) Hatching is completed after 100 to 145 days (Pratt 1992). Sac fry require at least 65 to 90 days after hatching to absorb their yolk sacs (Pratt 1992). Fry may live in the gravel for up to 3 weeks before they emerge (McPhail and Murray 1979, Pratt 1992).

Growth of juvenile bull trout is fairly fast in early years, but slows over time. Juvenile bull trout are approximately 2 to 2.8 inches at age 1, 4 to 5 inches at age 2, and 6 to 7 inches at age 3 (Pratt 1992, Ratliff et al. 1996). Bull trout eat larval and adult aquatic insects, fish, snails, leeches, amphibians, mice, salmon egg, and other bull trout, depending on availability (Delacy and Morton 1943, Jeppson 1963, Pratt 1992, Roos 1959, Wales 1939). Bull trout young may spend several months to several years in streams before they move downstream into a lake or larger river (Scott and Crossman 1973). Juvenile bull trout migrate from natal areas during spring, summer, or fall (Pratt 1992). Most of the migration occurs at night (Ratliff et al. 1996).

Adfluvial bull trout feed primarily on fish and grow rapidly (Jeppson and Platts 1959, Rieman and Lukins 1979, Shepard et al. 1984, Pratt 1992). Fluvial bull trout grow somewhat more slowly (Ratliff et al. 1996), while resident bull trout have much slower growth rates (Buchanan et al. 1997). Maximum size at maturity varies with location from as large as 32 pounds (McPhail and Lindsey 1970) to as small as 12 inches in inland, high-altitude areas, where body size of bull trout is often stunted (Scott and Crossman 1973). Spawning adults in the Deschutes River Basin range from 9 to 32 inches, with most spawners measuring 18 to 26 inches (Ratliff et al. 1996). Bull trout may live to be 20 years old (Carlander 1953), but 10 to 12 years seems to be the average life expectancy of this species (Scott and Crossman 1973).

HABITAT REQUIREMENTS

Bull trout have specific habitat requirements (Rieman and McIntyre 1993), and they are sensitive to habitat change (Rothschild and DiNardo 1987). Bull trout prefer cool lakes and pool areas of streams (McAfree 1966). The habitat of bull trout young is the gravelly spawning stream (Fraley and Shepard 1989, Oliver 1979, Pratt 1984). As they mature, bull trout move about over the length of natal streams (Pratt 1984). Juveniles live close to in-channel wood or undercut banks (Goetz 1991; Pratt 1984, 1992). Young-of-the-year use side channels, stream margins, and areas of low velocity. Older fish use pools (Hoelscher and Bjornn 1989, Pratt 1984). The stability of the channel will influence survival of young bull trout (Goetz 1989, Weaver 1985, Elwood and Water 1969, Seegrist and Gard 1972, Wickett 1958). For example, an increase in fine sediments in the gravel reduces survival rates (Leathe and Enk 1985, McPhail and Murray 1979, Shepard et al. 1984, Weaver and Fraley 1991). Winter cover also is important (Chapman 1966, Cunjak and Power 1986). Spawning areas often are near springs in cold streams (Allan 1980, Ratliff 1992, Shepard et al. 1984).

Dambacher and Jones (1997) found that there were six variables that determined the presence of juvenile bull trout. The variables were (1) high levels of shade, (2) high levels of undercut banks, (3) abundance of large woody debris, (4) high levels of gravel in riffles, (5) low levels of fine sediment in riffles, and (6) low levels of bank erosion.

Bull trout require a narrow range of cold temperature conditions to rear and reproduce (Buchanan and Gregory 1997). Temperatures in excess of about 60ºF limit bull trout distribution (Allan 1980, Brown 1992, Fraley and Shepard 1989, Goetz 1991, Oliver 1979, Pratt 1985, Ratliff 1992, Shepard et al. 1984, Rieman and McIntyre 1993). Buchanan and Gregory (1997) provide information on optimal temperatures for each bull trout life history stage (Table 1).

Table 1.   Bull trout optimal temperature regimes. From Buchanan and Gregory (1997).

Bull Trout Life History Stage	Optimal Temperature
Adult migration	50 – 54ºF
Egg development	34 – 43ºF
Fry growth	39 – 40ºF
Juvenile growth	39 – 50ºF
Adult density	< 54ºF

Adequate passage between natal, rearing, and spawning habitats is important for fluvial and adfluvial bull trout populations. Passage barriers and dams can be a major limiting factor for some populations of bull trout. The location of a barrier between spawning and juvenile rearing habitat can isolate bull trout populations (Ratliff and Howell 1992, Bond 1992, Donaldson and Cramer 1971, Buchanan et al. 1997).

Inter/intra specific Interactions

Bull trout have a repetition as voracious fish eaters and have been condemned as serious predators of young salmon (Foerster and Ricker 1942). This reputation may not be deserved, however (Armstrong 1965, DeLacy and Morton 1943, Lagler and Wright 1962, Roos 1959, Narver and Dahlberg 1965). The controversy concerning the impact of bull trout on salmon production is likely to continue. Little is known about fishes that prey on bull trout (Scott and Crossman 1973).

The Deschutes Basin Bull Trout Working Group initiated a diet study of bull trout in Lake Billy Chinook and the Metolius River to determine the prey consumed by various sizes of bull trout (Schulz et al. 1997). A total of 288 bull trout stomachs were examined to estimate the consumption of prey by bull trout (Lewis 1998). Figure 8 depicts contents of bull trout stomachs collected from Lake Billy Chinook.

Bull trout evolved with chinook, sockeye and coho salmon, cutthroat trout, rainbow, whitefish, sculpins and minnows (Mullan et al. 1992, Platts 1974, Pratt 1984, Shepard et al. 1984). Bull trout and other native species appear to use different resources thus reducing competition (McPhail and Murray 1979, Nakano et al. 1992, Platts 1974, Pratt 1984).

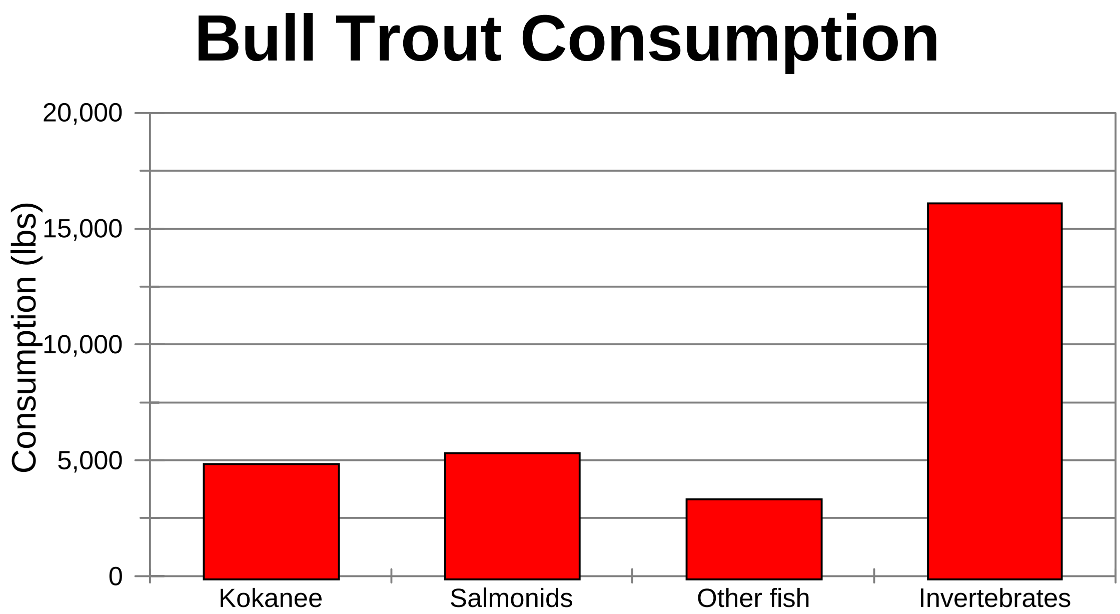

Figure 8. Contents of bull trout stomachs collected from Lake Billy Chinook (Lewis 1998).

Introduced, non-native fishes such as brown trout, rainbow trout, and lake trout have been associated with the decline of bull trout populations (Bond 1992, Moyle 1976, Mullan et al. 1992, Nelson 1965, Bowles et al. 1991, Rieman and Lukens 1979, Weaver 1991, Donald and Alger 1992). In addition, habitat changes such as increased summer water temperatures may increase the adverse effects of non-native species on bull trout (Rieman and McIntyre 1993). Dambacher et al. (1992) and Buchanan et al. (1997) speculate that changing habitat factors such as increased temperatures contribute to or result in non-native brook trout domination over native bull trout populations. Buchanan et al. (1997) made their observations while conducting fish surveys in the Metolius River Basin.

Bull trout breed with brook trout (Cavender 1978; Leary et al. 1983, 1991; Markle 1992). Hybrids are usually sterile and experience developmental problems (Leary et al. 1983, 1991). Brook trout have been widely introduced (Scott and Crossman 1973) and now live in most basins occupied by bull trout (Meehan and Bjornn 1991). Habitat characteristics influence the distribution of each species, the interactions between the species, and consequently the degree of hybridization (Campton 1987, Hobbs and Huenneke 1992, Markle 1992, Mullan et al. 1992).

Kitano et al. (1994) observed spawning behavior of adfluvial bull trout where they coexists with resident brook trout. Bull trout were bigger than brook trout, and the smaller brook trout were attacked by the larger bull trout males. In one case, a small male brook trout released sperm after sneaking into a redd during spawning by a pair of large bull trout. In this case, bull trout eggs could have been fertilized by a small male brook trout.

Leary et al. (1991) believes that brook trout have a reproductive advantage over bull trout because they mature earlier. Moyle (1976) documented that male brook trout may spawn at age 1, and that female brook trout can mature at age 2, although it is more common for male brook trout to mature at age 2 or 3 and female brook trout to mature at age 3 or 4. By contrast, first spawning for resident bull trout typically occurs at age 5 or age 6 (Williams and Mullan 1992, Leary et al. 1993, Pratt 1991).

Bull trout have special genetic risks because the populations are often fragmented and isolated as a result of habitat changes caused by human activities (Rieman and McIntyre 1993). There are no criteria for determining the viability of isolated populations (Shaffer 1991). However, Soule (1987) proposed that population size for this species must be at least 50 breeding individuals to prevent inbreeding and that 500 individuals are needed to maintain genetic variation.

Several efforts to reintroduce bull trout into historic habitat have failed (Buchanan et al. 1996), and extra effort is needed to ensure successful reintroduction (Buchanan et al. 1996, Montana Bull Trout Scientific Group 1996, Dunsmoor 1997 as reported in Buchanan et al. 1996). Reisenbichler (1988) demonstrated a direct relationship between distance of donor stock and recovery rate of introduced stock; in other words, the closer the source area for the donor stock is to the reintroduction area, the more likely the success of the reintroduction.

Pelton Round Butte Project Area

Population Distribution and Size

Bull trout were historically found throughout most of the Deschutes River Basin (Ratliff et al. 1996), but historic sizes of bull trout populations in the basin are unknown. Adfluvial populations of bull trout were present in the Blue/Suttle lake area, Crescent Lake, and Davis Lake. Bull trout populations upstream of Big Falls were reproductively isolated from populations in the lower Deschutes River. Populations of bull trout in the basin were further isolated with the construction of Crane Prairie, Wickiup, Round Butte, and Opal Springs dams. Other populations were extirpated because of over-harvest and changing habitat conditions (Buchanan et al. 1997).

Metolius River Basin

Bull trout in the Metolius River Basin are found in the mainstem of the Metolius River, Whitewater River, and in First, Jack, Canyon, Roaring, Brush, Abbot, Candle, and Jefferson creeks (Buchanan et al. 1997). Population densities of juvenile bull trout in Metolius River tributaries ranged from 2.0 to 20.6 fish in 84 square yards between 1983 and 1994 (Buchanan et al. 1996). Compared to other bull trout populations, this is a high density (Ratliff et al. 1996).

Bull trout spawning ground surveys have been conducted in the Metolius River Basin since 1986. Figure 9 depicts the estimated number of spawning bull trout, and Figure 10 shows number of redds counted during the years 1986 through 1998 in the basin.

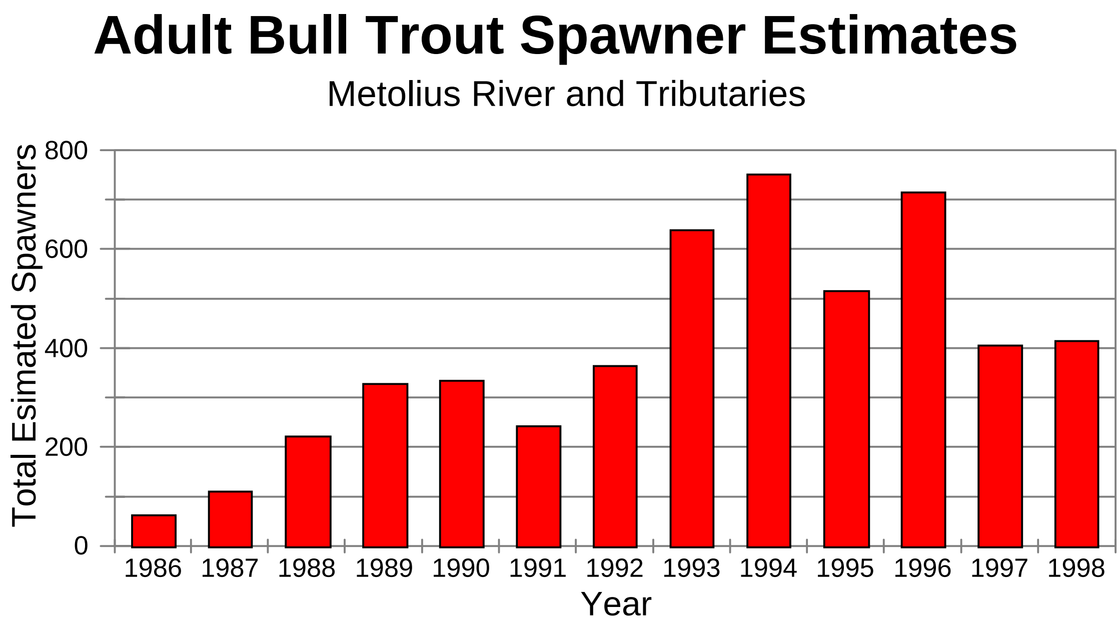

Figure 9. Adult bull trout spawner estimates, Metolius River and tributaries, 1986–1998. Data provided by Steve Thiesfeld, ODFW, Prineville, Oregon.

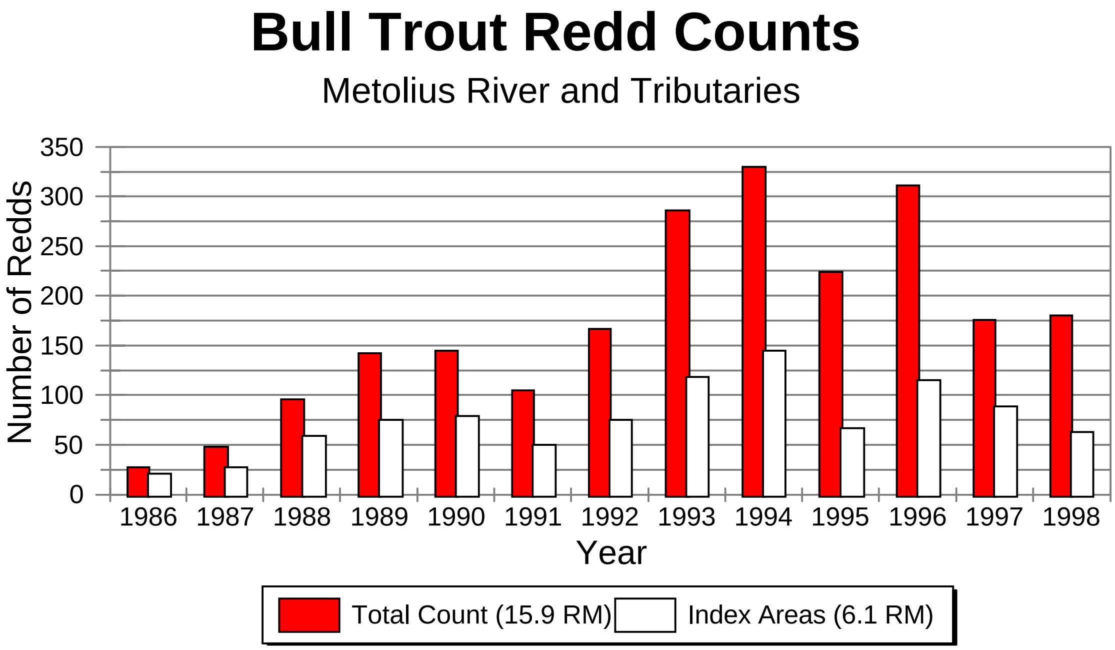

Figure 10. Bull trout redd counts, Metolius River and tributaries, 1986–1998. Data provided by Steve Thiesfeld, ODFW, Prineville, Oregon.

Redds and adult bull trout counted during spawning ground surveys indicate that the spawning bull trout population in the Metolius River Basin has decreased in the past two years. Reasons for the decline are unknown.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Bull trout are relatively common in the Deschutes River upstream to Steelhead Falls and in Squaw Creek. Bull trout have been extirpated above Bend except in Odell Lake (Ratliff et al. 1996, Goetz 1989). They have been subjected to habitat loss due to extreme fluctuation in streamflows associated with irrigation development, water quality degradation, fluctuations in water temperatures, over-fishing, and competition from introduced brown trout (Fies et al. 1996b).

Lower Crooked River

Bull trout are present in the lower Crooked River, from Lake Billy Chinook to Opal Springs (Buchanan et al. 1997). Bull trout have been extirpated from the Crooked River above Opal Springs (Stuart et al. 1997, Ratliff et al. 1996, Goetz 1989). Production potential of bull trout in the Crooked River is unknown (Stuart et al. 1996).

Lake Billy Chinook

Bull trout are common in Lake Billy Chinook. Lake Billy Chinook provides a rearing area for bull trout that spawn in tributaries upstream of the reservoir. The number of bull trout in Lake Billy Chinook is unknown, but anglers caught over 1,000 fish in 1992 (Stuart et al. 1996). In 1997, Merwin traps were used to capture fish species in each arm of Lake Billy Chinook. Fifty-six bull trout were collected in the Crooked River Arm, 70 were collected in the Deschutes River Arm, and 133 were collected in the Metolius River Arm (Hiatt et al. 1997).

Merwin traps were also used to capture fish species in each arm of Lake Billy Chinook and in the Round Butte Dam forebay in 1998 (Lewis 1999). A total of 388 bull trout were captured in the reservoir during the 1998 trapping effort — 47 in the Crooked River Arm, 18 in the Deschutes River Arm, 258 in the Metolius River Arm, and 65 in the forebay. Bull trout comprised 4.4 percent of the total fish caught in the reservoir by Merwin traps in 1998 (Lewis 1999).

Lake Simtustus

Bull trout are present in Lake Simtustus in low numbers. Bull trout cannot successfully reproduce in tributaries of Lake Simtustus because the water temperatures in the tributaries are too warm for successful egg hatching (Stuart et al. 1996).

Lewis (1999) used a Merwin trap to capture fish in Lake Simtustus in 1998. Only one bull trout was captured in Lake Simtustus in 1998.

Lower Deschutes River

Bull trout are found in the mainstem Deschutes between Sherars Falls and the Reregulating Dam, in Shitike Creek, in the Warm Springs River, and in the White River below White River Falls (ODFW et al. 1985, ODFW 1987, 1997). The only known suitable spawning sites in the lower Deschutes River Basin are located in the Warm Springs River and Shitike Creek (ODFW 1997). Estimated redd counts ranged from a high of 18 redds in 1989 to lows of six redds in 1992 and 1994 (Buchanan et al. 1997). Juvenile and sub-adult individuals migrate to the mainstem lower Deschutes River to rear (ODFW 1997). A former population of bull trout in Trout Creek has been extirpated (Ratliff et al. 1996). The production potential of bull trout in lower Deschutes River tributaries is less than in Metolius River tributaries (Buchanan et al. 1997).

Bull trout populations have been monitored by the Confederated Tribes of the Warm Springs Reservation of Oregon in Shitike Creek and the Warm Spring River (Fritsch and Hillman 1995). There appears to be a general downward trend in abundance of bull trout in these two streams (ODFW 1997).

FISHERIES

Historically, liberal bag limits and tackle restrictions resulted in high harvest rates of bull trout in the Deschutes River Basin. In recent years, however, bull trout harvest has been low and is likely not a major factor affecting current populations (ODFW 1997). Restrictive bull trout angling regulation changes, including the elimination of bull trout harvest in all spawning areas, may be the major reason why the Metolius River and Lake Billy Chinook populations showed significant increases beginning in 1993 (Ratliff 1992, Ratliff et al. 1996, Buchanan et al. 1997).

The only legal harvest of bull trout in Oregon at the present time occurs in Lake Billy Chinook and the Deschutes River upstream of Lake Billy Chinook (Buchanan et al. 1996). Estimated annual catch of bull trout in 1990–1991 and 1996–1998 varied from 1,094 in 1990 to 3,140 in 1997. Approximately 65 percent of these fish were released. Annual catch rates (hours per fish) varies from 0.001 to 0.009. Most of the harvest occurs in March, April, and September (data provided by S. Thiesfeld, ODFW).

Limiting Factors

Factors limiting existing populations of bull trout in reaches of the Deschutes River Basin are logging and road construction, which have increased water temperatures and sedimentation in spawning and juvenile rearing habitats (Ratliff et al. 1996; Newton and Pribyl 1994, as reported in Buchanan et al. 1996); forest practices such as tree thinning, spraying, and fire control (Buchanan et al. 1996); hybridization with brook trout (Brumback 1993, ODFW 1997); water fluctuations (Fies et al. 1996); fisheries (ODFW 1997); and livestock grazing (Newton and Pribyl 1994). In the Metolius River subbasin, competition with non-native brook and brown trout also may have impacted bull trout populations (Buchanan et al. 1997). Factors causing fractured and isolated populations of bull trout are natural barriers and construction of dams (Ratliff et al. 1996). However, the creation of Lake Billy Chinook has provided a large habitat area with ample prey where bull trout have the opportunity to grow larger in size than historic bull trout in the Deschutes River Basin (Buchanan et al. 1997).

Ecological Role

Bull trout have a special ecological significance in the Deschutes River Basin because they are, at least locally, at the top of the native fish food chain. Cool water temperatures associated with healthy bull trout populations would reduce metabolic rates of bull trout which could reduce predation activity. While bull trout may be at the top of the food chain, they can successfully coexist with other fish species as long as habitat conditions and species composition remain stable. Bull trout populations remain healthy in the Pelton Round Butte Project area because they have a good prey source in the reservoir and adequate spawning and early rearing habitat in the Metolius River Basin. Changes in the abundance or individual size of bull trout in this population could provide an early indication of change in prey fish abundance or composition, or changes in their habitat in Lake Billy Chinook.

MOUNTAIN WHITEFISH

Prosopium williamsoni

Other common names: Rocky Mountain whitefish, Williamson's whitefish, grayling

General

APPEARANCE

The body of the mountain whitefish is slender, elongated, and nearly circular to somewhat laterally compressed in cross section, depending on geographic region and age of the individual (young mountain whitefish are typically laterally compressed). The peduncle is narrow. The head of mountain whitefish is relatively short, making up about 20 percent of the total body length. The eye diameter is less than the snout length. The snout is pointed, laterally compressed, and extends slightly past the mouth. The mouth is small and is located on the bottom of the snout. The maxillaries extend to the front of the eye. The teeth are very small and are located on the tongue and gill rakers (Carl et al. 1959, Scott and Crossman 1973).

Mountain whitefish have a single dorsal fin and a large adipose fin (Carl et al. 1959). The dorsal fin has 11 to 15 rays. The tail fin is forked with rounded points. The anal fin has 10 to 13 rays. The pelvic fins are located low on the belly and have 10 to 13 rays. The pelvic fins have distinct axillary processes, and 10 to 12 rays. The pectoral fins do not have axillary processes, and they have 14 to 18 rays (Scott and Crossman 1973). The scales of mountain whitefish are large, round, and usually dark in color. The scales on the back have a color border (Scott and Crossman 1973).

Adult mountain whitefish are silver in overall appearance, but the color of the back can vary from brown or olive to dark-bronze. The belly may be white. The dorsal fin is often a dusky color and the pectoral fins of adults may have an amber tint. The adipose fin is colorless and lacks spots (Scott and Crossman 1973).

Young mountain whitefish are silvery with two or more rows of black spots on the sides. The lower row of parr marks, numbering eight to ten, are located along the lateral line (Scott and Crossman 1973). Some young mountain whitefish have distinct smaller black marks above the parr marks (Carl et al. 1959, Scott and Crossman 1973).

Distinguishing characteristics of mountain whitefish are the unspotted adipose fin and the narrow peduncle (Carl et al. 1959).

DISTRIBUTION

The mountain whitefish is found in lakes and streams of western North America from the Lahontan Basin in Nevada, north through the northwestern states, including Wyoming, Montana, and Idaho, to the Yukon-British Columbia border. They are widespread throughout the Columbia River system (Scott and Crossman 1973), including the Deschutes River Basin (Fies et al. 1996a, 1996b; ODFW 1997, Stuart et al. 1996).

LIFE HISTORY

Mountain whitefish spawn from late fall into the winter (McPhail and Lindsey 1970) in areas with gravel or coarser sediment (Scott and Crossman 1973). McPhail and Lindsey (1970) note that spawning times for mountain whitefish may vary within a single population when it is composed of two or more separate races of this species. Spawn timing also varies regionally.

Mountain whitefish do not construct a nest (Scott and Crossman 1973). The eggs are adhesive and, when discharged by the female, stick to the stream bottom (Simpson and Wallace 1978). There is some debate as to whether mountain whitefish spawn in lakes (Scott and Crossman 1973), although lake spawning has been reported in Wyoming (Hagen 1979). Mountain whitefish spawn at night (Brown 1952, McPhail and Lindsey 1970) and in water 5 inches to 4 feet deep (Brown 1952).

Eggs of mountain whitefish are relatively large (Brown 1952). The number of eggs per female varies depending upon the size of the female. Hagen (1970) figured mountain whitefish carry, on average, 7,757 eggs per pound of female, although other studies indicate the number is closer to 5,000 eggs per pound of female (Scott and Crossman 1973). Eggs of mountain whitefish in Montana that are spawned in October or early November hatch in early March (Brown 1952). Eggs of mountain whitefish in warmer conditions hatch more quickly. For example, eggs hatch in about 1 month at 48ºF (Wydoski and Whitney 1979). Newly hatched fry stay in shallower areas for a few weeks before they move into deeper water (Scott and Crossman 1973).

The growth rate of mountain whitefish is generally the same for males and females (McHugh 1942), but growth rates vary greatly among different regions (Northcote 1957). Mountain whitefish at age 1 can be 2.6 to 5.3 inches long, at age 5 can be 8.7 to 13.0 inches long, and at age 9 can be 14.8 to 17.4 inches long (Northcote 1957). Mountain whitefish become sexually mature at age 3 or 4 (McHugh 1942).

HABITAT REQUIREMENTS

Mountain whitefish live in lakes and rivers, although they seem to prefer larger streams to smaller streams (Scott and Crossman 1973). Mountain whitefish adapt well to changing conditions (Nelson 1965). Mountain whitefish are bottom feeders and consume a variety of organisms, including insect larvae such as mayflies, stoneflies, cadisflies, and midges. Mountain whitefish also will feed on drifting insects and occasionally other fish. When bottom food is scarce, mountain whitefish will eat midwater plankton (Godfrey 1955). During summer, mountain whitefish are able to use riffle habitat, but during winter they congregate in deep pool habitat.

INTER/INTRASPECIFIC INTERACTIONS

Mountain whitefish will eat the eggs of their own species and of other species (Foerster 1925, Simon 1946). They will also eat young fish, including small salmon (Ricker 1941). Larger predator fish feed on young, small mountain whitefish, but large adult mountain whitefish appear to have few predators (Scott and Crossman 1973). Young mountain whitefish are an important prey species for bull trout in the lower Deschutes River (ODFW 1997) and in the Metolius River

(D. Ratliff, PGE, personal communication, April 1998). Mountain whitefish may compete with rainbow trout and salmon for food (Scott and Crossman 1973).

Mountain whitefish are taken in sport and commercial fisheries (McHugh 1940). The popularity of mountain whitefish as a sport fish varies by region. Gaffney (1960) describes the popularity of mountain whitefish as a sport fish in Montana. In Oregon, on the other hand, mountain whitefish are not a popular sport fish compared to many other species.

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Mountain whitefish are the most abundant game fish in the Metolius River Basin. Detailed population and distribution data for the Metolius River mountain whitefish population is lacking, except for information for the reach from the Metolius River springs to Gorge Campground, which indicates a population there of 100 to 800 individuals. Mountain whitefish are most abundant in this section during November (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

A large population of mountain whitefish is present in the Deschutes River upstream of Lake Billy Chinook, where the fish are found in deep pools with cooler water (Fies et al. 1996b).

Lower Crooked River

Mountain whitefish are abundant in the Crooked River downstream of Prineville Reservoir. Mountain whitefish are the most abundant game fish, and comprise approximately 56 percent of the fish captured by electrofishing in the Crooked River during 1989 and 1993 (Stuart et al. 1996).

Lake Billy Chinook

Mountain whitefish are not commonly found in Lake Billy Chinook (Stuart et al. 1996). Fish sampling using Merwin traps in the three arms of Lake Billy Chinook in 1997 showed that numbers of mountain whitefish were relatively low in all three arms (Hiatt et al. 1997). Lewis (1999) also used Merwin traps to sample fish populations in Lake Billy Chinook in 1998. Mountain whitefish were trapped in all three arms of the reservoir, but represented less than 1 percent of the fish population sampled by Merwin traps in 1998 (Lewis 1999).

Lake Simtustus

The Crooked River Subbasin Plan (Stuart et al. 1996) reports that mountain whitefish are present in Lake Simtustus but gives no information about their relative abundance in this reservoir. Lewis (1999) used a Merwin trap in Lake Simtustus to sample fish populations, but no mountain whitefish were captured. Mountain whitefish, if present, are not abundant in Lake Simtustus.

Lower Deschutes River

Mountain whitefish are native to the lower Deschutes River and its major tributaries. Mountain whitefish are believed to be the most abundant sport fish in the mainstem lower Deschutes River (ODFW 1997). Approximately 5,000 mountain whitefish per mile are found in the lower Deschutes River from the Warm Springs River to Trout Creek (Schroeder and Smith 1989). There are approximately 100 mountain whitefish per mile in the 4.5 mile section of White River immediately above White River Falls (ODFW et al. 1985). Mountain whitefish in the lower Deschutes River feed mostly on immature forms of aquatic insects (Schroeder and Smith 1989).

FISHERIES

Mountain whitefish are classified as a game fish in the Deschutes River, but no catch or length limits have been established. Little information is available on the harvest of mountain whitefish in the Deschutes River Basin. However, mountain whitefish have gained popularity as a game fish for recreational anglers in recent years (ODFW 1997). Still, mountain whitefish harvest in the Deschutes River Basin is believed to be low, and managers believe the species is underutilized as a game fish in these waters (ODFW 1997).

Mountain whitefish are fished using a fly or small hook baited with stonefly larvae, salmon eggs, corn, or maggots (Scott and Crossman 1973). Gaffney (1960) provides fishing information for this species, including methods of fishing, where to fish, baits to use, and preparation of catch.

LIMITING FACTORS

Interspecific interactions between salmon, trout, other native fish, and mountain whitefish tend to favor salmon, trout, and other native fish. Chandler et al. (1993) and Maret et al. (1997) found that native mountain whitefish were intolerant of increased pollution.

Bull trout predation probably has a significant impact on small mountain whitefish populations in parts of the Deschutes River and in the Metolius River.

ECOLOGICAL ROLE

Mountain whitefish can be very abundant. Most likely, mountain whitefish compete for food and space with trout and salmon. Small mountain whitefish may be a buffer species between young trout, salmon, and their predators. Usually, when trout and salmon numbers increase, mountain whitefish numbers decrease. In some regions, mountain whitefish are a popular game fish, while in other regions they are ignored by anglers.

SHORTHEAD SCULPIN

Cottus confusus

General

APPEARANCE

The body of the shorthead sculpin is largest in front, decreasing in size toward the back. The back part of the body is laterally compressed (Scott and Crossman 1973). The common name for this species refers to its relatively small head (Wydoski and Whitney 1979). The head makes up about 26 to 34 percent of the total body length and is rounded when viewed from the top. The maxillary extends to below the pupil of the eye. The mouth is large and round and is located on the end of the snout. The teeth on the jaw are well developed (Scott and Crossman 1973). Adult shorthead sculpin are about 4 inches long (Wydoski and Whitney 1979, Markle et al. 1996). Shorthead sculpin are difficult to distinguish from mottled sculpin (Scott and Crossman 1973).

Shorthead sculpin have two dorsal fins. The first dorsal fin is the shorter and smaller of the two, with seven to ten spines. The second dorsal fin is longer and higher than the first and has 15 to 19 soft rays. The tail fin is paddle-shaped. The anal fin is moderately long with 12 to 14 rays. The pelvic fins are small with one sharp spine and four to five soft rays. The pectoral fins are large and fan-like with 13 to 15 rays. Shorthead sculpin usually do not have scales, but if scales are present they are like prickles and are located in an area behind the pectoral fin (Scott and Crossman 1973).

Shorthead sculpin are light brown or brownish gray to yellow with dark mottled bands that form poorly defined bars on the back. The sides of the body are usually pale and lack bars. The belly is light colored with fine speckles (Simpson and Wallace 1978). The chin is lightly and evenly speckled. The front part of the first dorsal fin is darker than the back part (Scott and Crossman 1973).

There is considerable variety in the appearance of shorthead sculpin as a result of isolation of different populations. Variations are found in the dorsal fin connection, coloration, and length of the lateral line (Markle et al. 1996).

Distinguishing characteristics of shorthead sculpin are the small head, which is usually less than one-third the total length, the slender body, and the four rays in the pelvic fins. The torrent and mottled sculpins are distinguished from the shorthead sculpin by their larger head and bodies. The slimy sculpin also has a slender body like the shorthead sculpin, but has only three rays in the pelvic fin (Wydoski and Whitney 1979).

DISTRIBUTION

Shorthead sculpin are found in the Puget Sound area, the Columbia River Basin and the Flathead River in southeastern British Columbia (Scott and Crossman 1973).

LIFE HISTORY

Shorthead sculpin spawn in the spring, but the precise time of spawning is not known (Wydoski and Whitney 1979). Egg production varies from nearly 50 eggs in a 2.4-inch female to 219 eggs in a 3.4-inch female. Shorthead sculpin reach maturity at age 2 or 3 (Scott and Crossman 1973). Eggs are deposited in clusters under stones or other hard objects. Nest guarding, usually performed by males, appears to be important to the survival of eggs. The incubation period is about 5 weeks at 50ºF, and the absorption of the yolk sac takes about 3 weeks at 50ºF (Bond 1963).

Sculpin generally eat aquatic insects, but their feeding habitats depend primarily on available food. The diet specific to the shorthead sculpin has not been studied (Wydoski and Whitney 1979). Sculpin live to be age 5 or 6 (Bond 1963).

HABITAT REQUIREMENTS

The shorthead sculpin generally lives in riffles in streams, although some individuals occasionally live in slow-moving water along shorelines and in backwater. In general, shorthead sculpin are found at higher altitudes than most other species of sculpin. However, specimens also have been collected at lower elevations, including at Bonneville Dam, in Gnat Creek, and in Big Creek in Oregon. They appear to prefer cool water temperatures, with summer temperatures lower than 60ºF. The highest water temperature in which shorthead sculpin have been found is about 75ºF. Their habitat usually has cobble or gravel bottom (Wydoski and Whitney 1979, Bond 1963).

INTER/INTRASPECIFIC INTERACTIONS

Several species of fish have been observed feeding on the eggs of sculpin (Bond 1963, Patten 1971), and shorthead sculpin may serve as food for game species (Bond 1963, Wydoski and Whitney 1979).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Shorthead sculpin are present in the Metolius River. Little is known about their abundance and distribution in the Metolius River Basin (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Sculpin species are not found immediately upstream of Lake Billy Chinook in the Deschutes River, but are present in Squaw Creek. The types of sculpin species present and their relative abundance in this portion of the Deschutes River are not known (Fies et al. 1996b).

Lower Crooked River

Sculpin species are not identified in the Crooked River below Prineville Reservoir (Stuart et al. 1996).

Lake Billy Chinook

Stuart et al. (1996) note that sculpin species are present in Lake Billy Chinook, and that their abundance goes almost unnoticed because of their relative small numbers. Sampling equipment (electrofishing, gill nets, and Merwin traps) presently used to sample fish populations in Lake Billy Chinook are not designed to collect sculpin. Consequently, the abundance of shorthead sculpin in Lake Billy Chinook is unknown. Also, Stuart et al. (1996) do not differentiate the different species of sculpin in Lake Billy Chinook. Because shorthead sculpin are present in the Metolius River upstream of Lake Billy Chinook, shorthead sculpin may be present in Lake Billy Chinook.

Lake Simtustus

Sculpin species are present in Lake Simtustus, but are much less abundant than other nongame fish species (Stuart et al. 1996). Shorthead sculpin may be among the sculpin species present in Lake Simtustus, but their abundance is unknown.

Lower Deschutes River

Several species of sculpin are native to the lower Deschutes River and many of its tributaries including White River, the Warm Springs River, and Shitike Creek (ODFW 1997). ODFW (1997) does not specify the types of sculpin species present and their relative abundance, but states that populations of sculpin above White River Falls may be genetically or morphologically unique.

FISHERIES

Shorthead sculpin are considered a nongame fish in the Deschutes River Basin, and there is no fishery for this species.

LIMITING FACTOR

Factors controlling populations of shorthead sculpin the Deschutes River Basin are unknown. Because of this species' preference for cool water and relatively high-gradient streams, some habitat conditions, natural and artificial, would presumably restrict shorthead sculpin abundance and distribution in the Deschutes River Basin. Habitat conditions should be good for shorthead sculpin in many reaches of the Metolius River and its tributaries, however.

ECOLOGICAL ROLE

Shorthead sculpin are probably a prey species for larger fish in higher elevation streams. If this is the case, they are probably a favorite prey species for bull trout.

TORRENT SCULPIN

Cottus rhotheus

General

APPEARANCE

The body of the torrent sculpin is stout, decreasing in size toward the rear of the fish. The caudal peduncle is narrow, and the rear of the body is laterally compressed. The average length of adults is about 4 inches (Scott and Crossman 1973) to 6 inches (McAllister and Lindsey 1961). The head is about 27 to 30 percent of the total body length. The maxillary extends to below the eye. The eye diameter is approximately 20 to 27 percent of the head length. The mouth is large with strong teeth and jaws (Scott and Crossman 1973).

Torrent sculpin have two dorsal fins. The first dorsal fin is shorter and has seven to nine sharp spines. The second dorsal fin, positioned behind the first, is longer and has 15 to 17 soft rays. The tail is rounded and paddle-shaped. The anal fin is long with 11 to 13 soft rays. The pelvic fins are small with one sharp spine and four soft rays. Pectoral fins are large and fan-like and have 15 to 18 rays (Scott and Crossman 1973, Wydoski and Whitney 1979).

Torrent sculpin lack scales but have well developed prickles on the back and sides, and sometimes on the caudal peduncle. However, in some specimens, the prickles may be confined to a patch behind the pectoral fin (Scott and Crossman 1973).

Torrent sculpin are brown or greyish brown with dark mottling. They have two distinct dark saddle-like bars that angle down and forward on the back under the second dorsal fin and a lateral line that extends to the caudal peduncle. The sides are lighter in color and the belly is white. The chin is distinctly mottled. The dorsal, tail, and, sometimes the anal and pectoral fins have bands or bars of color. The outer edge of the first dorsal fin is orange in spawning males (Scott and Crossman 1973, Wydoski and Whitney 1979).

Distinguishing characteristics of torrent sculpin are the stout body and large head, the long lateral line, and the two rather broad bars that slant forward from under the second dorsal fin (Wydoski and Whitney 1979).

DISTRIBUTION

The torrent sculpin is found in the Columbia River and its tributaries and in the upper Fraser River in British Columbia. It is also found in Pacific Coast rivers from the Puget Sound south to the Nehalem and Necanicum rivers in Oregon (Wydoski and Whitney 1979).

LIFE HISTORY

Torrent sculpin spawn in spring (Bond 1963) from April (Wydoski and Whitney 1979) to June (Northcote 1954). Torrent sculpin may mature as early as age 2 (Northcote 1954, Wydoski and Whitney 1979) but may not mature until they are age 4 or 5 (Bond 1963). Mature females spawn each year. Torrent sculpin appear to have an upstream spawning migration from late January to late April (Wydoski and Whitney 1979, Thomas 1973). The number of eggs produced by females varies, depending on locality and size of fish, but is low compared to numbers of eggs produced in other species (Bond 1963). Average numbers of eggs produced by torrent sculpin range from 100 in a 2.7-inch female to 412 in a 4.3-inch female (Wydoski and Whitney 1979). They deposit their eggs in clusters under stones or other hard objects in swift water. Nest guarding, usually performed by males, appears to be important to the survival of eggs. The incubation period is about 5 weeks at 50ºF, and absorption of the yolk sac takes about 3 weeks at 50ºF (Bond 1963).

C. Zimmerman (OSU, personal communication, May 1998) observed four torrent sculpin nests in side channels of the lower Deschutes River between Dry Creek and Frog Springs on May 14, 1996. In each case, a clump of about 75 to 100 eggs was attached to the underside of large, flat cobble. A 4-inch male sculpin was in the cavity under the rock, and the sculpin did not flee when the rock was lifted. Zimmerman noted that there was an absence of stonefly larvae and crayfish in the vicinity, indicating that torrent sculpin was the dominate species near the nest sites. An examination of the same nests on May 23, 1996 revealed that the eggs were gone, and Zimmerman believed that the eggs had hatched.

HABITAT REQUIREMENTS

Torrent sculpin are found in streams and lakes. In streams, they live in swift current with a stable bottom of rubble, gravel, and large rocks. In lakes, they live in beach areas. Generally, torrent sculpin live in streams that are wider than 8 feet and have currents with velocities of 1 to 4 feet per second (Wydoski and Whitney 1979).

Torrent sculpin eat a variety of organisms. In British Columbia, sculpin less than 2 inches long eat plankton and aquatic insect larvae, and sculpin 2 inches and longer feed mostly on fish (Northcote 1954). In Oregon, torrent sculpin feed primarily on mayflies and stoneflies, but larger torrent sculpin eat fish (Bond 1963). Crayfish form a substantial part of the diet of torrent sculpin (Wydoski and Whitney 1979).

INTER/INTRASPECIFIC INTERACTIONS

Torrent sculpin have a proportionally larger mouth for their body size than do other sculpin. This allows them to eat larger food for their size compared to other sculpin species. Fish are the exclusive food of torrent sculpin after they reach lengths of about 3 inches or longer (Scott and Crossman 1973). Although larger torrent sculpin consume fish of other species, Wydoski and Whitney (1979) suggest that torrent sculpin prey only on salmon fry that are in poor condition that would otherwise probably be lost to other causes. Torrent sculpin provide forage for game fishes. Bond (1963) documents game fish eating sculpin eggs.

Bond (1963) notes that occupancy of the same area by two or more species of sculpin could lead to competition or predation. Bond (1963) also suggests that torrent sculpin may have a competitive reproductive advantage over other species of sculpin because torrent sculpin mature at a larger size and older age. Larger sculpin may be more aggressive toward potential predators.

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Lower Crooked River

Sculpin have not been documented in the Crooked River below Prineville Reservoir (Stuart et al. 1996).

Metolius River Basin

Fies et al. (1996a) do not list torrent sculpin among the species present in the Metolius River (Fies et al. 1996a), but D. Ratliff (PGE, personal communication, April 1998) has noted the presence of this species in the Metolius River.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Torrent sculpin have not been collected in Merwin traps located in the Deschutes River Arm of Lake Billy Chinook (Hiatt et al. 1997). Torrent sculpin may be present in Squaw Creek, but their numbers, if any, are unknown (Fies et al. 1996b).

Lake Billy Chinook

Stuart et al. (1996) note that sculpin are present in Lake Billy Chinook, but in relatively small numbers. Sampling equipment (electrofishing, gill nets, and Merwin traps) used to sample fish populations in Lake Billy Chinook are not designed to collect sculpin. Consequently, the abundance of torrent sculpin in Lake Billy Chinook is unknown. Also, Stuart et al. (1996) do not differentiate the different species of sculpin in Lake Billy Chinook. Because torrent sculpin are common in Columbia River tributaries and inhabit standing water, they are probably among the sculpin present in Lake Billy Chinook.

Lake Simtustus

Sculpin are present in Lake Simtustus, but their abundance is much lower than that of other nongame fish species in the reservoir (Stuart et al. 1996). Stuart et al. (1996) do not specifically identify torrent sculpin in Lake Simtustus; however, for reasons similar to those mentioned for Lake Billy Chinook, they are probably found in low numbers in Lake Simtustus as well.

Lower Deschutes River

Several species of sculpin are native to the lower Deschutes River and many of its tributaries including White River, the Warm Springs River, and Shitike Creek (ODFW 1997). ODFW (1997) does not provide information on the particular species and relative abundance of sculpin present in this portion of the Deschutes River system. Torrent sculpin are likely present, but not abundant, in the lower Deschutes River and tributaries. Populations of sculpin above White River Falls may be genetically or morphologically unique (ODFW 1997).

FISHERIES

Torrent sculpin are considered a nongame fish in the Deschutes River, and no fishery occurs for this species. The torrent sculpin's feeding habits, including its ability to consume other fishes, may bring it into conflict with species of interest; however, no such conflict has been documented in the Deschutes River Basin.

LIMITING FACTOR

Populations of torrent sculpin may be controlled by competition and predation with other fishes.

ECOLOGICAL ROLE

Torrent sculpin are both predator and prey. While they are relatively small, they are capable of preying on fairly large fish because of the large size of their mouth. However, in the Deschutes River Basin, torrent sculpin's role as predator of other fish may be limited to consuming salmon fry that have low chance of survival (Wydoski and Whitney 1979). Torrent sculpin may be an important food for upper level predators such as bull trout.

SLIMY SCULPIN

Cottus cognatus

Other common names: Miller's thumb, cockatouch, slimy muddler, common slimy muddler, northern sculpin, stargazer, Bear Lake bullhead (Scott and Crossman 1973)

General

APPEARANCE

Slimy sculpin have the large, flat-shaped head characteristic of sculpin. The average body length of this species is about 2 to 4 inches. The body depth is about equal to the body width near the front of the body. The caudal peduncle has a moderate depth. The head length is about 22 to 30 percent of the total body length. The snout is rounded when viewed from the top. The upper lip extends beyond the lower lip. Eyes are located on the top of the head and they are relatively large. The maxillary extends to below the eye. There is one spine on each side of the head that extends upward and toward the rear of the fish. Other smaller spines on the head are directed downward. All of these smaller spines are covered by skin (Scott and Crossman 1973).

Slimy sculpin have two dorsal fins. The first dorsal fin is small with seven to nine sharp spines. The second dorsal fin is longer and higher with 14 to 19 soft rays. The tail is fairly large compared to the size of the fish and is slightly rounded. The anal fin is large with 10 to 14 soft rays. Pelvic fins are small with one sharp spine and three or four soft rays. Pectoral fins are large and fanlike, with 12 to 16 rays (Scott and Crossman 1973. Slimy sculpin do not have typical scales, but some specimens have small prickles behind the pectoral fins (Scott and Crossman 1973).

Slimy sculpin are dark brown with lighter sides and a white or near-white belly (Scott and Crossman 1973). However, there is considerable variation in color of slimy sculpin depending upon habitat conditions (Miller and Kennedy 1946). Some specimens have two dark saddle-shaped marks, one near the front of the second dorsal fin and one near the rear of the second dorsal fin. Some specimens also have a poorly defined bar at the base of the tail. In general, the first dorsal fin is dark colored at the base but the margins are clear. The second dorsal fin, tail fin, and anal fin may be lightly barred. The pectoral fins usually have wide bands. Breeding males are dark overall, with a broad reddish orange edge on the first dorsal fin (Scott and Crossman 1973).

Slimy sculpin show considerable body and color variation throughout their range (McAllister 1964). Dymond (1926), Walters (1955), Lindsey (1956), McAllister and Bleakney (1960), McAllister and Lindsey (1961), McAllister (1964, 1968), and McPhail and Lindsey (1970) describe these regional characteristics.

The distinguishing characteristic of slimy sculpin is that they have one spine and three or four rays in the pelvic fin (Wydoski and Whitney 1979).

DISTRIBUTION

Slimy sculpin are found from Virginia northward to Labrador, then west to Alaska, and south into the Columbia River Basin. The are also found in eastern Siberia (Wydoski and Whitney 1979). Simpson and Wallace (1978) note that slimy sculpin have a distribution pattern in which populations are not connected, a condition that is not understood.

LIFE HISTORY

Slimy sculpin spawn in the spring in water that is 41ºF to 50ºF (Koster 1936). The ripe male selects a spawning site under a rock, ledge or other such overhanging structure. The female is courted by the male until she enters the nest area. After additional courting in the nest area, the female deposits adhesive eggs in a mass on the ceiling of the nest. After spawning, the male drives the female off the nest area. The nest area may contain eggs from more than one female. The male guards the nest and young until they begin feeding (Koster 1936). Koster (1936) describes males that guard the young even after they begin to feed. A female 4 inches in length will produce approximately 1,400 eggs (Van Vliet 1964). The eggs hatch in about 4 weeks. Information concerning age at maturity of spawning and other life history traits of slimy sculpin has not been gathered (Wydoski and Whitney 1979).

HABITAT REQUIREMENTS

There is relatively little information concerning the ecology of slimy sculpin. Generally, slimy sculpin are found in riffles among the rocks of cold, clear streams (Wydoski and Whitney 1979, Meyers 1961). However, slimy sculpin are sometimes found along the gravel beaches of lakes, especially near inlet streams. Slimy sculpin may be found in lakes to a depth of 300 feet. Slimy sculpin are common in rocky shallows of lakes in the northern part of their range, but they are usually found in cool spring-fed streams in the south and east part of their range (Dymond 1926; Harkness and Hart 1927; Fowler 1948; Harper 1948, 1961).

INTER/INTRASPECIFIC INTERACTIONS

The primary food of slimy sculpin is insect larvae, snails, plant material, fish eggs, and some small fish (Scott and Crossman 1973). In turn, slimy sculpin are important forage fish for trout, char and other species (Scott and Crossman 1973). Competition for food between salmon fry, lake trout, brook trout, and sculpin is considered to be slight (Koster 1937, Rogers 1971). While slimy sculpin eat salmon eggs, it is not clear whether slimy sculpin seek salmon eggs or just eat eggs that were not covered in the redd (Wydoski and Whitney 1979, Koster 1937).

Slimy sculpin are often used as bait fish (Dymond 1926), and the name “cockatouch” is given to slimy sculpin used as bait (Scott and Crossman 1973).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not identify slimy sculpin in the Metolius River. Fish collection and identification would probably reveal the presence of slimy sculpin in the Metolius River, however.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Sculpin are not identified as a native species in the Deschutes River above Lake Billy Chinook, but they are identified as native in Squaw Creek (Fies et al. 1996b).

Lower Crooked River

Stuart et al. (1996) state that sculpin are present in the Crooked River, but do not identify the specific species of sculpin present.

Lake Billy Chinook

Slimy sculpin are native to the Lake Billy Chinook area, but their numbers are very small relative to other nongame and game fish species in the reservoir (Stuart et al. 1996). Sampling equipment (electrofishing, gill nets, Merwin traps) presently used to sample fish populations in Lake Billy Chinook are not designed to collect sculpin. Consequently, the abundance of slimy sculpin in Lake Billy Chinook is unknown. Also, Stuart et al. (1996) do not differentiate the different species of sculpin in Lake Billy Chinook.

Lake Simtustus

Sculpin are present in Lake Simtustus. Their abundance in this reservoir is relatively low, and they do not appear to influence the biology and management of game fishes (Stuart et al. 1996).

Lower Deschutes River

Several species of sculpin are indigenous to the lower Deschutes River system, including White River, the Warm Springs River, and Shitike Creek. Little is known about the types of species present or their relative abundance (ODFW 1997).

FISHERIES

Slimy sculpin are considered a nongame fish in the Deschutes River Basin, and no fishery occurs for this species. Slimy sculpin are not used for bait in the Deschutes River Basin. The feeding habits of this species, including its ability to consume other fishes and fish eggs, may bring it into conflict with game fish interests, but this is not the case in the Deschutes River Basin at the present time.

Limiting Factor

Populations of slimy sculpin may be limited by warm water and by competition and predation with other fishes in the Deschutes River Basin. However, very little is known of the life history traits, habitat requirements, and competition/predation conditions affecting slimy sculpin in the basin.

Ecological Role

Slimy sculpin are commonly associated with char (Koster 1937). Slimy sculpin and bull trout most likely inhabit the same cold water habitat, and, therefore, slimy sculpin may be an important food source for bull trout. Slimy sculpin may also compete with young bull trout for food in stream habitats of the Deschutes River Basin where young of both species occur together.

MOTTLED SCULPIN

Cottus bairdi

Other common names: Miller's thumb, Columbia sculpin, blob, gudgeon, freshwater sculpin (Scott and Crossman 1973)

General

APPEARANCE

Mottled sculpin have body characteristics typical of all sculpin. Average length of mottled sculpin is about 3 inches, but individuals as long as 5.2 inches have been documented. The body depth is about equal to the body width near the front of the fish. The rear section of the fish is laterally compressed. The caudal peduncle has a moderate depth. The top of the head is flattened, especially toward the rear of the head, and the head makes up 22 to 29 percent of the total length of the fish. Maxillaries extends to below the eye. There is a large opercular spine directed upward and to the rear, and two small spines directed downward that are covered with skin. The snout is rounded when viewed from above. The upper lip protrudes beyond the lower lip. The eyes are relative large, 21 to 38 percent of the head length (Scott and Crossman 1973).

Mottled sculpin have two dorsal fins. The first dorsal fin is small with seven to nine sharp spines, and the second dorsal fin is larger with 16 to 19 soft rays. The tail is slightly rounded. The anal fin is long with 10 to 14 soft rays. Pelvic fins are small with one to four soft rays. Pectoral fins are large and fanlike with 13 to 17 rays (Scott and Crossman 1973, Wydoski and Whitney 1979).

Mottled sculpin lack typical scales, but have small prickles in patches behind the pectoral fins. In some individuals, these patches with prickles extend onto the back (Scott and Crossman 1973).

Mottled sculpin are dark brown with darker brown to black mottling on the back and sides. The color becomes lighter to almost white on the lower sides and belly. There are two and sometimes three dark saddle marks under the second dorsal fin. The dorsal, tail, anal and pectoral fins are marked with pigment. The first dorsal fin has a spot on the front and back, and these spots connect in breeding males. The connecting band will develop a broad orange edge. Breeding males also have spots and bands on the second dorsal fin, speckles on the tail fin, dark speckles on the anal fin, and a band on the pectoral fins (Scott and Crossman 1973, Wydoski and Whitney 1979).

Distinguishing characteristics of the mottled sculpin are a stout body with a large head, an incomplete lateral line, a caudal peduncle with its length about 25 percent the length of the head, and three straight, vertical, dark bands on the body under the second dorsal fin (Wydoski and Whitney 1979).

Distribution

Mottled sculpin populations are distributed over a wide range but are not always connected. They are found through North America from the Tennessee River to Labrador, and in the Great Lakes, Missouri, upper Colorado, and the Columbia River systems. They are also found in the Bonneville and Harney basins (Scott and Crossman 1973, Wydoski and Whitney 1979).

Life History

Mottled sculpin mature when they are age 2 and they spawn from February to June, depending on location (Wydoski and Whitney 1979). Spawning occurs at water temperatures of about 50ºF (Koster 1936). Males select a spawning or nesting site under a rock or ledge, and a female enters the nest after being courted by the male. The female deposits adhesive eggs in a mass on the ceiling of the nest while upside down, and then departs or is driven off by the male. More than one female usually deposits eggs in the nest. The male remains to guard the eggs against predators. If the current is slow, the male will use his pectoral fins to maintain a flow over the eggs (Koster 1936, Bailey 1952, Savage 1963).

Mottled sculpin females deposit their eggs in the nest in clusters of 20 to 150. The number of eggs produced at spawning varies from 46 in a 1.8 inch female to 275 in a 3.6-inch female. The average number of eggs produced is 65 in age 2 females, 135 in age 3 females to 176 in age 4 females (Scott and Crossman 1973, Wydoski and Whitney 1979). Bond (1963) determined that mottled sculpin have average fecundity compared to other sculpin.

Mottled sculpin eggs hatch in 20 to 30 days at 50 to 60ºF. Newly hatched sculpin are about 0.25 inch long (Wydoski and Whitney 1979).

In Montana, age 1 mottled sculpin are 1.7 inches, age 2 are 2.6 inches, age 3 are 3.2 inches, and age 4 are 3.8 inches (Wydoski and Whitney 1979). Mottled sculpin live to a maximum of age 6 (Bailey 1952, Zarbock 1952).

Habitat Requirements

Mottled sculpin prefer cool, clear water in streams with moderate to rapid current and summer temperatures of 55 to 65ºF but have been found in water up to 70ºF. Mottled sculpin are generally associated with rubble, gravel, or rocky stream bottoms, and are seldom found in silted areas; however, Toner (1943) observed mottled sculpin most often on sandy substrate in lakes and streams. In summer, mottled sculpin are found in shallow water, 0.5 to 3 feet deep (Wydoski and Whitney 1979). Hallam (1959) found mottled sculpin in shaded areas with low water temperatures and in small streams with many rapids. Deason (1939) noted that mottled sculpin do not occur as far up headwater streams nor as deep in lakes as slimy sculpin.

Mottled sculpin feed mainly on aquatic insect larvae, fresh-water shrimp, snails crayfish, fish fry, and fish eggs. Winter feeding habitats differ little from those of summer (Daiber 1956).

INTER/INTRASPECIFIC INTERACTIONS

Hallan (1959) reported that mottled sculpin are most often found in association with brook trout. Greeley (1932) and Koster (1937) report that mottled sculpin eat trout eggs but that they are not considered to be destructive of brook trout eggs because they only eat eggs that were not covered with gravel by spawners. Wydoski and Whitney (1979) remark that the incidental consumption of trout fry and trout eggs is probably minor in comparison to the value of the mottled sculpin as forage for trout. Ricker (1934) and Tester (1932) report that sculpin are a part of the diet of large brook trout, other salmonids, and smallmouth bass. Mottled sculpin may compete with trout for food, but such competition is unlikely to be serious except under conditions marginal for trout (Scott and Crossman 1973).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not identify mottled sculpin in the Metolius River. Considering habitat preference of mottled sculpin, it seems likely that mottled sculpin would be present in the Metolius River.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) do not identify mottled sculpin in the Deschutes River above Lake Billy Chinook. Sculpin are present in Squaw Creek (Fies et al. 1996b), however, and these could be mottled sculpin. The size of the population is unknown.

Lower Crooked River

Sculpin are native nongame fish in the Prineville Valley section of the lower Crooked River. Stuart et al. (1996) do not identify different species of sculpin native to this section. Mottled sculpin are likely present in the lower Crooked River. The population size of sculpin in the lower Crooked River is unknown (Stuart et al. 1996).

Lake Billy Chinook

Mottled sculpin are native to Lake Billy Chinook (Fies and Robart 1988). Mottled sculpin are classified as nongame fish and receive little management attention. The population size is considered relatively small compared to populations of other nongame fish species in Lake Billy Chinook (Stuart et al. 1996). However, equipment used to sample fish populations in Lake Billy Chinook, including Merwin traps, rotary traps, gill nets, and electrofishing gear, are not designed to collect sculpin. It is likely, therefore, that sculpin populations are larger than projected.

Lake Simtustus

Mottled sculpin have not been identified in Lake Simtustus, although their presence in Lake Billy Chinook suggests they are present in Lake Simtustus as well. Their abundance in this reservoir is thought to be low relative to other nongame fish species (Stuart et al. 1996).

Lower Deschutes River

Several species of sculpin are native to the lower Deschutes River and many of its tributaries. Little is known about their abundance or life history characteristics (ODFW 1997).

FISHERIES

Mottled sculpin are considered a nongame fish in the Deschutes River, and no fishery is associated with this species. They also are not known to be used for bait in the Deschutes River Basin.

LIMITING FACTOR

Populations of mottled sculpin may be limited by warm water and by competition and predation with other fishes in some areas of the Deschutes River Basin. However, very little is known of the life history traits, habitat requirements, and competition/predation conditions affecting mottled sculpin in the basin.

ECOLOGICAL ROLE

Mottled sculpin are commonly associated with brook trout (Hallam 1959), which suggests that mottled sculpin may also be associated with bull trout. It is also likely that mottled sculpin have an ecological role associated with chinook salmon and steelhead production. Mottled sculpin live in the same cold-water habitats as brook trout, bull trout, chinook salmon and steelhead, and therefore may be a food source for these species. Mottled sculpin probably also feed on eggs and fry of these fish. Mottled sculpin may also compete with salmon and trout for food in stream habitats of the Deschutes River Basin. The mottled sculpin's feeding habits and its ability to consume individuals and eggs of other fishes may bring it into conflict with other species, but to date no such conflict has been documented.

PRICKLY SCULPIN

Cottus asper

Other common names: Prickly bullhead, bullhead (Scott and Crossman 1973)

General

APPEARANCE

Prickly sculpin have a body shape characteristic of sculpin, with the body largest toward the front and decreasing in size toward the rear. The body is laterally compressed from the midpoint to the rear. The head is about 25 to 32 percent of the total length of the fish. The maxillaries extend to the middle of the eye or beyond in adults. A large opercular spine is directed toward the rear of the fish, and one or two smaller spines point downwards. The eyes are large, making up about 18 to 33 percent of the head length. The mouth is also large with well developed teeth on the upper and lower jaws (Scott and Crossman 1973).

Prickly sculpin have two dorsal fins. The first dorsal fin is smaller with 8 to 10 spines, and the second dorsal fin is longer and higher than the first with 18 to 22 soft rays. Dorsal fins are joined at the base with a distinct notch between the two fins. The tail is slightly rounded. The anal fin has a long base that supports 15 to 19 soft rays. The pelvic fins are small and have one spine and usually four soft rays. The pectoral fins are large and fanlike, with 15 to 18 rays (Scott and Crossman 1973). Prickly sculpin lack typical scales but may have prickles over the upper half of the whole body (Scott and Crossman 1973).

Prickly sculpin are olive to dark brown or grey on the back and sides, with the belly yellowish white or white. There are three dark bands under the second dorsal fin, and the sides have light black mottling. The dorsal, tail, anal, and pectoral fins usually are barred, and the first dorsal fin has a distinct black oval mark near the rear. Spawning males are dark. Both sexes have a thin orange band on the edge of the dorsal fin at spawning time (Scott and Crossman 1973).

Distinguishing characteristics of prickly sculpin are prickles on the body (though specimens from brackish water have fewer prickles than those from fresh water), well developed teeth, a dark spot at the rear part of the first dorsal fin, and 15 to 19 (rarely 15 or 16) rays in the anal fin (Scott and Crossman 1973; Wydoski and Whitney 1979).

DISTRIBUTION

Prickly sculpin are found from the Ventura River in California to Seward, Alaska and along the Pacific slope of North America. This species is generally found along the coastal areas, but it has been found more than 400 miles upstream in the Columbia River Basin (Wydoski and Whitney 1979).

LIFE HISTORY

Prickly sculpin generally spawn in the spring, but spawning time for various populations ranges from February to late July, depending upon the region (Scott and Crossman 1973). In Washington, peak spawning occurs during April and May (Wydoski and Whitney 1979). Inland populations usually spawn later than coastal populations. Prickly sculpin will spawn in freshwater or brackish water (Scott and Crossman 1973). Bond (1963) notes that coastal populations often move downstream to spawn.

Spawning occurs in streams with boulders where the current flow is about 1 cfs. Males move onto spawning grounds before females and select a nesting site under a boulder or flat rock, preferably with a rough undersurface (Scott and Crossman 1973). Prickly sculpin also spawn under submerged artificial debris such as cans, cars, or other discarded metal (Wydoski and Whitney 1979). Females remain upstream until ready to spawn. When they are ready to spawn, they move downstream onto the spawning area and, following courting behavior outside the nest, a female selected by a male enters the nesting site. Further courtship occurs in the spawning area. Following courtship, females deposit a jelly-enclosed cluster of 700 to 4,000 eggs on the ceiling of the spawning chamber. After spawning, the female leaves the nest, and the males may spawn with as many as ten more females in the next few days. The egg mass from each female is identifiable by its separate location and different stage of development. Many thousands of eggs may be deposited (Scott and Crossman 1973). Krejsa (1967) counted 25,000 to 30,000 eggs in one nest. Prickly sculpin eggs are very small, orange in color, and adhesive. The male guards the eggs and fans them with his pectoral fins (Scott and Crossman 1973).

The eggs hatch in 15 to 16 days at 53.6ºF (Scott and Crossman 1973). Larvae begin swimming at once and may form schools (Northcote and Hartman 1959). Schools of larvae move to open water (Scott and Crossman 1973).

Prickly sculpin mature as early as age 2, although some may not spawn until age 4. Mature females 3.7 to 6.9 inches long have been collected in Washington. The number of eggs counted in prickly sculpin females range from 280 in a 3.7-inch female to 7,410 in a 6.9-inch female. The average number of eggs for each age is as follows: 956 at age 3; 1,734 at age 4; 2,158 at age 5; 4,020 at age 6; and 5,190 at age 7 (Wydoski and Whitney 1979). In Oregon, Bond (1963) recorded 584 eggs in a 2.4-inch female and 10,980 eggs in a 6.3-inch female.

Prickly sculpin may live to ages of 7 (Scott and Crossman 1973) to more than 10 years (Bond 1963) and reach a maximum length of 7 to 12 inches (Krejsa 1967; Carl et al. 1967).

HABITAT REQUIREMENTS

Prickly sculpin are usually found in pools and quiet water areas of larger coastal streams, but they may also live along lake shores. They tolerate salt water very well, and are abundant in some estuaries. Prickly sculpin are generally found on bottoms of lakes or rivers with silty, sandy, gravelly, or coarser material. Because they are often in open-water areas, prickly sculpin depend to a large extent on their protective coloration for concealment (Wydoski and Whitney 1979). During winter, prickly sculpin go into deeper water and live under cover of rocks, logs, and debris. They avoid fastwater areas of streams and are seldom found in small streams. Prickly sculpin prefer water temperatures of 50 to 64ºF, but they have been found in water temperatures as high as 82ºF (Wydoski and Whitney 1979). They are usually more active at night (Scott and Crossman 1973).

Prickly sculpin eggs do not survive water temperatures above 64ºF, and only 50 percent survive at 59ºF (Markle et al. 1996). Emerging fry live in open water for 30 to 35 days. After this initial period, small fry are generally found in vegetated areas in shallow water (Wydoski and Whitney 1979).

Prickly sculpin feed on insect larvae, small snails, plankton, fish eggs, young of their own, and other fish species (Scott and Crossman 1973). Because prickly sculpin reach larger sizes than other sculpin, they may eat more fish than other sculpin (Wydoski and Whitney 1979).

INTER/INTRASPECIFIC INTERACTIONS

Pritchard (1936), Munro and Clemens (1937), and Hunter (1959) present data showing that prickly sculpin feed on the eggs of salmon and trout. Prickly sculpin are probably a significant predator of salmon eggs, although the full effect of their feeding activities on salmon is unknown (Scott and Crossman, 1973). Control of prickly sculpin is discussed by Shapovalov and Taft (1954). Prickly sculpin are eaten by lake trout, bull trout, lake whitefish, and northern pikeminnow (Munro and Clemens 1936). Prickly sculpin was found to be the most important food item of largemouth bass in Lake Washington (Stein 1970).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not identify prickly sculpin as a species found in the Metolius River.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) do not identify prickly sculpin in the Deschutes River above Lake Billy Chinook. Sculpin are present in Squaw Creek (Fies et al., 1996b), but these are probably not prickly sculpin.

Lower Crooked River

Stuart et al. (1996) do not identify prickly sculpin among species found in the lower Crooked River. Most likely, water temperatures are too warm for prickly sculpin in the lower Crooked River.

Lake Billy Chinook

Stuart et al. (1996) do not identify prickly sculpin among the species present in Lake Billy Chinook.

Lake Simtustus

Prickly sculpin are not present in Lake Simtustus (Stuart et al. 1996).

Lower Deschutes River

Several species of sculpin are native to the lower Deschutes River and many of its tributaries. Little is known about the abundance or specific life history characteristics of these fish (ODFW 1997). Prickly sculpin are found in the Columbia River 400 miles upstream from the mouth (Markle et al. 1996). Prickly sculpin probably also are found in the mainstem of the lower Deschutes River.

FISHERIES

Prickly sculpin are readily caught on baited hooks (Wydoski and Whitney 1979). Prickly sculpin are classed as a nongame fish and are not caught for food fish in the Deschutes River Basin.

LIMITING FACTOR

Populations of prickly sculpin may be controlled by warm water in some areas of the Deschutes River Basin and by competition and predation with other fishes in other areas of the basin. However, very little is known of life history characteristics, habitat requirements, or competition/predation factors affecting prickly sculpin in the basin.

ECOLOGICAL ROLE

Prickly sculpin are associated with coastal habitats, and their occurrence in the Deschutes River Basin may be near the edge of their range. It is likely that prickly sculpin have an ecological role associated with coastal spawning salmon. It is also likely that prickly sculpin feed on eggs and fry of Deschutes River salmon and trout. Prickly sculpin may also compete with salmon and trout for food.

LONGNOSE DACE

Rhinichthys cataractae

Other common name: Long-nose dace (Scott and Crossman 1973)

General

APPEARANCE

Longnose dace have a long, slender body that is about 3 inches long in adults. The caudal peduncle is thick (Wydoski and Whitney 1979). The body is nearly round in cross section, especially near the head area. The head is shaped like a triangle and its length is about 19 to 25 percent of the total length of the fish. The eyes are relatively small, with the eye diameter about 16 to 24 percent of the head length. The snout is long and extends beyond and overhanging the mouth. The mouth is low on the head and the upper lip of the mouth is fleshy with a gape ahead of the eye. There are small barbels at each corner of the mouth, but the barbels are not obvious because they are hidden in a skin fold (Scott and Crossman 1973).

The longnose dace has one dorsal fin located behind the front part of the pelvic fin. The tail fin has a shallow fork with rounded lobes. The anal fin has seven rays and is located below the dorsal fin. The pelvic fins are small and originate forward of the dorsal fin. The pectoral fins are short, rounded, and paddle shaped. Scales on longnose dace are round and small (Scott and Crossman 1973).

Longnose dace in streams have olive-green to brown colored backs shading to cream or silvery white on the belly. Longnose dace in lakes are generally greyish with a faint mottling of scattered, darkened scales. Breeding males may display an orange-red color on the corners of the mouth to the cheeks. The pectoral fins also may show a bright orange color (Scott and Crossman 1973).

The bladder in adult longnose dace is quite small compared to other fish. This failure to develop normal swim bladders is discussed by Bailey and Allum (1962), Gee and Northcote (1963), McPhail and Lindsey (1970), and Gee (1968; 1972).

DISTRIBUTION

The longnose dace is widely distributed from coast to coast in north-central North America. In the eastern part of the continent, its range extends south along the mountains to Virginia; in the Mississippi drainage it occurs as far south as Iowa; and west of the continental divide its range extends south to northern Mexico (Scott and Crossman 1973). The longnose dace is relatively abundant in the Columbia River Basin. The wide range of the longnose dace creates questions about individual populations and their genetic makeup. Radforth (1944), McPhail and Lindsey (1970), Power (1965), and Bisson and Reimers (1977) report on the geographic distribution of different populations of longnose dace.

Life History

Despite its wide distribution, little is known about life history traits of longnose dace (Scott and Crossman 1973, Bartnik 1970). Spawning beings in May, June, or early July (Scott and Crossman 1973). McPhail and Lindsey (1970) noted that spawning may occur in late August in some Canada lakes. Carl et al. (1967) report that sexually mature adults were observed in spawning areas when the water temperature was 53ºF. Spawning occurs in riffles on gravelly stream bottoms. Nests are not made, but a territory is established and one parent guards the eggs (McPhail and Lindsey 1970). Females lay 200 to 1200 transparent, adhesive eggs that hatch in 7 to 10 days at 60ºF. The yolk sac is absorbed in about 7 days. The young move into quiet waters near the stream bank or lake shore. The young stay in quiet water for about 4 months before moving to the bottom of the stream or lake where they live as adults (Scott and Crossman 1973, Cooper 1980, Bartnik 1970).

Hybridization of longnose dace with river chub, *Nocomis micropogon*, redside shiner, *Richardsonius balteatus*, blacknose dace, *Notropis heterolepic*, and with lake chub, *Couesius plumbeus*, has been reported by Carl et al. (1967), Raney (1940), Hubbs and Lagler (1949), Cooper (1980), Nelson (1966) and Clayton and Gee (1969). However, Bartnik (1970) and Gibbons and Gee (1972) describes how longnose dace and blacknose dace avoid hybridization by selecting different spawning habitats and demonstrating different spawning behavior.

Longnose dace grow relatively slowly. They are about 2 inches long by age 1, 2.4 inches by age 2, 2.9 inches by age 3, 3.4 inches by age 4, and 3.9 inches by age 5 (Kuehn 1957, Reed and Moulton 1973).

C. Zimmerman (OSU, personal communication, May 1998) has observed that dace are active at night in the lower Deschutes River. Zimmerman has noted that they are very wary at night, and that he does not see dace at all during daylight hours.

Habitat Requirements

Longnose dace may live in swiftly flowing streams with gravel or boulders or in shore waters of lakes (Scott and Crossman 1973). RL&L Environmental Services, Ltd., (1995) reports on preferred habitat types of longnose dace in the lower Columbia River. Longnose dace appear to prefer summer temperatures of 55 to 70ºF (Wydoski and Whitney 1979).

Longnose dace are bottom living fish, and their food is composed of bottom-living organisms. Dymond (1926), Carl et al. (1967) and Reed (1959) found that longnose dace eat fish eggs, midge, and other insect larvae while Bangham and Hunter (1939) found that longnose dace ate worms. Gerald (1966) provides more detail on the food habits of the longnose dace.

Inter/intraspecific Interactions

Longnose dace tend to be rather solitary as individuals, but relatively large populations may occur in some types of stream habitats, including riffle areas with broken rocks (Wydoski and Whitney 1979). Fry may serve as food for juvenile trout or other game fish (Simon 1946).

Longnose dace are used in some regions as bait to catch other fish (Simon 1946, Dobie et al. 1956).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Longnose dace are present in the Metolius River, where little is known about their abundance and distribution (Fies et al. 1996a). Longnose dace were caught in relatively large numbers in downstream migrant traps at the outlet of Suttle Lake in the spring of 1997 (Thiesfeld 1997).

Middle Deschutes River—- Steelhead Falls to Lake Billy Chinook

Longnose dace are native to the Deschutes River above Lake Billy Chinook (Fies et al. 1996b) and were caught by seining below Steelhead Falls in the early 1980s (D. Ratliff, PGE, personal communication, April 1998). S. Lewis (PGE, personal communication, September 1998) captured longnose dace in Squaw Creek.

Lower Crooked River

Longnose dace are found at relatively low densities in the Crooked River downstream of Prineville Reservoir (Stuart et al. 1996).

Lake Billy Chinook

Longnose dace are present in small numbers as compared to other populations of nongame fish species in Lake Billy Chinook (Stuart et al. 1996). Thiesfeld (1997) captured relatively small numbers of longnose dace in a screw trap located at the mouth of the Metolius River from early April to early June 1997. Hiatt et al. (1997) did not capture longnose dace in Merwin traps, which were located in the three arms of Lake Billy Chinook in 1997. However, Lewis (1999) captured 17 longnose dace in the reservoir using Merwin traps in 1998. Approximately 88 percent of these longnose dace were trapped in the Metolius River Arm.

Lake Simtustus

Based on their documented presence in Lake Billy Chinook, longnose dace probably inhabit Lake Simtustus as well. However, their presence in this reservoir is not noted by Stuart et al. (1996) or by Lewis (1999).

Lower Deschutes River

Longnose dace are native to the lower Deschutes River and many of its tributaries including the White River, the Warm Springs River, and Shitike Creek (ODFW 1997). Little is known about their abundance. Populations of longnose dace in the White River above White River Falls may be genetically unique (ODFW 1997).

FISHERIES

Longnose dace are nongame fish in the Deschutes River Basin and are not taken for commercial or recreational purposes. It is illegal to use live longnose dace as bait, but dead longnose dace may be used as bait in the Deschutes River Basin, except where prohibited by special regulations (Oregon Sport Fishing Regulations 1999).

LIMITING FACTOR

Too little is known about life history traits and habitat requirements of longnose dace to speculate on factors that limit the abundance of this species. Most likely, longnose dace have reached a population balance caused by factors that we do not understand at this time.

ECOLOGICAL ROLE

There is no information on which to outline the ecological role that longnose dace play. Longnose dace are probably a minor prey species because of their low abundance in Lake Billy Chinook and Lake Simtustus. Their role as a predator or competitor may also be minor in other sections of the Deschutes River Basin.

SPECKLED DACE

Rhinichthys osculus

General

APPEARANCE

Speckled dace have a rather thick and elongated body with the greatest depth in front of the dorsal fin. The greatest body depth is 16 to 20 percent of the total length. The body is laterally compressed behind the dorsal fin. Speckled dace achieve a maximum length of 2 to 4 inches. The head is shaped like a blunt triangle, and there is a distinct hump behind the head. The head size is about 21 to 24 percent of the total body length. The eye diameter is large, making up about 20 to 25 percent of the head length. The snout is long and overhangs the mouth. The mouth is sucker-like with an upper lip that extends from the snout. A groove completely separates the upper lip from the snout. There is a barbel at each corner of the mouth in specimens from the United States but not in specimens from Canada (Scott and Crossman 1973, Wydoski and Whitney 1979).

Speckled dace have one dorsal fin, which originates behind the pelvic fin. The margins of the dorsal fin are generally straight, although the posterior edge may be slightly rounded. The tail is shallowly forked and has rounded lobes. The anal fin begins under the back of the dorsal fin and has six or seven rays. The pelvic and pectoral fins are relatively small and rounded. Scales on speckled dace are small and round (Wydoski and Whitney 1979).

The overall color of speckled dace is grey or grey-brown with scattered, vague darker flecks located above the lateral line. The belly is yellowish or creamy white. There is a faint lateral band that beings under the dorsal fin and extends into the caudal peduncle area. This band terminates at a spot on the base of the tail and is much more pronounced in young speckled dace than in adults. In some populations, spawning males turn red around the mouth and upper area of the gill opening and around the base of the anal area (Sigler and Miller 1963, Wydoski and Whitney 1979). Spawning coloration does not occur in all populations, however (Scott and Crossman 1973).

Scott and Crossman (1973) suggest that there are likely more than one form of speckled dace. La Rivers (1962) describes four subspecies in Nevada, and Carl et al. (1967) describe several varying characteristics among speckled dace.

Distinguishing characteristics of spackled dace are the rather thick body, a short caudal peduncle, and the location of the mouth below the overhanging snout. The snout does not overhang the mouth to the extent it does in longnose dace, however. Other distinguishing characteristics of speckled dace are the groove separating the upper lip from the snout, the shallow fork in the tail, and the pronounced dark band on the sides of juveniles (Wydoski and Whitney 1979).

DISTRIBUTION

Speckled dace are found in coastal and interior streams of western North America, including the Columbia River and Colorado River drainages. The range of speckled dace is restricted to areas west of the Continental Divide and extends as far south as southern California, as far north as south-central British Columbia, and as far east as the western slope of the Rocky Mountains (Wydoski and Whitney 1979, Miller 1952).

LIFE HISTORY

Speckled dace spawn from May (Simpson and Wallace 1978) through August with peak spawning activity in June (Wydoski and Whitney 1979). Spawning usually occurs only once per year, but in Arizona spawning may occur both in spring and in late summer (John 1963). Speckled dace spawn in riffles where rocks and stones are cleaned by the current, or in some cases, the male dace clean the rocks with their mouths. Ripe females find the males and spawn over the clean rocks. The adhesive eggs sink and attach themselves between the rocks. Eggs hatch in 6 days when the water temperature is 64 to 66ºF. On average, a 2-inch female has 174 eggs and a 2.8-inch female has 514 eggs. Speckled dace usually mature at age 2 (Wydoski and Whitney 1979, Jhingram 1948, Kaya 1991).

Speckled dace have a short lifespan, living only to about age 3. Age 1 fish are about 1.3 to 1.6 inches long. During the second year, females grow slightly larger than males, and age 2 females are 2.0 to 2.1 inches long while males are 1.8 to 1.9 inches long. Age 3 females are 2.5 to 2.6 inches long while age 3 males are 2.2 to 2.3 inches long (Wydoski and Whitney 1979).

C. Zimmerman (OSU, personal communication, May 1998) has observed that dace are active at night in the lower Deschutes River. Zimmerman has noted that they are very wary at night, and has not observed dace at all during daylight hours.

HABITAT REQUIREMENTS

Speckled dace will live in a variety of habitats, but normally prefer shallow, cool and quiet waters in contrast to longnose dace, which prefer faster flowing water (Simpson and Wallace 1978). Wydoski and Whitney (1979) state that speckled dace are usually found in water less than 3 feet deep. Speckled dace are associated with stream and lake bottoms (Bartoo 1972). Speckled dace young feed on plankton, while adults feed on aquatic insects, freshwater shrimp, plant material including algae, and zooplankton. Algae may compose 20 percent of food eaten by speckled dace (Wydoski and Whitney 1979). RL&L Environmental Services, Ltd., (1995) describes features of speckled dace habitat in the lower Columbia River.

INTER/INTRASPECIFIC INTERACTIONS

Speckled dace probably serve as forage for trout and other game fish (Wydoski and Whitney 1979). They are used for bait in some states (Simon 1946, Miller 1952).

Baltz et at. (1982) describe interactions between sculpin, Cottus gulosus and speckled dace.

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not classify speckled dace as a native species of fish in the Metolius River.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) note that dace are present in Squaw Creek. The species of dace or their abundance in Squaw Creek is not identified.

Lower Crooked River

The section of the Crooked River downstream of Prineville Reservoir has an indigenous population of speckled dace (Stuart et al. 1996). The numbers of speckled dace in this section of the Crooked River are unknown.

Lake Billy Chinook

Stuart et al. (1996) do not separate longnose from speckled dace in their assessment of dace in Lake Billy Chinook, but note that the general dace population in the reservoir is small compared to the numbers of other nongame and game fish present.

Lake Simtustus

Stuart et al. (1996) do not refer to speckled dace as among the species documented in Lake Simtustus. If present in this reservoir, the population of speckled dace is probably very small.

Lower Deschutes River

ODFW (1997) states that dace are native to the lower Deschutes River and many of its tributaries, but does not identify the species of dace or their abundance in the lower Deschutes River Basin. ODFW (1997) notes that little is known about the relative abundance or specific life history of dace in the lower Deschutes River.

FISHERIES

Speckled dace are classified as a nongame fish in the Deschutes River Basin. Because of the small body size of speckled dace, there is no fishery associated with this species. Dead speckled dace may be used as bait in the Deschutes River Basin.

Limiting Factor

The amount of shallow, cool, and quiet water in the Deschutes River Basin may limit the population of speckled dace. Predators also may control speckled dace numbers in the basin.

Ecological Role

Speckled dace have been found to serve as an important forage fish for larger fish in some regions (Simpson and Wallace 1978, Wydoski and Whitney 1979). The relatively low numbers of speckled dace in the Deschutes River Basin, however, may limit their importance as prey in the basin.

LARGESCALE SUCKER

Catostomus macrocheilus

Other Common names: Coarsescale sucker, Columbia River sucker (Scott and Crossman 1973)

General

APPEARANCE

The body of largescale suckers is generally long and deep with the greatest depth below the dorsal fin. It is vertically compressed more than other suckers (Scott and Crossman 1973) and tapers to a very narrow peduncle, giving the body a characteristic “tear drop” shape (Carl et al. 1959). The head is moderately long, about 20 to 23 percent of the total body length. The eyes are located high on the head, a little forward of center. The mouth of largescale suckers is located at the bottom and toward the front of the head. The lips are large with the lower lip deeply cut for its full length. Teeth of largescale suckers are soft and comb-like, giving the appearance that they do not have teeth (Scott and Crossman 1973).

Largescale suckers have one large dorsal fin with 12 to 17 soft rays. The dorsal fin is located a little forward of midpoint of the body. Largescale suckers do not have an adipose fin. The tail is moderately long with rounded points. The anal fin is long with seven prominent rays. Pelvic fins are located low on the body, have 9 to 12 soft rays, and are moderately long and somewhat pointed. Pectoral fins are located low on the body, are rather long and more or less pointed, and have 16 to 18 soft rays. The scales are round, large, and more abundant near the front of the body (Scott and Crossman 1973).

The backs and upper sides of largescale suckers are black or blue-grey to olive color, while the lower part of the head and belly are cream to white in color. There is a dark band on and below the lateral line, extending from the snout to the base of the tail. The fins are dusky color, with the leading edge either dark or white with dark color behind the white (Scott and Crossman 1973). Juvenile largescale suckers have three (Carl et al. 1959) or four (Scott and Crossman 1973) dark spots on their sides. Breeding largescale suckers have pronounced shading with an iridescent olive-green color. They also have a narrow, yellowish stripe between the black lateral band and the white belly (Nelson 1968).

Largescale suckers and bridgelip suckers sometimes breed, creating hybrids between the two species (Scott and Crossman 1973).

Largescale suckers are distinguished from other suckers by the lack of notches in the corner of the mouth, and by a lower lip with a complete cleft (Wydoski and Whitney 1979).

DISTRIBUTION

Largescale suckers are found in western North America. They occur mainly west of the Rocky Mountains, and are found from the Peace River in Alberta and western Montana’s river systems to the Pacific ocean. To the south, they are found to the Sixes River in Oregon as well as into western Utah and northern Nevada (Carl et al. 1959; Scott and Crossman 1973).

Life History

Largescale suckers spawn in the spring, from late April to late June, in deep, sandy areas of streams or on gravel or sandy lake shores (Geen 1958). They enter spawning streams when the temperature is 46 to 48ºF. A female may lay as many as 20,000 eggs. The eggs are yellow, quite adhesive, and fairly small. Eggs hatch in about 2 weeks. Sac fry remain in the gravel or on the sand for a few weeks until the yolk is absorbed. After the yolk sac is absorbed, fry tend to move into open water to feed. The mouth of fry is located on the end of the snout and they feed much like trout fry. The mouth moves to the lower position of the head when fry reach a length slightly over 0.5 inch. After the mouth moves to the lower position, largescale suckers become bottom feeders (Scott and Crossman 1973).

Largescale suckers grow relatively slowly; at age 1 they are about 1.8 inches long, at age 5 they are about 7.5 inches long, and at age 10 they are about 14 inches long (Clemens et al. 1939). Because largescale suckers grow so slowly, scales are very difficult to use to analyze age. Maximum length of largescale suckers is about 24 inches and maximum weight is about 7 pounds (McPhail and Lindsey 1970). Sexual maturity is reached by most males at age 5 and by females at age 6 (Carl et al. 1959).

Habitat Requirements

Largescale suckers live in lakes and in large rivers. Young feed in open water but may move to shallow water to feed in daylight hours and off into deeper water at night (McPhail and Lindsey 1970). As fry grow larger, they move toward the bottom of the lake or river. Adults are found at depths of only a few feet to as deep as 80 feet (Scott and Crossman 1973). Largescale suckers can survive in water temperatures as high as 85ºF if they are acclimated to warm temperatures (Black 1953).

Bridgelip suckers, on the other hand, are usually found in cooler water of small, swift rivers with gravel to rocky bottoms, but they are also found in rivers with beds composed of gravel or larger size rocks (Scott and Crossman 1973).

Immature largescale suckers eat water-fleas, copepods, and aquatic insect larvae mixed with small quantities of bottom ooze containing living plants and plant remains. Larger fish eat large numbers of crustaceans, insect larvae, molluscs, and other organisms associated with the bottom. Largescale suckers also may eat fish eggs during months when salmon are spawning (Carl 1936).

Inter/intraspecific Interactions

Young largescale suckers are eaten by many species of fish including northern pikeminnow. Birds also prey on young largescale suckers. Adult largescale suckers are eaten by bears and other mammals, osprey, and eagles (Scott and Crossman 1973).

Largescale suckers in large numbers could be serious food competitors with young and adult salmonids (Scott and Crossman 1973).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Largescale suckers are found in relatively small numbers in the lower Metolius River. Little is known about their abundance in this river (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Largescale suckers are found upstream of Lake Billy Chinook to Steelhead Falls. A spawning run of largescale suckers upstream of Lake Billy Chinook occurs annually. Largescale suckers are native in Squaw Creek, but numbers of fish are unknown (Fies et al., 1996b).

Lower Crooked River

Largescale suckers are a native nongame fish in the lower Crooked River below Prineville Reservoir. Numbers of largescale suckers in the lower Crooked River are unknown (Stuart et al. 1996).

Lake Billy Chinook

Suckers (all types together) are the most abundant of several nongame fishes found in Lake Billy Chinook. Gillnet samples conducted from 1964 to 1974 indicate that suckers, as a group, often make up over 70 percent of the gillnet catch in the reservoir (Stuart et al. 1996).

Largescale suckers make up 40 percent of the sucker population and are the third most abundant fish species in Lake Billy Chinook. In 1997, Merwin traps were operated in upper reaches of each arm of Lake Billy Chinook, resulting in capture of 589 largescale suckers in the Crooked River Arm, 75 largescale suckers in the Deschutes River Arm, and 49 largescale suckers in the Metolius River Arm (Hiatt et al. 1997). Lewis (1999) also used Merwin traps to sample fish populations in Lake Billy Chinook in 1998. A total of 1,526 largescale suckers were captured in Merwin traps in the reservoir, with approximately 83 percent of these captured in the Crooked River Arm (Lewis 1999).

Largescale suckers grow to lengths of 20 inches or more in the Lake Billy Chinook.

Lake Simtustus

Largescale suckers are one of the most abundant of several nongame fish species found in Lake Simtustus. They are well distributed throughout the reservoir (Stuart et al. 1996). Lewis (1999) used a Merwin trap to sample fish populations in Lake Simtustus in 1998. Of 1,100 fish caught by Merwin traps, 37 percent were largescale suckers (Lewis 1999).

Lower Deschutes River

Largescale suckers are native to the lower Deschutes River and many of its tributaries. However, largescale suckers are not found in the White River above White River Falls. The abundance of suckers was estimated to be 8,400 suckers per mile in the Warm Springs to Trout Creek section of the Deschutes River in 1975 (Schroeder and Smith, 1989).

C. Zimmerman (OSU, personal communication, May 1998) has observed relatively high numbers of sucker fry in calm waters associated with sandy areas in the lower Deschutes River. Zimmerman has noted especially high concentrations of sucker fry in the Dry Creek side channel and in other areas associated with warmer water.

FISHERIES

There is not currently a fishery associated with largescale suckers in the Deschutes River. Largescale suckers may have played a role in traditional tribal cultures as related in legends and creation mythology (ODFW 1997). Scott and Crossman (1973) state that the flesh of largescale suckers is firm, white, flaky, and edible but bony and not highly favored.

LIMITING FACTORS

Concern has been raised about the number of suckers in Lake Simtustus and how they could affect the survival of juvenile salmonids (Stuart et al. 1996). This concern is based on the large biomass and potential competition of largescale suckers with game fish (A. Stuart, ODFW, personal communication, December 1998). Hatchery reared brown trout were introduced into Lake Simtustus to control largescale suckers and northern pikeminnow, but this effort was discontinued (Stuart et al. 1996).

ECOLOGICAL ROLE

Largescale suckers are a major biomass in the Deschutes River Basin. Scott and Crossman (1973) state that largescale suckers in large numbers could be serious food competitors with young and adult salmonids. Young largescale suckers could be competitors with young salmonids in the Deschutes River Basin. However, adult largescale suckers eat some foods, such as algae, that are not used much by many other fish. Largescale suckers probably eat large amounts of algae in the Deschutes River Basin. Young largescale suckers provide a food source for larger game fish such as rainbow trout. In addition, the carcasses of adult largescale suckers contribute to the production of food eaten by game fish.

BRIDGELIP SUCKER

Catostomus columbianus

Other common names: Columbia small scale sucker (Scott and Crossman 1973), redhorse sucker

General

APPEARANCE

Bridgelip suckers are rounded in cross section and taper, with a slight lateral compression, toward the tail (Scott and Crossman 1973). The caudal peduncle area is slender (Carl et al. 1959). The greatest depth of the body is forward of the origin of the dorsal fin (Scott and Crossman 1973). The length of the head is about 20 percent of the total length of the body, and the width of the head is about 40 to 45 percent of its length. The eyes are located high on the head at its midpoint. The mouth is located below the head, slightly back of the snout, and has a very slight notch in each corner. The lips are thick and the lower lip is rounded with a cleft that does not extend the full length of the lip (Scott and Crossman 1973). The incomplete cleft in the lower lip and the slight notches in the corners of the mouth distinguish the bridgelip sucker from other suckers (Carl et al. 1959). The teeth are comb-like (Scott and Crossman 1973).

Bridgelip suckers have one dorsal fin, which is fairly long and has 11 to 14 soft rays (Carl et al. 1967). Bridgelip suckers do not have an adipose fin. The tail is long, deeply forked, with rounded points. The anal fin is moderately long with rounded points, and has seven soft rays. The pelvic fins are very low on the body and originate at the midpoint of the dorsal fin. The pelvic fins have 10 to 11 soft rays, a wide base with fleshy pads, and rounded points. Pectoral fins are low, long, and pointed, and have rounded point tips and 17 soft rays (Scott and Crossman 1973). Scales on bridgelip suckers are small and more abundant near the front of the fish. Scales are larger in the caudal peduncle area (Scott and Crossman 1973).

The backs and heads of bridgelip suckers are dark brown, olive, green, or mottled, while the lower sides, head (below the eyes), and belly are white to pale yellow. Breeding males have a prominent orange band on the side, and small, pimple-like projections on the anal and tail fins. Juvenile bridgelip suckers have three dark lateral blotches (Scott and Crossman 1973; Carl et al. 1959).

Bridgelip and largescale suckers sometimes breed, creating hybrids between the two species (Scott and Crossman 1973). Characteristics of hybrids vary between individuals.

Characteristic features of bridgelip suckers are the incomplete cleft on the lower lip and very slight notches in the corners of the mouth (Wydoski and Whitman 1979).

DISTRIBUTION

Bridgelip suckers are found in the Fraser and Columbia (including the Deschutes) river systems (Carl et al. 1967). Natural barriers restrict their distribution within these systems.

Life History

Very little is known about the life history of bridgelip suckers. Spawning occurs in late spring and early summer, depending on location; it occurs earlier in the southern range and later in the northern range of its distribution (Scott and Crossman 1973). Bridgelip suckers typically spawn in March and April in Bakeoven and Buck Hollow creeks, tributaries of the lower Deschutes River (ODFW 1997). Spawning occurs in sandy or gravelly areas of the streams, and fecundity may be as high as 20,000 eggs per female (ODFW 1997). Their eggs, which measure approximately 0.1 inch in diameter, typically hatch about 2 weeks after they are deposited (Scott and Crossman 1973).

Bridgelip sucker young are about 2.5 to 3.0 inches in length at the end of their first summer, and sexual maturity in the species is reached when the fish is about 5 inches long. Adult bridgelip suckers reach a maximum length of 10 to 15 inches (Smith 1966; Carl et al. 1967). Data from the Metolius River Arm of Lake Billy Chinook indicated that bridgelip suckers in that area are 3.5 inches long at age 1, 4.9 inches long at age 2, 7.1 inches long at age 3, and 8.2 inches long at age 4 (Stuart et al. 1996).

Habitat Requirements

Bridgelip suckers are usually found in cooler water of small, swift rivers with gravel to rocky bottoms. In addition, they are found in rivers with moderate current and sand or mud bottoms (Scott and Crossman 1973). Bridgelip suckers make spawning runs from larger rivers to smaller streams. In the Snake River Basin, their spawning runs follow directly after steelhead runs. Bridgelip suckers may spawn in gravels near where steelhead spawn.

Bridgelip suckers are primarily bottom feeders. Their diet consists primarily of plant material, but they increase their invertebrate consumption in the winter, when plant material is scarce (Schroeder and Smith 1989). The cartilage edge of their jaws suggests that they feed by scraping algae from rocks (Scott and Crossman 1973).

Inter/intraspecific Interactions

Inter/intraspecific interactions involving bridgelip suckers are not well understood. Bridgelip suckers may be preyed on by mammals and birds (Scott and Crossman 1973) or by predator fish. Scott and Crossman (1973) suggest that bridgelip suckers are not abundant in areas where large predator fish are found.

Pelton Round Butte Project Area

Population Size and Distribution

Metolius River Basin

Bridgelip suckers have not been reported in the Metolius River (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Bridgelip suckers have not been reported in the Deschutes River above Lake Billy Chinook, but they are present in Squaw Creek. Population densities are unknown (Fies et al. 1996b).

Lower Crooked River

Bridgelip suckers are native to the Prineville Valley section of the lower Crooked River. They are found in relatively low densities in the Chimney Rock section of the lower Crooked River. Numerical data for population densities of bridgelip sucker in this river are not available (Stuart et al. 1996).

Lake Billy Chinook

Different methods of sampling appear to result in different estimates of relative species abundance in Lake Billy Chinook. Stuart et al. (1996), using electrofishing equipment, found large numbers of bridgelip suckers in Lake Billy Chinook and determined that the bridgelip sucker population size was second only to that of kokanee. Approximately 60 percent of suckers captured during the 1990–1991 electroshocking surveys were bridgelip suckers. However, Merwin traps located in each arm of the reservoir caught 393 bridgelip suckers in 1997, suggesting the species was the fifth most abundant fish species in Lake Billy Chinook, after smallmouth bass, chiselmouth, largescale sucker, and rainbow trout (Hiatt et al. 1997).

In 1998, Lewis (1999) used Merwin traps to capture bridgelip suckers in Lake Billy Chinook. Lewis (1999) captured 238 bridgelip suckers in the Crooked River Arm, 512 in the Deschutes River Arm, 194 in the Metolius River Arm, and 27 in the Round Butte Dam forebay. Bridgelip sucker represented 11.1 percent of the fish caught in Lake Billy Chinook in 1998 (Lewis 1999).

Lake Simtustus

Bridgelip suckers are present in Lake Simtustus, but their abundance is low compared to other nongame fish species (Stuart et al. 1996). Numerical data are not available for population densities of bridgelip suckers in Lake Simtustus.

Lower Deschutes River

ODFW (1997) does not separate information by species for suckers in the lower Deschutes River. ODFW (1997) notes that both bridgelip and largescale suckers are native to the lower Deschutes River but are not found in the White River above White River Falls. Abundance of both species combined was estimated to be 8,400 suckers per mile in the reach of the Deschutes River from Warm Springs to Trout Creek in 1975 (Schroeder and Smith 1989).

C. Zimmerman (Oregon State University [OSU], personal communication, May 1998) has observed large numbers of sucker fry in calm waters associated with sandy areas in the lower

Deschutes River. C. Zimmerman has noted especially high concentrations of sucker fry in the Dry Creek side channel and other areas associated with warmer water.

FISHERIES

Bridgelip suckers from the Deschutes River system are not consumed by humans today, although they may have been eaten at one time by native peoples in the area.

LIMITING FACTORS

The large population of bridgelip suckers in Lake Billy Chinook suggests that environmental conditions in the reservoir are favorable for bridgelip suckers.

ECOLOGICAL ROLE

When small, they may provide food for economically important salmonids (Scott and Crossman 1973). Bridgelip suckers also are a major component of the biomass in the Deschutes River Basin, and their carcasses may provide nutrients for other sources of food eaten by game fish. Bridgelip suckers feed on matter not eaten by many other fish in the Deschutes River Basin.

Bridgelip suckers may be an important food for river otter in the lower Deschutes River Basin. It is not uncommon to observe river otter chasing and feeding on bridgelip suckers in the mainstem and in smaller tributaries of the lower Deschutes River.

CHISELMOUTH

Acrocheilus alutaceus

Other common names: Hardmouth, squaremouth (Scott and Crossman 1973)

General

APPEARANCE

Chiselmouth have a long body that is round in cross section. The caudal peduncle is long and slender. The head is blunt and about 17 to 19 percent of the total length of the fish. Their eyes are relatively large, with the diameter of the eye about 20 to 30 percent of the head length. The snout is blunt and the mouth is located near the bottom of the snout. A fleshy upper lip covers small cartilage plates in the upper jaw, but the lower lip is covered with a hard cartilage sheath with an almost straight-cutting edge shaped like a chisel. Young chiselmouth do not have a chisel-shaped lower lip (Scott and Crossman 1973).

Chiselmouth have one dorsal fin located behind the pelvic fins. There are usually 10 rays in the dorsal fin. The tail is distinctly forked. The anal fin is located behind the dorsal fin and has nine or ten rays. The pelvic fins are rather narrow. The pectoral fins have 15 to 18 rays. Scales on the chiselmouth are round and small (Scott and Crossman 1973).

Chiselmouth are dark brown on the upper back. The sides are rather drab colored with many small black dots. The belly is lighter color than the sides. Young chiselmouth have a light colored black spot at the base of the tail (Scott and Crossman 1973).

The distinguishing characteristic of chiselmouth is the chisel-like mouth and the very narrow peduncle (Carl et al. 1959).

DISTRIBUTION

Chiselmouth are found in the Fraser and Columbia river basins and in the Malheur Lake drainage (Scott and Crossman 1973).

LIFE HISTORY

Very little information is available describing life history characteristics of chiselmouth. Moodie (1966) described some aspects of the chiselmouth in Canada. According to that research, chiselmouth that live in lakes migrate upstream to spawn, usually in late June and early July. They spawn in temperatures of about 62.5ºF or warmer. Eggs were found on the bottom of the stream and also buried under rocks. Other research indicates female chiselmouth have about 6,200 eggs at spawning (Wydoski and Whitney 1979). Chiselmouth often breed with other fish (Patten 1960), making the young hard to identify. Males attain sexual maturity and spawn when they are age 3, and females may spawn when they are age 3 or 4. The maximum age for chiselmouth is about 6 years when fish reach about 8.8 inches long (Moodie 1966). Chiselmouth in the Columbia River Basin often reach lengths over 8 inches.

HABITAT REQUIREMENTS

Adult chiselmouth use the chisel-like lower jaw along rocks to dislodge algae and small plankton in the algae. Young chiselmouth feed on surface insects (Scott and Crossman 1973, Wydoski and Whitney 1979). Because of their limited distribution, chiselmouth may be restricted to certain special types of habitat (Carl et al. 1959). Those types of habitats are not clearly understood.

INTER/INTRASPECIFIC INTERACTIONS

Young chiselmouth feed on the same food as young northern pikeminnow and trout. Consequently, there may be some competition with these species during the early stages of their life history (Scott and Crossman 1973).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Chiselmouth have not been reported in the Metolius River (Fies et al. 1996a). Hiatt et al. (1997) recorded small numbers of chiselmouth in the Metolius Arm of Lake Billy Chinook. It is likely that chiselmouth are present in low numbers in the lower section of the Metolius River.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Chiselmouth are present upstream of Lake Billy Chinook to Big Falls, but the size of the population is unknown (Fies et al. 1996b). Hiatt et al. (1997) captured two size groups representing at least two age groups of chiselmouth in the Deschutes River Arm of Lake Billy Chinook. Hiatt et al. (1997) speculates that the larger chiselmouth captured in the Deschutes River Arm were typical spawning size (Scott and Crossman 1973), indicating that chiselmouth were spawning in the Deschutes River above Lake Billy Chinook.

Lower Crooked River

Fairly low densities of chiselmouth are found in the Crooked River below Prineville Reservoir (Stuart et al. 1996).

Lake Billy Chinook

Stuart et al. (1996) found that chiselmouth were present in low numbers in Lake Billy Chinook. However, Hiatt et al. (1997) found that chiselmouth were the second most abundant fish species captured in Merwin traps located in the three arms of Lake Billy Chinook. Hyatt et al. (1997) captured 487 chiselmouth in the reservoir, with most captured in the Crooked River and Deschutes River arms. Lewis (1999) also used Merwin traps in Lake Billy Chinook to sample fish populations. Lewis (1999) captured 893 chiselmouth in the Crooked River Arm, 139 chiselmouth in the Deschutes River Arm, 1 chiselmouth in the Metolius River Arm, and 66 chiselmouth in the Round Butte Dam forebay. Chiselmouth represented 12.5 percent of fish caught in Merwin traps in Lake Billy Chinook in 1998 (Lewis 1999).

These three population size studies employed different sampling techniques. Stuart et al. (1996) used gill nets while Hiatt et al. (1997) and Lewis (1999) used Merwin traps. The differing sample size results may be less attributable to different sampling techniques, however, than to timing of the studies. Chiselmouth captured in Merwin traps were large enough (8 to 11 inches) to be caught in gill nets, so size was not a factor limiting their capture in gill nets. More likely, the Merwin traps were located and fished when chiselmouth were abundant, while gill nets were located and fished when chiselmouth were not abundant.

Lake Simtustus

Chiselmouth are relatively abundant and found throughout the reservoir. The population size is unknown (Stuart et al. 1996).

Lower Deschutes River

Chiselmouth are native to the lower Deschutes River and its tributaries including Warm Springs River, and Bakeoven, Buck Hollow, Shitike, and Trout creeks. Chiselmouth are not native in the White River system above White River Falls. The population of chiselmouth in the lower Deschutes River system is relatively low (ODFW 1997).

Chiselmouth populations in the lower Deschutes River increase downstream of Trout Creek; they are present, but in much lower numbers, above Trout Creek (C. Zimmerman, OSU, personal communication, May 1998).

FISHERIES

Chiselmouth are considered nongame fish and have no catch or length limits. Chiselmouth, however, have a cultural importance to members of the Confederated Tribes of the Warm Springs Reservation of Oregon. Chiselmouth are important for tribal subsistence purposes and are harvested by dip netting from the stream bank (ODFW 1997). Historically, chiselmouth were harvested primarily in Buck Hollow, Bakeoven, and Trout creeks (ODFW 1997). The timing of harvest was associated with seasonal movement of the chiselmouth into these tributaries in the late winter and early spring (ODFW 1997).

LIMITING FACTOR

Cool water may be the limiting factor controlling chiselmouth populations in the Deschutes River Basin. Where waters are warmer, chiselmouth populations increase. Numbers of chiselmouth captured with Merwin traps in the three arms of Lake Billy Chinook were associated with increasing water temperature, and more chiselmouth were caught in the Crooked River Arm where, water temperatures were warmer than in the two other arms of Lake Billy Chinook.

ECOLOGICAL ROLE

Chiselmouth could play an important role in the food chain in the Deschutes River Basin. Adult chiselmouth feed on algae, and, in turn, are prey for higher order predators that may only feed on meat.

NORTHERN PIKEMINNOW

Ptchocheilus oregonensis

Other common names: Northern squawfish, Columbia squawfish, Columbia River dace, bigmouth minnow (Scott and Crossman 1973). The American Fisheries Society changed the common name of northern squawfish to northern pikeminnow in 1998 (Nelson et al. 1998). Campton (1998) endorses changing the common name of squawfish, but he states that "squawfish" are not minnows of the family Cyprinidae, and therefore should not be called minnows. Campton (1998) prefers the common name "pikefish."

General

APPEARANCE

Northern pikeminnow have an elongated body shape with a slight lateral compression. The head is moderately long, about 22 to 23 percent of the total body length, and somewhat flattened between the eyes (Wydoski and Whitney 1979). The eyes are small in adults (about 16 to 19 percent of the head length) but fairly large in juveniles (about 23 to 27 percent of the head length). The snout is long, making up 32 to 35 percent of the head length. The mouth is located on the end of the snout and is quite large, extending to the front of the eye (Scott and Crossman 1973). Adult northern pikeminnow typically weigh from 2 to 5 pounds, but individuals up to 29 pounds and 25 inches long have been documented (Simpson and Wallace 1978).

Northern pikeminnow have one dorsal fin with nine or ten soft rays. Northern pikeminnow do not have an adipose fin. The tail is distinctly forked with pointed lobes. The anal fin has eight rays. The pelvic fins are relatively short and small with nine soft rays. The pectoral fins are relatively short with 15 or 16 rays. Northern pikeminnow have small, round scales (Scott and Crossman 1973).

Northern pikeminnow have dark green or green-brown backs, lighter colored sides and silvery white or cream-colored bellies. Males are colorful at spawning time when the lower fins become yellow or yellow-orange. Young fish have a black spot at the base of the tail and a light colored narrow band that originates forward of the dorsal fin and ends almost at the tail (Scott and Crossman 1973).

The distinguishing characteristics of northern pikeminnow are the somewhat flattened head between the eyes, the relatively long snout that is 1.5 or more times the diameter of the eye, and the relatively large mouth.

DISTRIBUTION

The northern pikeminnow is found on the Pacific slope of western North America, the Malheur Lake system, the Columbia River system, and north to the Nass River of British Columbia. It occurs east of the Continental Divide only in the Peace River system (Scott and Crossman 1973).

LIFE HISTORY

Northern pikeminnow mature at age 4 or 5 for females and age 3 or 4 for males (Simpson and Wallace 1978). Females grow slightly faster and live longer than males (Hill 1962).

Northern pikeminnow spawn from late May to July (Carl et al. 1967). Northern pikeminnow spawn in shoal areas at the mouths of tributaries in Lake Simtustus during July and August (A. Stuart, ODFW, personal communication, November 1997). Spawning occurs in gravelly shallows, sometimes along a lake shore or in streams. Jeppson and Platte (1959) and Patten and Rodman (1969) postulate that lake-dwelling northern pikeminnow spawn in streams only when suitable gravelly shallows in lakes are not available. However, Simpson and Wallace (1978) state that northern pikeminnow prefer to spawn in gravelly streambeds. Northern pikeminnow migrate distances ranging from a few hundred yards up to several miles to spawn (Simpson and Wallace 1978). This species does not build nests, and several fish may gather in one location to spawn. A female may be accompanied by a few to many males, and when eggs are released they are fertilized as they drift to the bottom. The eggs are adhesive and stick in the gravel. Female northern pikeminnow carry large numbers of eggs, but probably do not release them all at one time (Scott and Crossman 1973, Patten and Rodman 1969).

The number of eggs in a spawning female may range from 12,000 to 100,000 with an average of at least 40,000 (Simpson and Wallace 1978). The eggs are greenish (Carl et al. 1967) to pale orange (Patten and Rodman 1969). No parental care is provided for the eggs or newly hatched fry (Simpson and Wallace 1978). The eggs hatch in about 1 week at 65ºF. The young become free-swimming in 14 days (Carl et al. 1967). Northern pikeminnow may live to be 15 to 20 years old (McPhail and Lindsey 1970).

Northern pikeminnow spawn with chiselmouth, creating a hybrid that is fairly easy to identify. The length of the jaw of hybrids is about half the length of northern pikeminnow and longer than the normal length of jaws on chiselmouth. Because of the smaller mouth, hybrids eat smaller size prey than do northern pikeminnow of the same body size (Hisata et al. 1997).

HABITAT REQUIREMENTS

Scott and Crossman (1973) note that the northern pikeminnow is typically a lake-dwelling species preferring still waters to streams. However, Simpson and Wallace (1978) state that northern pikeminnow prefer to spawn in streams, spawning along lake shores only if stream spawning areas are not available. Young northern pikeminnow live in shoreline areas during summer months, and move offshore into deeper water in the fall. Larger individuals tend to remain offshore in deeper water in lakes or streams throughout the year (Scott and Crossman 1973, Simpson and Wallace 1978).

Small northern pikeminnow (4 to 10 inches in length) feed primarily on insects. As they get larger, they feed mostly on other fish, including crayfish (Olney 1975, Thompson 1959, Thompson and Tufts 1967). Northern pikeminnow eat all species of fish available. They are considered a serious predator of young salmon and trout (Scott and Crossman 1973).

INTER/INTRASPECIFIC INTERACTIONS

Northern pikeminnow are predators and competitors for food and space with salmon and trout (Simpson and Wallace 1978). The predatory habits and long lifespan of northern pikeminnow are thus significant factors in reducing survival rates of those species of interest (Wydoski and Whitney 1979). Isaak and Bjornn (1996) determined that northern pikeminnow abundance in the Snake River migration corridor is related to changing prey densities and water temperature. Vigg et. al. (1991) estimated that northern pikeminnow accounted for 78 percent of the predation loss of juvenile salmonids in John Day Reservoir. Poe and Rieman (1988) estimated that there were 85,316 northern pikeminnow in John Day Reservoir and that each northern pikeminnow killed 24.6 salmonids per season (April–August). Consequently, each northern pikeminnow killed 0.16 salmonids per day during the period April through August.

Lewis (1999) examined the stomach contents of 147 northern pikeminnow captured in Lake Billy Chinook and 53 northern pikeminnow captured in Lake Simtustus in 1998. Stomach contents of the Lake Billy Chinook fish consisted of chiselmouth, rainbow trout, and other unknown fish, as well as amphipoda (freshwater shrimp), crayfish, aquatic insects, and fish eggs. Similarly, the stomach contents of the northern pikeminnow from Lake Simtustus consisted of chiselmouth, smallmouth bass, other unknown fish (salmonids), crayfish, aquatic insects, and fish eggs. Approximately 40 percent of the stomachs sampled were full (Lewis 1999).

Documented impacts of northern pikeminnow predation on salmon and steelhead in the Columbia and Snake river migration corridor has led to considerable management effort directed toward control of northern pikeminnow in these waters (Rieman et al. 1991, Smith et al. 1995, Zimmerman et al. 1995, Beamesderfer and Rieman 1991, Willis and Ward 1994, Young 1997). In some areas, managers have used a selective toxin called "squoxin" to reduce northern pikeminnow populations in Northwest states (Simpson and Wallace 1978).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Northern pikeminnow are not found in the Metolius River (Fies et al. 1996a), and Hiatt et al. (1997) did not catch any northern pikeminnow with Merwin traps at the mouth of the Metolius River in 1997.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Northern pikeminnow are present in the Deschutes River above Lake Billy Chinook, but the population appears to be relatively small. Hiatt et al. (1997) collected 19 northern pikeminnow in upper reaches of the Deschutes River Arm of Lake Billy Chinook. Northern pikeminnow are not reported as native to the Deschutes River above Big Falls or Steelhead Falls (Fies et al. 1996b).

Lower Crooked River

Northern pikeminnow are present in the reach of Crooked River below Prineville Reservoir. Electrofishing surveys in 1989, 1993, 1994, and 1995 showed that northern pikeminnow were present but not abundant from Prineville Reservoir downstream 12 miles to the Crooked River Feed Canal diversion, but fairly abundant downstream of the diversion (Stuart et al. 1996; A. Stuart, ODFW, personal communication, November 1997).

Chemicals were used to eliminate fish populations, including northern pikeminnow, in the lower reaches of the Crooked River during the fall of 1963. Fish surveys were not conducted immediately after the 1963 chemical treatment project to determine the impact of chemicals on northern pikeminnow populations.

Lake Billy Chinook

Northern pikeminnow are relatively abundant in Lake Billy Chinook (Stuart et al. 1996). Northern pikeminnow are more numerous in the Crooked River Arm of Lake Billy Chinook than in other areas of the reservoir. In 1997, Merwin traps caught 238 northern pikeminnow in the Crooked River Arm, 19 northern pikeminnow in the Deschutes River Arm, and 0 northern pikeminnow in the Metolius River Arm (Hiatt et al. 1997). Sampling in 1998 using Merwin traps (Lewis 1999) yielded similar results, with 237 northern pikeminnow caught in the Crooked River Arm, 20 caught in the Deschutes River Arm, 0 caught in the Metolius River Arm, and 19 caught in the Round Butte Dam forebay. Northern pikeminnow represented 3.1 percent of the total fish sample in Lake Billy Chinook in 1998. Most of the northern pikeminnow were captured in May and June (Lewis 1999).

Northern pikeminnow caught in Lake Billy Chinook ranged from 6 to 18 inches in length (Hiatt et al. 1997; Lewis 1999).

Lake Simtustus

Northern pikeminnow are relatively abundant in Lake Simtustus and they are found throughout the reservoir (Stuart et al. 1996). It is not clear why northern pikeminnow are more abundant in Lake Simtustus than in Lake Billy Chinook. A. Stuart (ODFW, personal communication, November 1997) has observed large numbers of northern pikeminnow spawning in very low velocity water near the mouths of Seekseequa Creek, Willow Creek, and the Mallard Haven area, tributaries of Lake Simtustus. This type of habitat appears to be ideal for northern pikeminnow spawning.

Lewis (1999) captured 443 northern pikeminnow using a Merwin trap in Lake Simtustus in 1998. Northern pikeminnow represented over 40 percent of the fish caught in Lake Simtustus in 1998 (Lewis 1999).

Lower Deschutes River

Northern pikeminnow are native to the mainstem lower Deschutes River, the Warm Springs River, Trout and Shitike creeks, and other tributaries of the lower Deschutes River (ODFW 1997). The abundance of northern pikeminnow in this part of the Deschutes River Basin is unknown, but they are present throughout the lower 100 miles of the lower Deschutes River, and several thousand adults have been observed in lower Trout Creek in May and June, apparently making spawning runs (ODFW 1997). Northern pikeminnow are more abundant downstream than upstream of Trout Creek (C. Zimmerman, OSU, personal communication, May 1998).

FISHERIES

Northern pikeminnow are a nongame fish in the Deschutes River Basin and are not targeted for commercial or recreational fisheries. Northern pikeminnow are not regarded as a good food fish, although the flesh is edible (Scott and Crossman 1973). Rostlund (1952) suggested that Indians were not enthusiastic about northern pikeminnow as food. However, the northern pikeminnow qualifies as a sport fish because it is large, feeds at the surface in the evening, and will take flies and lures as bait. When caught, it quickly succumbs to the angler (Scott and Crossman 1973).

LIMITING FACTOR

Habitat requirements of northern pikeminnow include slow moving or still warm water during summer. These requirements may limit northern pikeminnow numbers in the Metolius River, in the Crooked River, and in the reach of the Deschutes River upstream of Lake Billy Chinook.

ECOLOGICAL ROLE

Northern pikeminnow are an upper level predator. Their impact on game fish in the Pelton Round Butte Project area is unknown. However, northern pikeminnow are native to the lower Deschutes River Basin, and, most likely, an ecological balance has developed between game fish and northern pikeminnow in the Project area.

REDSIDE SHINER

Richardsonius belteatus

Other common names: Red-sided bream, Columbia River minnow, Richardson's minnow, silver-sided minnow, shiner, silver shiner (Scott and Crossman 1973)

General

APPEARANCE

The body shape of redside shiners varies, but the body is laterally compressed and moderately deep, with the greatest depth between the paired fins. The length of redside shiners is rarely over 7 inches. The head is long, making up about 20 percent of the length of the fish. The eyes are large, with the eye diameter about 25 percent of the head length, and are located forward on the head. The mouth is on the end of the snout and angles downward. The lower lip protrudes slightly beyond the snout and upper lip when the mouth is closed (Scott and Crossman 1973).

Redside shiners have one dorsal fin located in the midpoint of the body. The dorsal fin is moderately large and has ten soft rays. The tail is deeply forked with the tips pointed. The anal fin has a long base with 10 to 24 rays — typically there are 15 rays, but the number varies from region-to-region and between the sexes. The pelvic fins are located very low on the belly and have eight or nine rays and rounded tips. The pectoral fins are larger than the pelvic fins and have rounded points. Both the pectoral and pelvic fins are longer in males than in females. Scales on redside shiners are round and small (Scott and Crossman 1973).

Redside shiners have a steel blue, olive, or dark brown to black back. There is a narrow area without color along the flanks and below the dorsal area. Below this clear area there is a dark band extending from the snout to the caudal peduncle. The body is silver to white below the dark band. The fins are clear to amber or dusky colored. The eyes have a black pupil, and there appears to be a narrow stripe that carries from the lateral line through the eye. Both sexes are highly colored at spawning time. The spawning female is a golden color above and below the lateral band and on the head. Males have a brilliant orange, gold to crimson color on the head, fins, and sides during spawning-time. The lower fins of spawning redside shiners are bright yellow, especially in males (Carl et al. 1959, Scott and Crossman 1973).

Redside shiners are known to crossbreed with northern pikeminnow, longnose dace, and peamouth chub (Scott and Crossman 1973).

Several subspecies of redside shiner have been described based on regional variations in the number of rays in the anal fin (Lindsey 1953, Weisel 1961); however, current thought is that the number of subspecies is actually quite limited. McPhail and Lindsey (1970) believe that there are only two subspecies — the redside shiner, which has 10 to 24 rays in the anal fin, and the Lahontan redside, which has eight or nine rays in the anal fin. Carl et al. (1959) speculate that the variation in number of anal fin rays is correlated with water temperature during development of the young.

The distinguishing physical characters of redside shiners are the very long anal fin base and the far back placement of the dorsal fin (Carl et al. 1959).

DISTRIBUTION

Redside shiners are found in North America mainly west of the Rocky Mountains. Their range extends from the Peace River in northwestern Alberta throughout much of British Columbia from the Nass River south, in coastal streams of Washington and Oregon, and throughout the Columbia River Basin in Washington, Oregon, Idaho, Montana, Nevada, and Utah. Redside shiners have been introduced into the Colorado River (Carl et al. 1959, Scott and Crossman 1973).

LIFE HISTORY

Because the redside shiner was formerly thought to have numerous subspecies based on the variation in the number of anal rays, a fairly high interest has been shown in the species. As a result, more life history information is available for redside shiners than for many other nongame species of fish (Scott and Crossman 1973).

Redside shiners spawn in groups of 30 to 40 individuals in streams or in lakes from May to early-August. Spawning occurs when temperatures exceed 50ºF. Redside shiners seem to have a strong homing tendency. Males appear in the spawning areas earlier than females. In streams, spawning occurs in riffles where the water is fairly shallow. During the spawning act, a female and one or two males thrash side by side for a short period of time. During the thrashing, 10 to 20 eggs are released at irregular intervals. The number of eggs per female at spawning ranges from 800 to 3,600. The eggs are small, have a pale yellow color, and are adhesive, sticking to gravel or vegetation. Redside shiners do not make nests (Scott and Crossman 1973).

Hatching takes place within 3 to 15 days of spawning, depending upon the water temperature. Redside shiner fry are about 0.2 inch long when they hatch. Sac fry lie dormant on the bottom of the stream or lake for about a week while the yolk is absorbed. The fry are often carried downstream by the stream current into a larger river or lake after hatching. Fry begin feeding about 10 days after hatching. Growth rates for the fish vary from year to year and from one location to another, but is always slow. Redside shiners are only about 1 to 2 inches long at age 1, 2 to 3 inches long at age 2, and 4 inches long at age 4. The maximum length observed for this species was 6.7 inches for a fish aged 6 or 7. Females generally grow faster and live longer than males. The maximum age for redside shiners varies by locality but probably does not exceed age 7. Most individuals do not grow longer than 3 to 5 inches (Scott and Crossman 1973, Lindsey and Northcote 1963, Weisel and Newman 1951).

Sexual maturity in redside shiners occurs at age 3. Spawning may occur more than once during a summer (Weisel and Newman 1951). Nearly half of spawners typically live to spawn the following year, and some individuals may survive to spawn three years (Scott and Crossman 1973, Weisel and Newman 1951).

Redside shiners school in large numbers in lakes and streams. In lakes, redside shiners school by size; the smaller fish school closer to the surface and closer to the shore. In the daytime and during summer months, shiners tend to be found inshore over shoals that have rooted vegetation. They are rarely seen more than 25 feet beyond shoals except at night. Other than during spawning migrations, redside shiners seem to stay in the same general area, except that they move on and off the shore area in response to water changing temperatures (Scott and Crossman 1973, Lindsey and Northcote 1963).

HABITAT REQUIREMENTS

Redside shiners use generally the same type of habitat as juvenile steelhead trout, but appear to be less stressed at warmer temperatures (66ºF to 72ºF) than are steelhead (Reeves et al. 1987). Not much information is available concerning specific habitat requirements of redside shiners. Upper lethal temperature for redside shiners is about 77ºF (Scott and Crossman 1973).

INTER/INTRASPECIFIC INTERACTIONS

Redside shiner fry feed on small plant and animal plankton and crustaceans. Larger redside shiners feed on aquatic and terrestrial insects, but also eat small fish and fish eggs. Redside shiners feed on eggs and young of their own species and of trout. Redside shiners also are very active foragers, competing for food with more economically important fish, and may be serious competitors for food and space with trout (Scott and Crossman 1973).

Interspecific competition may also occur between juvenile steelhead and redside shiners. Reeves et al. (1987) noted that the presence of steelhead limited access of redside shiners to food in cool water, but in warm water, redside shiners were more active and responded to food more quickly than did steelhead. When water temperatures reach 66ºF to 72ºF, redside shiners displace steelhead trout in some types of habitat (Reeves et al. 1987).

Redside shiners are prey for a variety of fishes including rainbow trout, bull trout, and northern pikeminnow. They also are eaten by many waterfowl and by numerous species of mammals (Scott and Crossman 1973).

Because redside shiners are a schooling fish, incidence of disease is common in the species. Hoffman (1967) and Bangham and Adams (1954) list pathogens common to redside shiners.

Redside shiners have received more attention from biologists than have other species of minnows in part because of their potential impacts on sport fisheries (Lindsey and Northcote 1963). Where they have been introduced, they have had serious effects on the growth rate and production of trout (Scott and Crossman 1973, Larkin and Smith 1954).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Redside shiners are not recorded as present in the Metolius River (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Redside shiners are not recorded as present in the Deschutes River upstream of Lake Billy Chinook or in the tributaries that flow into this section of the Deschutes River (Fies et al. 1996b)

Lower Crooked River

Redside shiners are not recorded as present in the lower Crooked River (Stuart et al. 1996)

Lake Billy Chinook

Stuart et al. (1996) do not identify redside shiners as a species present in Lake Billy Chinook. Redside shiners were not caught in Merwin traps set in the reservoir in 1997 (Hiatt et al. 1997) or 1998 (Lewis 1999).

Lake Simtustus

Redside shiners are not recorded as present in Lake Simtustus (Stuart et al. 1996). Lewis (1999) did not capture redside shiners in a Mewin trap set in Lake Simtustus in 1998.

Lower Deschutes River

Redside shiners are native to the lower Deschutes River and its tributaries. They are found in the mainstem of the river as well as in Bakeoven, Buck Hollow, Shitike, and Trout creeks and in the Warm Springs River. Redside shiners are occasionally caught in these waters during periodic fish sampling activities, but the population size of this species in the lower Deschutes system is unknown (ODFW 1997).

Redside shiner populations in the mainstem Deschutes River are most numerous downstream of Trout Creek (C. Zimmerman, OSU, personal communication, May 1998). Numerical distribution of redside shiners in the lower Deschutes River is probably caused by increased water temperature in lower reaches of the mainstem.

FISHERIES

Redside shiners do not enter or appear to affect fisheries in the Pelton Round Butte Project reservoirs or tributaries.

LIMITING FACTORS

The small size and slow growth rate of redside shiners make them suitable forage throughout their life for predator species such as trout. In turn, redside shiners compete for food with trout (Crossman 1959). Inter/intraspecific interactions may be the primary factor controlling the population of redside shiners. In particular, egg availability for predation by redside shiners may be one of the most important limiting factors controlling survival of this species.

ECOLOGICAL ROLE

Redside shiners are both predators and prey. Their ecological role may be to balance populations of other species. Reeves et al. (1987) determined that redside shiners appeared to use generally the same habitat as juvenile steelhead trout, with cooler water favoring juvenile steelhead and warm water favoring redside shiners. However, Reeves et al. (1987) determined that the presence of redside shiners had no effect on rainbow trout production.

BROWN TROUT

Salmo trutta

Other common names: German brown trout, German, English brown trout, von Behr trout, Lochleven trout, European brown trout, truite, breac, gealag, brownie (Scott and Crossman 1973)

General

APPEARANCE

Brown trout have a laterally compressed body shape with the greatest body depth below the dorsal fin. The depth of the body is about 20 to 25 percent of its total length. The caudal peduncle is deep — about 12.5 percent of the total body length. In adults, the head length is about 23 percent of the total body length, with the eyes making up approximately 16 to 18 percent of the total head length. The snout is rounded with a length greater than the eye diameter in adults. The mouth is located on the end of the head and is quite large. The maxillaries extends beyond the back of the eye. Mature males develop a hook or kype on the lower jaw. The average length of a full-sized brown trout is about 16 inches (Scott and Crossman 1973).

Brown trout have one dorsal fin with 12 to 14 major rays (Scott and Crossman 1973). The adipose fin is small and fleshy (Hart 1973). The tail of adult brown trout is square, while the tail of young brown trout has a shallow fork (Scott and Crossman 1973). The anal fin has about 10 to 12 major rays and is rounded in males and sickle-shaped in females (Gruchy and Valadykov 1968). Pelvic fins have nine or ten rays and a distinct axillary process. Pectoral fins have 13 or 14 rays. Brown trout have small, round scales (Scott and Crossman 1973).

The color of brown trout varies with habitat type. In streams, brown trout are light brown or dull dark yellow overall with brown on the back (becoming silvery on the sides) and pronounced black spots on the back, sides, and head. The spots spread below the lateral line, but are more abundant in the body section near the front of the fish than near the rear of the fish. The black spots are often surrounded with a lighter ring or halo. The ring or halo spots on the sides are rusty red and irregular shaped. Dorsal and adipose fins also have dark spotting, but spots on the tail, if present, are only slightly visible. The adipose fin is orange or orange-red and may have red spots (Carl et al. 1959). The other fins on adults have a smoky, opaque, sometimes yellowish color. Lower fins on spawning males may be slate color (Scott and Crossman 1973).

In large lakes or in the sea, the overall color of brown trout is silvery, masking most of the spotting on the body. Spots on the head are small and numerous, and the adipose fin usually is orange or orange-red. Young brown trout in these settings have 9 to 14 short, narrow parr marks and a few reddish spots along the lateral line (Scott and Crossman 1973).

The characteristic that distinguishes brown trout from other trout is the dark spots with pale halos on the sides of its body. The orange adipose fin of brown trout fry distinguishes them from fry of other species (Wydoski and Whitney 1979).

Brown trout hybridize with brook trout to produce a strikingly marked stocky fish called a "tiger trout." Buss and Wright (1956, 1958) describe brown trout hybrids.

DISTRIBUTION

Brown trout are native to Europe and western Asia. They were introduced into New York and Michigan as early as 1883 (Scott and Crossman 1973). Brown trout were introduced widely into many parts of the United States beginning in 1900 (Wydoski and Whitney 1979). MacCrimmon and Marshall (1968) and MacCrimmon et al. (1970) review brown trout introduction throughout the world.

LIFE HISTORY

Most brown trout males mature at age 4, although, in some cases, males may mature by age 1. Most brown trout females mature at age 5 but females may mature as early as age 2 (Wydoski and Whitney 1979).

Spawning by brown trout occurs from late autumn into winter, from about October through December (Scott and Crossman 1973) and into January (Carl 1938) in various parts of the United States and Canada. Spawning occurs primarily during daytime hours (Wydoski and Whitney 1979). Water temperatures during spawning are 44 to 48ºF (Mansell 1966). Spring and seepage water may be necessary for the eggs to survive in winter water temperatures (Wydoski and Whitney 1979). Eddy and Surber (1960) noted that lake-spawning brown trout spawn on rocky reefs along the shore of lakes. Spawning females create a shallow depression, or redd, at the tail of a pool in gravel 0.25 to 3 inches in diameter. The eggs and sperm are deposited in the redd. The spawning process is repeated many times, and when spawning is completed, the female covers the redd with gravel (Scott and Crossman 1973). Both males and females defend the redd during spawning (Wydoski and Whitney 1979).

The number of eggs deposited depends upon the size of the female (larger fish deposit more eggs), and varies between waters (Wydoski and Whitney 1979, Scott and Crossman 1973, Brynildson et al. 1963). Fewer eggs are found in brown trout from streams with low fertility (McFadden et al. 1965). Fecundity data indicate that on average, a 7-inch female will lay about 144 eggs, while a 32.5-inch female will lay about 20,856 eggs (Carlander 1969). Brown trout eggs hatch in about 50 days when the water temperature is 50ºF (Wydoski and Whitney 1979).

Brown trout grow fast and attain a relatively large size. In general, males grow faster than females (Wydoski and Whitney 1979, Beyerle and Cooper 1960). Brown trout attain a total length of about 6.5 inches at age 1, 9.8 inches at age 2, 15.3 inches at age 3, and 16.8 inches at age 4 (Mansell 1966). Although brown trout over 10 pounds in weight are not rare, average adult weights in inland streams are typically 1 to 2 pounds (Scott and Crossman 1973).

Newly emerged fry and fingerling brown trout feed on small organisms such as blackflies, mayflies, and stoneflies (Idyll 1942). In winter, fry feed on freshwater shrimp and small crustaceans. Large brown trout feed on aquatic insects and insect larvae, crayfish, snails, frogs, and smaller fish including sculpins, minnows, suckers, darters, lampreys, and trout. Large brown trout feed more extensively on fish than most other trout. When large populations of nongame fish are available, they make up most of the diet of large brown trout (Wydoski and Whitney 1979, Elliott 1970). Brown trout feed primarily at night or in the early morning and late evening.

During the day, brown trout tend to stay in deep pools of streams or under banks (Wydoski and Whitney 1979).

HABITAT REQUIREMENTS

Brown trout have been introduced mainly into stream or river habitats, although a number of lake or sea-run populations now exist. Habitat requirements for this species are nearly the same as for brook trout (Scott and Crossman 1973). However, brown trout can survive and thrive in warmer water than brook trout. Brown trout may survive in water up to 81ºF for short periods. In warm streams, brown trout are likely to replace other trout. Brown trout also tolerate turbid water and lower oxygen levels better than most other trout. There has been a tendency to believe that brown trout do best in slow-moving waters at the lower reaches of trout streams, but Marshall and MacCrimmon (1970) do not support this view.

INTER/INTRASPECIFIC INTERACTIONS

There has been concern that brown trout displace native trout either by competition or direct predation and that brown trout may be carriers of disease (Scott and Crossman 1973). Attempts in Michigan to remove large brown trout was not a success (Shetter and Alexander 1965).

Brown trout are considered to be the most difficult trout to catch. Eddy and Surber (1960) note that large brown trout are seldom taken except at twilight or after dark when they are actively feeding. Availability of food dictates feeding habitats and catchability of brown trout. Once a brown trout has been caught and released, chances are that it will not be caught again for some time, if at all, even though it may survive for several years. Consequently, brown trout are able to maintain their populations by natural reproduction in spite of heavy fishing pressure (Wydoski and Whitney 1979).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Lower Crooked River

Brown trout are common in the lower Crooked River below Opal Springs. Stuart et al. (1996) do not estimate brown trout population size in the lower Crooked River. Brown trout are not found in the lower Crooked River in reaches above Opal Springs. A total of approximately 4,294 brown trout were released into the lower Crooked River from Opal Springs Hatchery in 1992, 1994, and 1995.

Metolius River Basin

Brown trout are common throughout the mainstem Metolius River, Lake Creek, and Suttle Lake. Suttle Lake has long sustained an abundant population of brown trout. Brown trout spawn in Link and Lake creeks (Fies et al. 1996a). Ely (1977) found that brown trout comprised 2 percent of the angler creels in 1975 and 1 percent in 1976. Fies and Robart (1988) found that 23 percent of the trout population in the Metolius River above Camp Sherman was brown trout. Snorkel surveys in 1993 and 1994 showed that brown trout accounted for 5 percent of all trout present in the Metolius River from the headwaters downstream to lower Gorge campground (Hemmingsen et al. 1994).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) report an excellent population of brown trout in the Deschutes River from Lake Billy Chinook to Big Falls and further upstream. There were 532 brown trout per mile from Odin to Big Falls, with 63 percent of the fish less than 6 inches. There is no comprehensive creel census data for the section, but the brown trout appear to be smaller from Big Falls to Lake Billy Chinook than in sections upstream. A general consensus of anglers is that brown trout populations have declined in this section in recent years. Concentrations of large, spawning brown trout have been observed below Steelhead Falls during autumn (Fies et al. 1996b).

Brown trout are common in Squaw Creek. Most of these fish are small (Fies et al. 1996b). Population size and distribution of brown trout in Squaw Creek is not reported (Fies et al. 1996b).

Lake Billy Chinook

Brown trout were introduced into Lake Billy Chinook, and they are now common, though not abundant, in this reservoir. Populations of brown trout appear to be higher near the mouths of all three river tributaries than in the main body of the reservoir. Merwin traps located in each arm of Lake Billy Chinook caught 170 brown trout in1997 (Hiatt 1997). Brown trout were most abundant in the Deschutes River Arm, comprising nearly 57 percent of the total number of brown trout collected throughout the reservoir. Collection methods and locations undoubtedly affected sample size, however. Rainbow trout appear to outnumber brown trout (Stuart et al. 1996). There is no information to indicate trends in brown trout population size in the reservoir (Stuart et al. 1996).

Merwin traps were also located in each arm of Lake Billy Chinook and in the Round Butte Dam forebay in 1998. Fourteen brown trout were caught in the Crooked River Arm, 38 brown trout were caught in the Deschutes River Arm, 11 brown trout were caught in the Metolius River Arm, and 44 brown trout were caught in the Round Butte Dam forebay. Brown trout represented 1.2 percent of the total number of fish caught by Merwin traps in Lake Billy Chinook in 1998 (Lewis 1999).

Brown trout were released from Opal Springs Hatchery into the lower Crooked River in recent years. A total of approximately 4,294 brown trout were released in 1992, 1994, and 1995. Some of these brown trout likely drifted downstream into Lake Billy Chinook. All the fish released were fin clipped, but records of recoveries have not been found.

Lake Simtustus

Artificially propagated brown trout were released into Lake Simtustus between 1986 and 1996 in hopes of providing a featured fishery and as a predator to control nongame fish species in the reservoir. Prior to their release in Lake Simtustus, brown trout were virtually nonexistent in the reservoir (ODFW 1997). The release of brown trout into Lake Simtustus was discontinued in 1997 because the fish did not appear to be accomplishing nongame fish control objectives, and they were known to leave the reservoir and take up residence in the lower Deschutes River (Stuart et al. 1996). Fishery managers feared that brown trout drifting downstream from Lake Simtustus would compete with native fish species in the lower Deschutes River (J. Newton, ODFW, personal communication, 1998).

Lewis (1999) placed one Merwin trap in Lake Simtustus in 1998. Only one brown trout was captured. Apparently, brown trout do not reproduce in Lake Simtustus or in its tributaries.

Lower Deschutes River

Brown trout were present in the lower Deschutes River in the vicinity of the Pelton Round Butte Project prior to its construction. ODFW reports that brown trout abundance decreased following construction of the Pelton Round Butte Project (ODFW 1997), although brown trout population estimates were not made prior to construction of the hydroelectric complex.

As described above, brown trout were stocked from 1987 to 1996 in Lake Simtustus to provide a featured fishery and to help control nongame species in the reservoir. Brown trout are known to move out of Lake Simtustus through the turbines and through the turbines or in spill over the Reregulating Dam. The number of brown trout captured at the Round Butte Hatchery adult salmon and steelhead trap located at the base of the Reregulating Dam comprised 7, 8, 11, and 4 percent of all trout captured at the Pelton trap 1992, 1993, 1994, and 1995, respectively. The current abundance of brown trout in the lower Deschutes River is unknown (ODFW1997).

ODFW made a decision in 1995 to stop the release of brown trout after 1996 in Lake Simtustus in part because brown trout were leaving the reservoir to take up residence in the lower Deschutes River. ODFW also developed management directions for managing the mainstem lower Deschutes River for natural production of native wild rainbow trout and other native fish species (ODFW 1997). Brown trout are not a native species in the lower Deschutes River. Brown trout that pass from Lake Simtustus into the lower Deschutes River may jeopardize management of native fish species in the lower Deschutes River.

FISHERIES

As mentioned above, Wydoski and Whitney (1979) note that brown trout are difficult to catch, and that when they are caught and released, they often do not get caught again. Anderson and Nehring (1984) found rainbow trout more vulnerable to angling than brown trout. Anderson and Nehring (1984) also found more brown trout in streams with catch-and-keep regulations as compared to streams with catch-and-release regulations, where rainbow trout were the dominate fish species. Cooper (1951) found that brook trout were easier to catch than wild brown trout and that anglers took 3.0 brook trout for each one remaining as compared for brown trout where anglers took only 0.4 fish for each one remaining at the end of the season. Carline et al. (1991) observed that hooking mortality of brown trout was relatively low in areas managed for catch-and-release fisheries. Barwick (1985) conducted tests to establish put-grow-and-take fisheries for rainbow trout and brown trout. Barwick (1985) failed to establish a put-grow-and-take rainbow trout fishery, but such a fishery for brown trout was established successfully by planting far fewer fish. Brown trout in some heavily fished headwater streams provide more fish, better growth rates and higher catch rates than many other fish species (Marshall and MacCrimmon 1970).

Brown trout are most active during the spring of the year (Chaston 1969, Schulz and Berg 1992). Their movement peaks near sunrise, near sunset, and throughout the night, when they are searching for food (Bunnell and Isely 1998, Jenkins 1969, Oswald 1978, McIntosh and Townsend 1995). Lack of movement throughout the other parts of the year and during daylight hours is either caused by stationary feeding behavior (Bachman 1984) or occupancy of a nonfeeding site (Bunnell and Isely 1998). The fact that brown trout feed mainly at night during the spring of the year would limit their availability to be caught by anglers. Considering the fact that brown trout are generally difficult to catch, some anglers consider them a challenge that cannot be resisted.

Metolius River Basin

Fies and Robart (1988) found that 23 percent of the trout population above Camp Sherman was comprised of brown trout. A creel census study in 1975 and 1976 (Ely 1977) showed that brown trout comprised 2 percent of the total fish caught in 1975 and 1 percent of the total catch in 1976. This study was done when all species of trout could be kept. Catch-and-release regulations recently adopted by ODFW for rainbow trout in the Metolius River fishery will probably result in an increase in the rainbow trout population and a decrease in the brown trout population (Anderson and Nehring 1984).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) note that anglers target brown trout in the Deschutes River upstream of Lake Billy Chinook, but they do not provide any quantitative information on harvest in this reach of the Deschutes River.

Lower Crooked River

Stuart et al., (1996) do not report fisheries activities in lower reaches of the Crooked River. The limited access to the angling area would restrict brown trout harvest in this reach.

Brown trout have been released in recent years from the Opal Springs Hatchery into the Opal Springs area of the lower Crooked River. Approximately 4,294 brown trout, 6 to 8 inches in length, were released from 1991 to 1995. The numbers of these fish harvested are not known.

Lake Billy Chinook

Approximately 300 to 600 brown trout are harvested from Lake Billy Chinook annually. They range from 10 to 14 inches in length, with some fish reaching lengths of over 16 inches. The brown trout catch rate in Lake Billy Chinook was about 0.004 fish per hour during the period from 1990 to 1993 (Thiesfeld et al. 1995).

Lake Simtustus

Estimated harvest of brown trout from Lake Simtustus for the period 1990 through 1992 was 3,705 in 1990, 2,287 in 1991, and 2,981 in 1992. Because the total catch rate in the lake during that period was less than 0.5 fish per hour for bull trout, kokanee, rainbow trout, and brown trout combined (Stuart et al. 1996), it is assumed that the catch rate for brown trout is relatively slow. The discontinuation of releasing hatchery-reared brown trout will probably result the elimination of brown trout in creels in Lake Simtustus.

Lower Deschutes River

ODFW (1997) does not mention brown trout in harvest data for the lower Deschutes River.

LIMITING FACTOR

It appears that there are biological factors inherent in the basin that control brown trout populations in ways that contradict observed population patterns for this species in other basins. For example, brown trout are found in lower reaches of many basins (Scott and Crossman 1973), whereas they are found in the uppermost reaches of the Deschutes River Basin, including the upstream portions of the Metolius River subbasin (Fies et al. 1996a, 1996b). Brown trout can withstand less favorable temperatures and turbidity than rainbow trout (Scott and Crossman 1973), yet rainbow trout are found in sections of the Crooked River that are devoid of brown trout (Stuart et al. 1996). Brown trout grow fast, live longer, and are harder to catch than bull trout, yet populations of bull trout are greater than brown trout in the Deschutes River Basin. Because brown trout are an introduced species in the Deschutes River Basin, it is likely that genetically fit native fish populations have filled niches that would be occupied by brown trout in other bodies of water.

ECOLOGICAL ROLE

Brown trout were introduced into the Deschutes River Basin to provide a species of large fish for anglers. Brown trout are popular among anglers, but less so among biologists because this species has been found to have a negative impact on fisheries. However, MacCrimmon et al. (1970), Shetter and Alexander (1965), Brynildson et al. (1963), and Cooper (1952, 1953) suggest that introduction of brown trout in streams that support native trout and that are subjected to heavy fishing pressure should help establish self-sustaining populations of both species. Brown trout were stocked annually in Lake Simtustus from 1987 to 1996.

SMALLMOUTH BASS

Micropterus dolomieui

Other common names: Northern smallmouth bass, smallmouth black bass, black bass, brown bass, green bass, white trout, mountain trout (Scott and Crossman 1973)

General

APPEARANCE

Smallmouth bass are laterally compressed, though less so than other sunfishes. The cross-section of smallmouth bass is a narrow oval. The greatest body depth is at the front to middle of the first dorsal fin, and this distance is 20 to 28 percent of the total length. The angle from the snout to the back is low, and the back is flat to slightly rounded. The caudal peduncle is long and rather deep. The head is 26 to 30 percent of the total body length and is deep and moderately wide. The top surface of the head is rounded or has a shallow depression over the eyes. The operculum is bony to the edge and pointed into a flap. The eyes are large, with a diameter making up 14 to 30 percent of the head length. The snout is long and bluntly pointed and measures about 35 percent of the total head length. The mouth is located on the end of the snout. The lower jaw is slightly longer than the upper jaw. Maxillaries are 40 to 47 percent of the head length and usually extend to the middle of the eye (Scott and Crossman 1973).

Smallmouth bass have two dorsal fins that are joined and appear more like one fin. The first dorsal fin is rather low and has ten spines, the last of which appears to be part of the second dorsal fin. The second dorsal fin is higher and has 12 to 15 soft rays. The edge of the second dorsal fin is rounded. The tail is quite broad and moderately forked and has blunt to rounded tips. The anal fin has three spines and 10 to 12 soft rays. The edge of the anal fin is rounded. The pelvic fins originate forward of the dorsal fin and are joined to the body by a membrane. The pelvic fins have one spine and five soft rays. The pectoral fins are not long but are broad and rounded and have 13 to 15 soft rays. Scales on the smallmouth bass are round with needle-like projections on the back of each scale (Scott and Crossman 1973).

Coloration in smallmouth bass varies with size, condition, and habitat. In clear, vegetated water, smallmouth bass are darker and have pronounced, contrasting markings. In turbid water, they are lighter and have vague markings. The back and head are brown, golden brown, or olive to green, and their sides are lighter, more golden colored, and have golden flecks on most scales. The belly surface is cream to milk-white in color. The sides of adults have pronounced to vague, thin, vertical bars that are sometimes broken. The head has dark bars radiating backwards from the eyes. The eyes are usually red or orange. The fins are dusky to amber color. The pectorals fins are clear, while the other fins are opaque with some black on the rays, spines, or membranes. Young smallmouth bass have very prominent vertical bars or rows of spots on the sides, and the tail has distinctive orange marks at the base followed by a black band with white to yellow tips (Scott and Crossman 1973).

Distinguishing characteristics of smallmouth bass are: (1) a small mouth compared to largemouth bass; (2) maxillaries that usually do not extend beyond the center of the eye except in large specimens (even in large specimens, however, the maxillaries do not reach the back of the eye); and (3) spines and soft-rayed parts of the dorsal fin that are broadly joined, not separated, nearly to the base. Young smallmouth bass have three distinguishing vertical bands on the tail — orange and yellow bands at the base of the tail and a white tip on the tail (Wydoski and Whitney 1979).

DISTRIBUTION

The original range for smallmouth bass was from the middle of Minnesota east to southern Quebec, southeast to northern Georgia, and west to Oklahoma, (Wydoski and Whitney 1979). Smallmouth bass were first introduced to the west coast in California in 1874 (Curtis 1949). Their range now extends across nearly all parts of the United States and many parts of Canada. They also have been introduced into many places in England, Europe, Russia, and Africa (Scott and Crossman 1973).

LIFE HISTORY

Males mature at age 3 to 5 and females at age 4 to 6 (Fraser 1955, Scott and Crossman 1973). Females probably spawn every year. Spawning occurs in spring. Smallmouth bass move into spawning areas at water temperatures ranging from 40ºF (Trautman 1957) to 60ºF (Cleary 1956). Studies have documented spawning activity at 58ºF (Watson 1955), 55 to 60ºF (Henderson and Foster 1956), 59 to 65ºF (Hubbs and Bailey 1938), 61 to 65ºF (Dymond 1931), 62ºF (Latta 1963), and 63 to 70ºF (Stone et al. 1954). Hubbs and Bailey (1938) report that nesting stopped if the temperature dropped below 60ºF.

The male builds a nest measuring 1 to 6 feet in diameter in water 2 to 20 feet deep. The completed nest is a saucer-shaped depression that is usually about twice the length of the male. Nest construction takes 4 to 48 hours, depending upon temperature and bottom type. Smallmouth bass nesting sites are on sandy, gravelly, or rocky bottoms of lakes and rivers, usually near the protection of rocks, logs, or dense vegetation (Dymond 1931, Hubbs and Bailey 1938, Curtis 1949, Watson 1955). Males typically return to the same nest or build a nest in the same area year after year (Emig 1966).

After nest building, there is considerable prespawning activity including displays, rubbing, and nipping. Smallmouth bass spawning is most active during daylight hours. The male and female swim around the nest and eventually come to rest on the bottom with their bellies nearly in contact; the male vertical and the female at a 45º angle. Actual egg deposition and fertilization takes place for about 5 seconds, and is repeated numerous times during a period of about two hours with intervening periods of nest-circling lasting 25 to 45 seconds. The eggs sink to the center of the nest and adhere to clean rocks. After spawning, the female leaves the nest and may spawn in another nest with another male; females may spawn two or three times with different males during the annual spawning period (Emig 1966).

The total number of eggs per female each spawning season ranges from approximately 5,000 to 14,000, depending upon the size of the female. A common rule of thumb is that a female will carry about 7,000 eggs per pound of body weight. Smallmouth bass eggs are light amber to pale yellow in color and are small, measuring about 0.1 inch in diameter (Watson 1955).

The male smallmouth bass guards the nest, fans the eggs, and guards the young after they hatch. Generally, the larger the female and male, the greater the egg hatching success (Emig 1966). Smallmouth bass eggs hatch in 4 to 10 days (Scott and Crossman 1973). Sigler (1959) reported smallmouth bass eggs hatching in 9½ days at 55ºF. Newly hatched young remain among the rocks of the nest for 3 to 4 days before emerging (Hubbs and Bailey 1938, Watson 1955, Latta 1963). In about 12 more days, the young have absorbed the yolk and rise off the bottom of the nest. The larvae are about 0.2 inches long at hatching and about 0.35 inches long when they rise from the nest bottom (Hubbs and Bailey 1938). After 5 to 7 more days, fry begin to leave the nest, but continue to be guarded by the male for several days (Reighard 1906, Fish 1932, Doan 1939, Scott and Crossman 1973, Wydoski and Whitney 1979).

Several factors affect survival of the eggs and young of smallmouth bass, and egg survival may be low if there are rapid changes in temperature, changes in water level, or fungal infections. If the air temperatures drops and remains low, nests are abandoned (Cleary 1956). A rise in water level of 6 inches will sweep nests bare (Henderson and Foster 1956). Insect larvae prey on smallmouth bass eggs and fry (Langlois 1936).

Growth of smallmouth bass fry is rapid at first. Growth rates of older fish vary by location and fluctuate from year to year. The approximate average size of smallmouth bass from the Columbia River ranges from a weight of 1 pound and length of 11.6 inches at age 3 to a weight of 4 pounds and a length of 18.6 inches at age 10 (Wydoski and Whitney 1979). Males and females generally grow at the same rate (Bennett 1938, Tate 1949, Westman and Westman 1949, Latta 1963). The maximum age attained by smallmouth bass is about 15 years (Scott and Crossman 1973).

Studies indicate that an individual smallmouth bass has a relatively small home range and does not travel far during its lifetime (Larimore 1952, Latta 1963, Forney 1961, Munther 1970). Smaller smallmouth bass tend to wander more than larger ones (Larimore 1952). There is evidence that smallmouth bass home to spawning grounds and summer territory (Larimore 1952, Fraser 1955, Scott and Crossman 1973).

Population densities of smallmouth bass calculated for several Ohio streams vary from 3 to 10 pounds per acre (Brown 1960). Mortality rates vary among different waters, but natural mortality rates are generally higher than angling mortality rates (Forney 1961, Latta 1963); angling mortality rates range from 5 to 22 percent, while natural mortality rates range from 13 to 37 percent (Forney 1961, Latta 1963).

HABITAT REQUIREMENTS

Smallmouth bass usually live in cool, clear streams or in lakes with some current. They are most abundant in streams wider than 35 feet, with gradients of 4 to 25 feet per mile, and with sandy to bouldery bottoms (Hubbs and Bailey 1938, Trautman 1957). In lakes, smallmouth bass are found around rocky reefs and gravel bars.

Smallmouth bass prefer water temperatures of 70 to 82ºF (Sigler 1959, Scott and Crossman 1979). They become lethargic at water temperatures of 50ºF and lower (Trautman 1957). The upper lethal water temperature for this species may be as high as 95ºF (Scott and

Crossman 1973). The lower lethal dissolved oxygen concentration for smallmouth bass is about 0.87 to 0.96 parts per million (Burdick et al. 1954).

Smallmouth bass begin feeding actively when the water temperature nears 60ºF (Bennett 1962). They cease feeding in the fall (Langlois 1936), when cool water retards their metabolism. Smallmouth bass feed as long as food is available and water temperatures are favorable. They will gorge at any opportunity, except when temperatures are low (Doan 1940). Low temperatures following a day of vigorous eating may increase the period before they eat heavily again. However, high temperatures are not always correlated with increased feeding (Langlois 1936). The growth rate of smallmouth bass increases with warmer water temperatures (Doan 1940, Langlois 1936).

In early morning hours, smallmouth bass locate near the edge of the current to feed. When they stop feeding, they lay motionless within 3 feet of the water surface near the side of exposed rocks. This behavior is termed “sunning” (Wydoski and Whitney 1979). At night, smallmouth bass move to the substrate in quiet water, where they remain motionless until daylight (Scott and Crossman 1973).

Smallmouth bass fry feed on plankton. Adult smallmouth bass feed on zooplankton, insects, crayfish, and fishes, eating larger sized food as they grow. The diet composition of any particular size group of smallmouth bass shifts with availability of various food items and also varies by locality. For adults in most habitats, crayfish make-up approximately 60 to 90 percent of the food volume, fish make up 10 to 30 percent, and aquatic and terrestrial insects make up 0 to 10 percent. Frogs, tadpoles, fish eggs, and plant material also are often present in the stomach contents of smallmouth bass (Scott and Crossman 1973, Wydoski and Whitney 1979).

Lewis (1997) found that crayfish composed over 95 percent of the food in the stomachs of smallmouth bass during the months of May through September in Lake Billy Chinook. However, zooplankton represented the bulk of food in stomach samples from smallmouth bass captured in the reservoir in 1998 (Lewis 1999). Other food items found in the 1998 stomach samples included crayfish, aquatic and nonaquatic insects, and one bull trout. Of the 56 smallmouth bass stomachs examined in 1998, 59 percent were full (Lewis 1999).

INTER/INTRASPECIFIC INTERACTIONS

Smallmouth bass may feed on their own young, but they usually feed on minnows and young of other species (Hubbs and Bailey 1938, Doan 1940, Curtis 1949, Westman and Westman 1949, Lachner 1950, Watson 1955, Harlan and Speaker 1956). In turn, young smallmouth bass are eaten by many predators. Some predation occurs at the nest while the guarding male is chasing another predator (Scott and Crossman 1973). Backswimmers and dragon fly larvae also prey upon smallmouth bass fry (Langlois 1936).

Smallmouth bass may compete for food with other fishes, but they are unable to compete with largemouth bass, blue gill, green sunfish, and black bullheads in warm-water ponds (Scott and Crossman 1973, Bennett and Childers 1957, Bennett 1962). However, smallmouth bass displaced largemouth bass in Lake Billy Chinook (Stuart et al. 1996) probably because water temperatures are more favorable for smallmouth bass in the reservoir. There also may be some competition for nesting areas with other species and with other smallmouth bass (Scott and

Crossman 1973). Smallmouth bass, when introduced into lakes that have just barely enough oxygen and cold water to support trout and salmon, can survive better than the salmonids and soon outnumber salmonids (Watson 1955).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Smallmouth bass are not recorded as present in the Metolius River (Fies et al. 1996a).

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Smallmouth bass have been observed in the Deschutes River between Steelhead Falls and Lake Billy Chinook. Smallmouth bass have access to Squaw Creek but have not been observed there, probably because of cool water temperatures at the mouth of the creek (Fies et al. 1996b). Factors other than water temperature also may preclude or minimize their presence in Squaw Creek.

Lower Crooked River

The Crooked River downstream of Prineville Reservoir supports relatively small numbers of smallmouth bass. The smallmouth bass population does not extend far below Bowman Dam (Stuart et al. 1996).

Lake Billy Chinook

Smallmouth bass are not native to Lake Billy Chinook. The origin of smallmouth bass in Lake Billy Chinook is believed to be Prineville Reservoir. The Oregon Game Commission stocked largemouth and smallmouth bass into Prineville Reservoir in 1961, and both species moved downstream 70 miles into Lake Billy Chinook (A. Stuart, ODFW, personal communication, January 1999). Smallmouth bass were rare in Lake Billy Chinook until the early 1970s and were first observed in creel surveys conducted in 1972. Only two smallmouth bass were recorded in creels in 1973. Subsequent increases in smallmouth bass populations in Lake Billy Chinook probably displaced largemouth bass from the reservoir (Stuart et al. 1996).

Smallmouth bass were the most abundant species captured in Merwin traps from each arm of Lake Billy Chinook in 1997 (Hiatt et al. 1997; Lewis 1999). The traps, however, are located in areas where smallmouth bass are concentrated. Consequently, Merwin traps may be capturing a disproportionately large number of smallmouth bass in Lake Billy Chinook. Smallmouth bass catch in 1997 slowly increased through the season and dramatically increased when water temperatures increased to about 65ºF in the third week of May (Hiatt et al. 1997; Lewis 1999). Of the 1,312 smallmouth bass captured in 1997, only 3 came from the Metolius River Arm (Hiatt et al. 1997). Of the 3,316 smallmouth bass captured in 1998, only 85 came from the Metolius River Arm (Lewis 1999).

Smallmouth bass in Lake Billy Chinook are generally small and young. None of the smallmouth bass sampled with electroshocking gear in 1990 and 1991 were older than age 4. Samples collected from 1990 through 1993 showed that only 1 percent to 8 percent of the smallmouth bass population greater than 7 inches were longer than 11 inches (Stuart et al. 1996). The average length of smallmouth bass captured from both the Crooked and Deschutes river arms Merwin traps in 1997 was nearly the same, approximately 7 inches (Hiatt et al. 1997). Shrader (1992) determined that the weight-to-length relationship for Lake Billy Chinook smallmouth bass is better than average for the species. Shrader (1992) speculates that the small size of smallmouth bass is related to cold water temperatures or food limitations in Lake Billy Chinook.

As is typical of other smallmouth bass populations, smallmouth bass in Lake Billy Chinook do not move far from the natal area (Stuart et al. 1996).

Lake Simtustus

Smallmouth bass may be present in Lake Simtustus in very low numbers. Capture of one smallmouth bass in the reservoir was reported in 1994 (Stuart et al. 1996). Lewis (1999) used a Merwin trap to sample fish populations in Lake Simtustus in 1998, but no smallmouth bass were captured.

Lower Deschutes River

ODFW (1997) does not identify the presence of smallmouth bass in the lower Deschutes River.

FISHERIES

Smallmouth bass are classified as a game fish in the Deschutes River Basin. The only area where smallmouth bass are harvested in significant numbers is in Lake Billy Chinook. Over 3,500 smallmouth bass were estimated harvested there in the 1990/1991 season (Stuart et al. 1996). Approximately 4,300 smallmouth bass were harvested in 1996, and 2,600 smallmouth bass were harvested in 1997 from Lake Billy Chinook (preliminary report, S. Thiesfeld, ODFW, 1998). The mortality rate for smallmouth bass in the reservoir appears to be low. Shrader (1992) estimated a total mortality rate of 37 percent, and creel surveys 1990 through 1993 suggest that angling resulted in a mortality rate of 4.5 to 6.7 percent of the total smallmouth bass population in Lake Billy Chinook.

LIMITING FACTOR

The limited shore areas may restrict total numbers of smallmouth bass in Lake Billy Chinook and Lake Simtustus, and cool water temperatures may limit their growth rates in both reservoirs (Shrader 1992). In Lake Billy Chinook, the documented slow growth rates and preponderance of relatively small, younger aged fish in the population limit smallmouth bass management options (Stuart et al. 1996). Habitat conditions suitable for smallmouth bass may be limited to upper reaches of the Crooked River Arm and lower reaches of the Crooked River.

Ecological Role

The relatively small population and small average size of individuals among smallmouth bass in Lake Billy Chinook indicates that the population may not have a strong footing in the reservoir. Minor changes in environmental conditions could eliminate the smallmouth bass population in Lake Billy Chinook.

GOLDFISH

Carassius auratus

Other common name: Golden carp

General

APPEARANCE

Goldfish have stout, thick bodies. The body thickness of goldfish is about 28 to 34 percent of the total length. Goldfish average about 5 to 10 inches in length. The head of a goldfish is shaped like a triangle and is 24 to 25 percent of its total body length. The diameter of the eye is about 19 to 32 percent of the head length. The snout is relatively short, making up about 25 to 37 percent of the head length. The mouth is relatively small and protrudes beyond the snout. The caudal peduncle is thick and short. The dorsal fin of goldfish is long and has 1 stout spine and 15 to 18 soft rays. The tail has rounded tips and a rounded fork. The anal fin has one short, stout spine and five or six soft rays. The pelvic fins are short and broad and have eight or nine soft rays. The pectoral fins are broad and have 15 to 17 soft rays. The scales are large, nearly round, and have smooth edges (Scott and Crossman 1973).

The color of goldfish is quite variable, ranging from olive-green to creamy white. Some specimens are golden in color with black blotches. Young goldfish are green, brown, greyish bronze, or almost black. Goldfish are often bred for specific coloration, but when the domesticated stocks are released into the wild they usually revert to an olive-green color. Individual goldfish that retain bright colors in the wild are selected by predators (Scott and Crossman 1973).

Goldfish breed with carp, and the offspring may show a blending of both parents. Unlike carp, goldfish do not have barbels (Scott and Crossman 1973).

DISTRIBUTION

Goldfish are native to eastern Asia. Goldfish have been used as household pets since the 11th century. As a consequence of domestication, they were introduced into many parts of the world beginning in the late 17th century. Goldfish were brought to North American sometime during the 1800s, but the specific date of introduction is unknown. Goldfish were recorded being reared in a fish farm in Maryland in 1889. Goldfish are presently found throughout the United States (Scott and Crossman 1973).

LIFE HISTORY

Goldfish usually spawn in May or June (Scott and Crossman 1973), but they may spawn as late as August (Battle 1940). They seek warm water and shallow, weedy areas to spawn. When the female is getting ready to spawn, it may be accompanied by two or more males. The female releases its eggs and the male releases its sperm over submerged aquatic plants. The adhesive fertilized eggs fall to the plant material, where they stick. Spawning usually occurs during bright, sunny mornings. Eggs hatch in 3 or 4 days when the water temperature is 65 to 85ºF (Scott and Crossman 1973).

Goldfish feed on plants and animals including larvae and adult aquatic insects, clams and snails, worms, and aquatic vegetation. A goldfish 10 inches long will weigh about 1.5 pounds (Scott and Crossman 1973).

Habitat Requirements

Goldfish will live and reproduce in natural conditions, but they are mostly found in ornamental ponds or fish bowls. In natural conditions, goldfish seem to have the most success living and reproducing in small warmwater ponds that have abundant aquatic vegetation.

Goldfish are used as laboratory animals and are the aquatic counterpart of the guinea pig, mouse, and rabbit.

Inter/intraspecific Interactions

Goldfish are prone to parasites and diseases that affect wild fish. Crowding in artificial conditions make them more prone to disease. Progeny of goldfish and carp breeding are larger than goldfish, and therefore have more potential for impact on native fish than do pure-breed goldfish.

Pelton Round Butte Project Area

Population Size and Distribution

Metolius River Basin

Fies et al. (1996a) do not report goldfish in the Metolius River. Water temperatures in the Metolius River are probably too cold for goldfish.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) do not report goldfish in the Deschutes River between Steelhead Falls and Lake Billy Chinook.

Lower Crooked River

Goldfish were common in small ponds adjacent to the Crooked River in 1963. Efforts to kill goldfish with rotenone in the Crooked River below Bowman Dam in 1963 were mostly unsuccessful. Goldfish appeared to avoid rotenone by sticking their mouths above the surface of the water, appearing to be breathing air. The numbers of goldfish remaining alive after the chemical treatment project in 1963 is unknown.

Stuart et al. (1996) do not report the presence of goldfish in the Crooked River, although they report the "customary assemblage of nongame fish" in the lower Crooked River. This assemblage may include goldfish.

Lake Billy Chinook

There is a small population of goldfish in the Crooked River Arm of Lake Billy Chinook (Stuart et al. 1996). Lewis (1999) captured fish in Lake Billy Chinook in 1998 using a Merwin trap net. This trapping effort yielded a total of 111 goldfish in Lake Billy Chinook — 9 were captured in the Crooked River Arm, 91 in the Deschutes River Arm, and 11 in the Round Butte Dam forebay. Goldfish represented 1 percent of the fish caught in 1998 (Lewis 1999).

Lake Simtustus

Goldfish have not been reported in Lake Simtustus. Lewis (1999) used a Merwin trap net in Lake Simtustus in 1998 and did not capture goldfish.

Lower Deschutes River

ODFW (1997) does not report goldfish in the Deschutes River downstream of the Pelton Round Butte Project.

FISHERIES

There is no fishery for goldfish in the Project area. Although goldfish are used as bait in some parts of the southeastern United States (Scott and Crossman 1973), live goldfish are not allowed to be used as fish bait in Oregon.

LIMITING FACTORS

Cold water, large rivers, and large reservoirs found in the Deschutes River basin are not preferred habitat of goldfish. Laws prohibiting the release of goldfish may play a role in restricting their numbers in the lower Crooked River, where they were common in 1963.

ECOLOGICAL ROLE

Goldfish are bred for culture in ornamental ponds and fish bowls. They are also widely used in laboratories to measure sensitivity to various levels of dissolved gases such as carbon dioxide, sensitivity to temperature, swimming speeds, and toxicity to various industrial wastes (Scott and Crossman 1973).

BLACK CRAPPIE

Pomoxis migromaculatus

Other common names: Crappie, crawpie, calico bass, strawberry bass, speckled bass, grass bass, Oswego bass, shiner, moonfish (Scott and Crossman 1973), bream, Mason perch, slab, speckled perch, specks

General

Appearance

Black crappie have deep, laterally compressed bodies typical of sunfish. Their body is thickest at the front of the dorsal fin, where the thickness is about 30 to 33 percent of their total length. The backs of black crappie are rounded and their caudal peduncle appears short and deep. The head of black crappie is narrow, has a marked depression over the eye and is about 26 to 28 percent of the total length. The operculum has a bony edge and is rather large and pointed. There is a black spot at the rear edge of the operculum. The eyes are located high and ahead of the center of the head. The eyes have a diameter of approximately 25 to 32 percent of the head length. The snout is short and bluntly pointed. The large mouth is located on the end of the snout, and the lower jaw is slightly longer than the upper jaw. The maxillaries are long, about 42 to 46 percent of the head length, reaching to the rear of the eye (Scott and Crossman 1973).

Black crappie have two dorsal fins that are joined so that they appear as one fin. The length of the base of the two dorsal fins is nearly identical to the length of the base of the anal fin. The first dorsal fin, which has seven or eight graduated-length spines, is shorter than the second dorsal fin. The last dorsal spine in the first dorsal fin is almost as long as the second dorsal fin. The second dorsal fin is longer and higher than the first dorsal fish. The second dorsal fin has rounded edges and 14 to 16 soft rays. The tail fin is long and broad with a shallow fork and rounded tips. The anal fin has a long base and has 6 or 7 spines followed by 16 to 18 soft rays. The edge of the anal fin is slightly rounded to square. The pelvic fins are located far forward below the pectoral fins and are connected to the shoulder girdle. The pelvic fins have one sharp spine and five soft rays. Tips of the pelvic fins are rounded. The pectoral fins are moderately long, broad and rounded and have 13 to 15 soft rays. Scales on black crappie are large and have needle-like projections. The scales are smaller and more abundant toward the front of the body (Scott and Crossman 1973).

Black crappie have a general dark color with a metallic green to golden brown overcast of silver or blue on the back and head. The sides of black crappie are iridescent green to silvery. There is a vague horizontal grouping of dark body pigment on the sides of some individuals. The pelvic fins are clear with some black on the tips. The pectoral fins are a dusky color and appear transparent. Young black crappie have less dark pigment and less visible patterns than older black crappie. Breeding males become darker. The color of black crappie varies with habitat type and size of the individual fish. In some locations, black crappie have vermiculations with black or oblong yellow to pale green spots in the center of the vermiculations on the dorsal, tail, and anal fins (Scott and Crossman 1973).

The general appearance of black crappie is similar to that of white crappie. Black crappie and white crappie are not, as the names imply, black and white, respectively. Black crappie appear to be shorter and blockier in shape than white crappie. The blocky appearance of black crappie is a result of a deeper snout and a shorter caudal peduncle. The base of the dorsal fin is further forward in black crappie than in white crappie. White crappie often have vertical dark bars on their sides, while black crappie tend to have mottled or horizontal coloration on their sides (Scott and Crossman 1973). White crappie are more tolerant of muddy water than are black crappie (Phillips et al. 1982).

DISTRIBUTION

Black crappie are native to freshwater areas of eastern and central North America. Native black crappie populations occur from southeast Canada through western New York and, west of the Appalachian Range, to the Gulf coast in Alabama; throughout Florida and along the Atlantic coast as far north as Virginia; from Alabama to central Texas; and from eastern Oklahoma to North Dakota and eastern Montana. Black crappie have been introduced into almost all other areas of the Unites States (Scott and Crossman 1973).

LIFE HISTORY

Black crappie spawn in late spring and early summer when water temperatures reach 61 to 68ºF. Sexual maturity occurs in black crappie during their second to fourth year of life, and maturing adults are usually 6 to 8 inches long. Males establish spawning territories, and build and protect the nests. Nests are made by clearing shallow depressions in sand, gravel, or mud in water 10 inches to 2 feet deep. Nests are 8 to 15 inches in diameter, and, if there are several nests, they are about 5 to 6 feet apart. Crappie may nest in colonies that include as many as 35 nests. Spawning takes place during morning hours. A male may chase a female away. When a pair does spawn, they swim in circles around the nest until they come to rest with their bellies touching and pushing against each other. Both fish quiver as the female releases its eggs and the male releases its milt (Becker 1983; Phillips et al.1982). Only a small portion of the total number of eggs in a female are released at a time, and the same female may spawn in the nests of several different males. Number of eggs per female range from 27,000 to 68,000 with an average of 38,800 eggs per female. The eggs are small, whitish, and sticky. They stick to one another and to vegetation.

Black crappie eggs hatch in about 4 days when the water temperatures is 78ºF. Males guard the nest, fan the eggs until they hatch, and guard the young for a short time after they hatch (Pearse 1919; Breder 1936; Breder and Rosen 1966). The tiny, transparent, young remain near the nest for a short period of time after hatching (Siefert 1969). Black crappie fry congregate in large schools in shallow water.

Initial growth of the newly hatched young is fast (Trautman 1957). By fall the young black crappie may be nearly 3 inches in length. Growth slows after the first year; age 4 black crappie may be 10 inches long, while age 8 black crappie may be nearly 12 inches long. The maximum age of black crappie is about 8 to 10 years (Pearse, 1919; Breder 1936; Breder and Rosen 1966).

Habitat Requirements

Black crappie are intolerant of turbid waters. They prefer large, clear, quiet, warmwater reservoirs and lakes. They also may live in quiet areas of larger rivers. Black crappie are found in areas where there is some aquatic vegetation (Keast and Webb 1966; Keast 1968a, 1968b; Scott and Crossman 1973).

Black crappie feed at night or during early morning hours in open waters on zoo-plankton, insect larvae, younger crappie, and other fish (Scott and Crossman 1973).

Black crappie may move to new locations as a result of changing temperature, oxygen levels, seasons, and food availability.

Inter/intraspecific Interactions

Black crappie prey on yellow perch, bluegill, pumpkinseed, bass, perch, and other crappie. They are active feeders during winter months (Scott and Crossman 1973).

Young black crappie are preyed on bass and larger sunfish. Spines in the fins and the robust body of black crappie protect them from predators. Their habit of feeding in open water also aids their survival (Keast and Webb 1966; Keast and Welsh 1968; Keast 1968a, 1968b; Scott and Crossman 1973).

Pelton Round Butte Project Area

Population Size and Distribution

Metolius River Basin

Fies et al. (1996a) do not report black crappie in the Metolius River. The Metolius River is probably too fast and cold a stream for black crappie spawning and rearing.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) do not report black crappie in the Deschutes River between Deschutes Fall and Lake Billy Chinook or in Squaw Creek.

Lower Crooked River

Stuart et al. (1996) do not report black crappie in the Crooked River downstream of Bowman Dam. Black crappie in the Crooked River Arm of Lake Billy Chinook probably have escaped from private ponds located along the Crooked River downstream of Bowman Dam. The escapees drift downstream in the Crooked River into Lake Billy Chinook.

Lake Billy Chinook

Hiatt et al. (1997) captured one black crappie in a Merwin trap set in the Crooked River Arm of Lake Billy Chinook in 1997. Hiatt et al. (1997) do not provide any information on this fish. In 1998, Lewis (1999) captured 79 black crappie in Lake Billy Chinook — 30 in the Crooked River Arm, 16 in the Deschutes River Arm, and 33 in the Round Butte Dam Forebay. Lewis (1999) caught most of the black crappie in late June and July.

Stuart et al. (1996) report that black crappie are present, but rare in Lake Billy Chinook. Stuart et al. (1996) state that black crappie do not appear to affect other game fish in Lake Billy Chinook.

Lake Simtustus

Stuart et al. (1996) do not report black crappie in Lake Simtustus. Lewis (1999) did not capture black crappie in Lake Simtustus in 1998.

Lower Deschutes River

ODFW (1997) does not report black crappie in the Deschutes River downstream of the Pelton Round Butte Project.

Fisheries

Harvest of black crappie in Lake Billy Chinook is undoubtedly limited by their low numbers in this reservoir. The flesh of black crappie is highly edible, and in areas of the Unites States where black crappie are abundant, this species supports valuable sport and commercial fisheries (Chambers 1963).

Limiting Factors

Lake Billy Chinook has deep water with limited vegetation, and this type of habitat does not produce large numbers of black crappie. Also, cool water temperatures during the spring spawning period may limit natural production of black crappie in Lake Billy Chinook. Black crappie may spawn and reproduce in private ponds located adjacent to the Crooked River. Escapees from private ponds drift into Lake Billy Chinook, where they rear.

Ecological Role

Black crappie, because of low populations, play no significant role in the ecology of Lake Billy Chinook or Lake Simtustus.

BROWN BULLHEAD CATFISH

Ictalurus nebulosus

Other common names: Brown bullhead, northern brown bullhead, marbled bullhead, common bullhead, bullhead, brown catfish, common catfish, mudcat, hornport, horned pout, minister (Scott and Crossman 1973)

General

APPEARANCE

Brown bullhead catfish have bodies that are rounded in front and become laterally compressed behind the dorsal fins. The average length of mature brown bullhead catfish is approximately 8 to 14 inches. Their head is long, making up 22 to 26 percent of the total length. The snout of brown bullhead catfish is broad, rounded, and about 35 to 44 percent of the head length. The eyes of brown bullhead catfish are small, with the diameter of the eye 10 to 19 percent of the head length. Brown bullhead catfish have two pairs of nostrils that are widely separated, with one pair behind the other pair. Brown bullhead catfish have a wide mouth that is located at the end of the snout. The upper jaw of the mouth is longer than the lower jaw (Scott and Crossman 1973).

Brown bullhead catfish have four pairs of barbels. The longest barbels, located where the maxillaries are usually located in other fish species, reach to the base of the pectoral fin. There is one pair of flattened barbels located on the snout forward of the nostrils that protrude up and forward. There are two pair of barbels on the underside of the head that protrude down and backward. The inside pair is shorter than the outside pair of barbels (Scott and Crossman 1973).

Brown bullhead catfish have one dorsal fin, located forward of the middle of the body. The dorsal fin has one stout spine followed by six soft rays. The dorsal fin spine can be locked into an erect position, and the locked spine is slightly over half the height of the dorsal fin. The base of the dorsal fin is about 6 to 9 percent of the total body length, and the height of the dorsal fin is about twice the length of the base. The dorsal fin is rounded. Brown bullhead catfish have an adipose fin that is long (10 to 15 percent of the total length of the body), fleshy, and somewhat curved upward. The tail is nearly square with rounded tips and has 22 or 23 soft rays. The anal fin is long (17 to 21 percent of the total length), and the height of the anal fin is over half the length of the base length. The anal fin is rounded and has 18 to 21 soft rays, with the middle rays longer than the front and rear rays. The pelvic fins are broad, rounded, low on the body, have eight soft rays, and originate behind the dorsal fin. The pectoral fins are broad, rounded, and have one recurved spine with barbs and seven to nine soft rays. Brown bullhead catfish do not have scales, but the skin is supplied with strong taste glands (Scott and Crossman 1973).

The color of the head and back of brown bullhead catfish is either yellow-brown, olive, grey, or almost blue-black. Their sides are lighter colored than the head and back, and some individuals have mottled or vague brown blotches on their sides. The lower sides and belly of brown bullhead catfish are a dirty white to pale yellow color. The barbels are dark brown to nearly black, except for the chin barbels, which are sometimes pale yellow to white. Fins on brown bullhead catfish are a pale color compared to the color of their sides except that the rays in the fins are a darker color (Scott and Crossman 1973; Rasquin 1949).

DISTRIBUTION

Brown bullhead catfish were native to fresh waters of eastern and central North America. They have been introduced into many areas throughout North American, Europe and Russia. Brown bullhead catfish have been introduced into many areas in the Columbia River Basin (Scott and Crossman 1973), including the Deschutes River subbasin. While brown bullhead catfish are primarily found in fresh water, they are sometimes found in low salinity water (McKenzie 1959).

LIFE HISTORY

Sexual maturity of brown bullhead catfish occurs at age 3 for females, when they are 8 to 13 inches long. Male brown bullhead catfish mature at a slightly smaller size. Brown bullhead catfish spawn in the spring when water temperatures reach 70ºF. In some areas, spawning may occur as late as September. Brown bullhead catfish may spawn more than once in one year. Usually the male, but sometimes both sexes, builds a saucer-shaped nest by clearing an area slightly larger than its body length in mud or sand among the roots of aquatic vegetation. The nests are built in standing water that varies in depth from 6 inches to several feet (Scott and Crossman 1973).

Brown bullhead catfish usually spawn during the day. The male and female caress one another with their barbels while either circling about the nest or remaining quietly over it. After this action, they settle onto the nest, bodies in contact, but facing in opposite direction, and they begin spawning. The release of eggs by the female and milt by the male occurs several times, and the number of eggs released increases with each spawning. The eggs are small, pale cream color, and coated with an adhesive gelatin mucus. Females 8 to 13 inches long may have from 2,000 to 10,000 or more eggs (Scott and Crossman 1973).

Brown bullhead catfish guard, fan, and move the eggs during the incubation period, which may be 5 to 8 days. The eggs must be fanned because the gelatinous coat on the outside of the eggs prevents oxygen from reaching the egg. Fanning circulates the water, providing oxygen to the eggs. The eggs take 6 to 9 days to hatch at 69 to 74ºF water temperature. Newly hatched brown bullhead catfish are about 0.2 inches long, yellow, and somewhat transparent. The yolk sac is too large to enable sac fry to swim, so the sac fry lie on their sides in the nest until the sac is nearly gone. After about 7 days, the fry begin to swim and feed. The fry are herded in schools by the parents for several weeks until the fry are about 2 inches long. At this point, guarding by the parents and schooling of the fry stops and the individuals disperse (Scott and Crossman 1973).

Brown bullhead catfish reach lengths of about 2.5 to 4 inches at the end of their first year. They are about 6 inches long at age 2, 8 inches long at age 3, 9.5 inches long at age 4, and 10.5 inches long at age 5. Brown bullhead catfish 10 to 12 inches long weigh 8.3 to 13.0 ounces (Scott and Crossman 1973). Brown bullhead catfish reach a maximum size of about 29 inches long and 4 to 8 pounds (Carlander 1969; Trautman 1957). In some coldwater habitats, brown bullhead catfish become over-crowded and grow slowly (Scott and Crossman 1973). Brown bullhead catfish live to be about age 6 to 8.

HABITAT REQUIREMENTS

Brown bullhead catfish live on or near the bottom of shallow ponds or lakes or in large, slow-moving streams. They are usually found near abundant aquatic vegetation. Brown bullhead catfish are more tolerant than many fish species of high water temperatures, low oxygen, and pollution. They can live in water temperature as high as 97ºF and in water with dissolved oxygen levels as low as 0.2 ppm, and they can tolerate domestic and industrial pollution (Scott and Crossman 1973).

Brown bullhead catfish feed mainly at night near or on the bottom of lakes, reservoirs, or large streams. Their barbels are used to locate food including insects, leeches, crayfish, zooplankton, worms, algae, fish, and fish eggs (Scott and Crossman 1973).

INTER/INTRASPECIFIC INTERACTIONS

Brown bullhead catfish may compete with other fish that feed on food found near the bottom of ponds, lakes, or large, slow moving rivers. Brown bullhead catfish eat eggs of other fish including trout eggs (Martin 1957). Young brown bullhead catfish feed primarily on plankton, insect larvae and insects (Keast and Webb 1966; Raney and Webster 1940).

Young brown bullhead catfish are eaten by several different species of fish, but adult brown bullhead catfish may be protected by their spines. Predator fish have been observed with brown bullhead catfish spines protruding through their body. In some cases, a wound caused by the spine of brown bullhead catfish had healed but the scar was prominent (Scott and Crossman 1973).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not report brown bullhead catfish in the Metolius River. Water temperatures are probably too cold and stream flows too high for brown bullhead catfish production in the Metolius River subbasin.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Brown bullhead catfish are present in the Deschutes River upstream of Lake Billy Chinook (Fies et al. 1996b). Fies et al. (1996b) do not describe the distribution or population size of brown bullhead catfish in the Deschutes River upstream of Lake Billy Chinook. Numbers of brown bullhead catfish in the Deschutes River are probably limited by cool water and high stream velocities.

Lower Crooked River

Brown bullhead catfish were observed during a chemical treatment project of the Crooked River in the fall of 1963. The chemical treatment project in 1963 probably did not affect the abundance or distribution of brown bullhead catfish in the Crooked River. Stuart et al. (1996) note small numbers of brown bullhead catfish in the Crooked River downstream of Bowman Dam.

Lake Billy Chinook

Stuart et al. (1996) do not report brown bullhead catfish in Lake Billy Chinook. Hiatt et al. (1997) captured 1 brown bullhead catfish in the Crooked River Arm, 16 brown bullhead catfish in the Deschutes River Arm, and 0 brown bullhead catfish in the Metolius River Arm of Lake Billy Chinook using Merwin traps in 1997. Hiatt et al. (1997) do not describe brown bullhead catfish captured in Lake Billy Chinook. Hiatt et al. (1997) note the difference in numbers of brown bullhead catfish caught in the Deschutes River Arm compared to the other areas of Lake Billy Chinook.

Lewis (1999) captured 34 brown bullhead catfish in Lake Billy Chinook in 1998 — 5 in the Crooked River Arm, 28 in the Deschutes River Arm, and 1 in the Round Butte Dam forebay.

It may be that brown bullhead catfish rear in areas of the Deschutes River upstream of Lake Billy Chinook and drift into Lake Billy Chinook as young or adult fish. Cool and deep water probably limit natural production and rearing of brown bullhead catfish in Lake Billy Chinook.

Lake Simtustus

Stuart et al. (1996) do not describe brown bullhead catfish in Lake Simtustus. Cool and deep water probably restrict production and rearing of brown bullhead catfish in Lake Simtustus. Lewis (1999) did not catch brown bullhead catfish in Lake Simtustus in 1998.

Lower Deschutes River

ODFW (1997) reports that stunted populations of brown bullhead catfish are found in low elevation reservoirs and ponds in the lower Deschutes River subbasin. ODFW (1997) does not, however, report brown bullhead catfish in the mainstem Deschutes River downstream of the Pelton Round Butte Project. If brown bullhead catfish are present in the lower Deschutes River, their numbers are probably low.

FISHERIES

Brown bullhead catfish contribute very little to the fisheries in the Pelton Round Butte Project area. Minor fisheries for brown bullhead catfish may occur in private ponds adjacent to the Crooked River.

Limiting Factors

Cool and deep water probably limit the population of brown bullhead catfish in Lake Billy Chinook and Lake Simtustus. Cool water and water velocities probably limit brown bullhead in the Crooked, Metolius, and Deschutes rivers.

Ecological Role

Brown bullhead catfish, because of low numbers, play no significant role in the ecology of Lake Billy Chinook or Lake Simtustus.

TUI CHUB

Gila bicolor

Other common name: Roach (Stuart et al. 1996)

General

SCIENTIFIC NAME

Gila bicolor

Tui chub are found in a number of isolated subbasins within the Great Basin area of Nevada, California, and Oregon. Because of their isolation, a number of subspecies have been identified and the complex of tui chub is still under investigation. The Deschutes River Basin is one area where subspecies of tui chub are still under investigation (K. Kostow, ODFW, personal communication, March 1999).

APPEARANCE

The appearance of tui chub varies from drainage to drainage, and these different characteristics create considerable confusion and some disagreement as to their classification. Almost every isolated or partially isolated drainage system in California, Nevada, and Oregon has at least one distinctive form of tui chub (Sigler and Sigler 1987). Generally, tui chub have an elongated body that is slightly laterally compressed. They may reach 16 inches in length, but the average length is 9 to 11 inches. The body depth of tui chub is about 14 to 20% of the total length. The caudal peduncle is long and rather slender. The head of the tui chub is pointed. The eyes vary in size. The size of the mouth is moderate and located on the end of the snout. The corners of the mouth appear to slant down.

Tui chub have one dorsal fin that is no longer than the head and is located at slightly different locations on the body depending upon the origin and perhaps the sex of the fish (Hubbs 1942; McPhail and Lindsey 1970). The tail fin is moderately forked with rounded tips. The anal fin is located behind the rear of the dorsal fin and usually has eight or nine rays. The pelvic fins are well developed and originate slightly ahead of the origin of the dorsal fin. The pectoral fins are also well developed and broad. The scales are fairly small.

The color of tui chub varies from area to area. The backs of tui chub are usually deep olive color, while the sides are lighter and the belly is yellow to nearly white. The back and sides often have a brassy reflection (Sigler and Sigler 1987). Some scales are lighter than others and the light scales may appear almost pink. The fins are olive color but in some subspecies may be strongly tinted with red. Some specimens can be more green than olive, and some specimens may have a dark color on their sides, extending almost to the belly. Tui chubs in lakes have more pronounced coloration than tui chubs in streams (Sigler and Sigler 1987).

Young tui chub have a narrow dark stripe along the lateral line and the lateral line curves slightly down. Young tui chub have pointed heads and rather large eyes (Sigler and Sigler 1987).

DISTRIBUTION

Tui chub are found in isolated pockets in California, Nevada, and Oregon. Tui chub are native in the San Joaquin, Klamath, and Columbia river systems, although some populations in the Columbia River system may have been introduced (Sigler and Sigler 1987; Moyle 1976). Lee et al. (1980) depict native populations of tui chub in the Deschutes River Basin near the upper reaches of Lake Billy Chinook. Fies et al. (1996b) state that tui chub are the most abundant fish species in the Deschutes River Basin, and that they are found in the upper Deschutes and Little Deschutes rivers; Odell, Crescent, Davis, East, Paulina, Lava, Little Lava, and Cultus lakes; and in Crane Prairie and Wickiup reservoirs. Fies et al. (1996a) believe that tui chub were introduced into the Deschutes River Basin from the Klamath River Basin, probably by anglers using them as live bait for trout.

LIFE HISTORY

Female tui chub mature at age 2 or 3 at lengths of 8 to 10 inches. Males may mature as early as age 1, but most males mature at age 2 when they are 8 inches long.

Tui chub spawn in water temperatures ranging from 62 to 72ºF. Spawning may occur from as early as late April to as late as early August, but peak spawning occurs in June when water temperatures are approximately 60 to 65ºF. Males move to spawning areas before females. Males find spawning areas that are located in heavy vegetation where the water is shallow and quiet. The female arrives and is attended by several males. The female drops adhesive eggs over a wide area, and the eggs are then fertilized by the male. The number of eggs per female varies from 6,000 to 69,000, with an average of 23,000. Adult tui chub do not care for the eggs or young. The eggs hatch in about 1 week. After hatching, the young remain in the vicinity of the vegetation for most of the summer (Sigler and Sigler 1987).

Growth of tui chub varies site to site, but tui chub may average 5 inches long at age 1, 7 inches long at age 2, 9 inches long at age 3, and 11 inches long at age 4. Females grow faster than males and tend to live longer (Sigler and Kennedy 1978).

Tui chub may school in large numbers near the surface of lakes. Some of the schools may be larger than 100 yards across. Schooling occurs mostly during the spring and summer, and the tui chub tend to disperse during late fall. Young tui chub form schools and swim parallel to shore in shallow water, or they may congregate in heavy vegetation (Sigler and Sigler 1987).

HABITAT REQUIREMENTS

Tui chub are highly adaptable to habitats that range from small streams to large reservoirs and lakes. Tui chub feed on most invertebrates, including insect larvae and insects, and plants, including algae. Occasionally they feed on fish (Sigler and Kennedy 1978). During summer, tui chub may follow food vertically to depths of 200 feet in dissolved oxygen concentrations of less than 2 ppm (Sigler and Sigler 1987).

INTER/INTRASPECIFIC INTERACTIONS

The tui chub is an important prey species over most of its range. Tui chub have a high reproduction rate, but they grow slowly and are usually vulnerable to predation throughout their life. Tui chub have evolved with larger trout providing food for these larger species. They seldom become serious competitors or predators in native habitat (Sigler and Sigler 1987). However, in some locations, such as Diamond Lake in Oregon, where tui chub have been introduced, their reproductive rate exceeds predation and natural mortality rates. In these areas, tui chub can compete for food and space with game fish populations, reducing game fish to very low levels (Fies et al. 1996b).

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not report tui chub in the Metolius River or its tributaries.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) do not report tui chub in the Deschutes River from Lake Billy Chinook upstream to Steelhead Falls. However, Fies et al. (1996b) report that introduced populations of tui chub are very abundant and are serious competitors with game fish in Deschutes River Basin lakes and reservoirs such as Paulina Lake, East Lake, Crescent Lake, Crane Prairie Reservoir, and Wickiup Reservoir. Fies et al. (1996b) note that tui chub are not competitors with game fish in stream habitats of the upper Deschutes River Basin.

Lower Crooked River

Stuart et al. (1996) do not report tui chub in the Crooked River between Bowman Dam and Lake Billy Chinook. If tui chub are present in this reach of river, their numbers are low.

Lake Billy Chinook

Stuart et al. (1996) report that tui chub are present in Lake Billy Chinook, but that the population appears to decreasing. Stuart et al. (1996) do not describe fish sampling techniques or distribution of tui chub in Lake Billy Chinook.

Hiatt et al. (1997) captured one tui chub using Merwin traps in the Deschutes River Arm of Lake Billy Chinook in 1997. Hiatt et al. (1997) do not describe the date or location of capture of the tui chub caught in Lake Billy Chinook.

Lewis (1999) captured five tui chub using Merwin traps in Lake Billy Chinook in 1998. Four tui chub were captured in the Deschutes River Arm and one tui chub was captured in the Round Butte Dam forebay.

Lake Simtustus

Stuart et al. (1996) do not report tui chub in Lake Simtustus. Tui chub are probably present but in low numbers in Lake Simtustus.

Lower Deschutes River

ODFW (1997) does not report tui chub in the Deschutes River downstream of the Pelton Round Butte Project or in any of the ponds or reservoirs adjacent to the lower Deschutes River.

FISHERIES

Tui chub are used for bait by sport anglers to catch game fish. While tui chub are easy to catch on hook and line (Sigler and Sigler 1987), they are not used as a sport or commercial fish in the Pelton Round Butte Project area.

LIMITING FACTORS

Tui chub at all life stages are preyed upon by fish, birds, and mammals. In some cases, a dominant subspecies of tui chub may extirpate another subspecies (Sigler and Sigler 1987).

ECOLOGICAL ROLE

Stuart et al. (1996) note that tui chub play an insignificant role in the ecology of Lake Billy Chinook.

THREESPINE STICKLEBACK

Gasterosteus aculeatus

Other common names: Twospine stickleback, banstickle, spantickle, saw-finned stickleback, pinfish, tiddler, common stickleback, European stickleback, eastern stickleback, New York stickleback (Scott and Crossman 1973)

General

APPEARANCE

Threespine stickleback are a scaleless fish that have a rather wide mouth filled with small, sharp teeth and a head protected by hard bone. Threespine stickleback are laterally compressed, and the body tapers to a slender caudal peduncle. The body depth is 20 to 22 percent of the total length. The average length of threespine stickleback is about 2 inches. Their head is 24 to 26 percent of the total length and is pointed. The eye diameter is 25 percent of the head length. Teeth on the jaws are slender and sharp (Scott and Crossman 1973).

Threespine stickleback have three nonconnected, erect, stout, serrated dorsal spines, each with triangular membrane. The length of the longest spine is variable, but is usually 33 to 50 percent of the head length. The last spine is very short. Threespine stickleback also have a fourth soft dorsal fin with 11 to 13 rays located behind, but not attached to, the third hard spine. The tail fin is slightly forked with 12 rays. The anal fin has one spine and eight to ten soft rays. The spine in the anal fin is lightly serrated and free from the soft rays. Pelvic fins are situated on the ventral surface below the middle of the pectoral fins. The pelvic fins have one spine and one soft ray. The spine is slightly longer than the longest dorsal spine. Pectoral fins are large, with the length about half that of the head. Pectoral fins are situated a short distance behind the gill openings. All fin spines can be locked into an erect position (Scott and Crossman 1973).

The body of threespine stickleback does not have scales, but there are a variable number of vertical, oblong shaped, bony plates on each side. The number of bony plates on the sides is highly variable and is the distinguishing characteristic between marine and freshwater threespine stickleback. Some freshwater specimens do not have any bony plates on the sides. Marine specimens have bony plates along the sides to the caudal penduncle, while freshwater specimens have bony plates only immediately behind the head, if at all. Each specimen, whether freshwater or marine, has a single bony plate located on the belly between and behind the pelvic fins. The lateral line in threespine stickleback runs the full length of the body (Scott and Crossman 1973).

Adult threespine stickleback have variable color ranging from silvery green, grey, olive, greenish brown, or sometimes mottled with dark markings. Males are occasionally black. The sides in threespine stickleback are lighter with silvery reflection. The belly is silvery. The fins are pale in color, but the membranes are often red. During breeding season, ripe males become red on the belly and flanks, and have bright blue eyes, while females assume pink tints on the throat and belly. Newly hatchery larvae are yellowish. Young fish are silvery (Scott and Crossman 1973).

There is some question whether the marine and freshwater forms of threespine stickleback are subspecies or even separate species. As noted earlier, the marine form has more bony plates and is more sliver in color. The freshwater form has fewer bony plates and is more olive colored. Because there are so many taxonomic differences, Scott and Crossman (1973) suggest that the group be classified as Gasterosteus aculeatus complex.

DISTRIBUTION

Threespine stickleback are widely distributed in Europe, northern Asia, and North America in both salt and fresh water. In North America, it occurs from Chesapeake Bay north to the Hudson Bay region and Baffin Island. Threespine stickleback also occurs on the Pacific Coast from Alaska to as far south as southern California. The natural range of threespine stickleback in the Columbia River is upstream of the mouth of the Deschutes River (Scott and Crossman 1973). Threespine stickleback were first observed in the upper Deschutes River near the mouth of Spring River in 1981 or 1982. Its range has expanded to nearly all habitats in the Deschutes River (S. Marx, ODFW, personal communication, September 1998). Threespine stickleback are seen throughout the lower Deschutes River (C. Zimmerman, OSU, personal communication, September 1998). S. Marx believes the origin of threespine stickleback in the upper Deschutes River is from releases for mosquito control or from aquariums. ODFW does not have records approving the release of threespine stickleback into the Deschutes River.

LIFE HISTORY

All threespine stickleback spawn in fresh or very low salinity water between April and September (generally in June or July). They build a nest on sandy areas in shallow water (Fish 1932). The nest is constructed of small twigs and plants held together by the kidney secretion released by males. The nest is barrel shaped, hollow, and smooth, with circular openings in each end (Scott and Crossman 1973).

The male stickleback stakes out a territory then begins secreting large quantities of the gluelike substance from its kidney and uses it to paste together aquatic plants to prepare a nest. The male’s belly turns bright red, attracting females. The male performs a ritual courtship dance in the form of zig zags to lure the female to the nest, then pokes the female to induce egg laying. After the female has deposited the eggs, the male chases the female away. The male then loosens the top of the nest to provide better ventilation. As many as 600 eggs may be found in one nest. The eggs are yellowish and somewhat opaque in color. The eggs are small, but their size varies from one location to another (Vrat 1949). The eggs are laid in a cluster, sticking to each other. Hatching occurs in 7 days at 66.2ºF (Breder and Rosen 1966). The male protects the newly hatched stickleback from predators (Scott and Crossman 1973).

Growth of threespine stickleback is rapid during the first year, slower in the second year, and very slow in the third year. Threespine stickleback do not live much longer than 3½ years. At the end of the first summer, the size of an individual ranges from 0.5 to 1.3 inches, and at the end of the second summer, an individual may be 1 to 2 inches long. At the end of the third year, they range in length from 1.5 to slightly over 2 inches (Jones and Hynes 1950). Maximum size is about 3 inches, but some specimens may grow to 4 inches in length. Sexual maturity is attained during the first year. A threespine stickleback may spawn twice during its lifetime (Scott and Crossman 1973).

HABITAT REQUIREMENTS

Threespine stickleback are found in shallow waters. They are common in drainage areas of tidal marshes and along shoals of lakes. In Hudson Bay, stickleback live in tidal pools, creeks, estuaries, and shore waters, and in the ocean as far as 1 mile from shore (Cox 1922). Greenbank and Nelson (1958) observed threespine stickleback in the center of large lakes and even a few in deep water. S. Marx (Assistant District Biologist, ODFW, Bend) reports seeing threespine stickleback in backwater areas out of the main flow in the upper Deschutes River. In the lower Deschutes River, threespine stickleback have been observed in edge habitat with slow to stagnant water associated with vegetation (C. Zimmerman, OSU, personal communication, September 1998).

INTER/INTRASPECIFIC INTERACTIONS

The threespine stickleback is a voracious feeder, feeding on worms, small crustaceans, aquatic insects and larvae, fish eggs, and fry of fish, including their own species (Hynes 1950). They eat essentially all available animal food.

There is considerable evidence of competitive interactions between juvenile sockeye and threespine stickleback (Rogers 1973, 1986; Burgner et al. 1969; Jaenicke et al. 1987; Krogius and Krokhin 1948, 1956; McIntyre 1980). Threespine stickleback is the most abundant species associated with juvenile sockeye salmon in several Canadian waters (O'Neill and Hyatt 1987). Bull trout may benefit young sockeye by destroying competing stickleback (Savvaitova and Reshetnikov 1961). Hanamura (1966) noted that a high abundance of stickleback apparently reduced bull trout predation on sockeye but potentially increased competition for food between stickleback and sockeye.

Despite its sharp dorsal and pelvic spines, the threespine stickleback is preyed upon by a variety of creatures such as fish-eating birds, salmon, and trout. Chamberlain (1907) and Zorbidi (1977) report that coho feed on threespine stickleback.

Pelton Round Butte Project Area

POPULATION SIZE AND DISTRIBUTION

Metolius River Basin

Fies et al. (1996a) do not report the presence of threespine stickleback in the Metolius River.

Middle Deschutes River — Steelhead Falls to Lake Billy Chinook

Fies et al. (1996b) report the presence of threespine stickleback in the Deschutes River above Lake Billy Chinook. Fies et al. (1996b) note that threespine stickleback are present in an off-channel fishing pond at Shevlin Park. Water from the fishing pond flows directly from Tumalo Creek. Fies et al. (1996b) does not provide information on numbers of threespine stickleback in the Deschutes River directly above Lake Billy Chinook.

S. Marx (Assistant District Biologist, ODFW, Bend) reports the presence of threespine stickleback in the upper Deschutes River, its tributaries, and tributary reservoirs. The population size is unknown. However, S. Marx reports that threespine stickleback appear to have displaced trout fry in backwater, edge habitat.

Lower Crooked River

Stuart et al. (1996) do not report the presence of threespine stickleback in the lower Crooked River.

Lake Billy Chinook

E. Schulz (PGE, Madras, Oregon) reports collection of 85 threespine stickleback in 1997 and 54 threespine stickleback in 1998 in Lake Billy Chinook. These specimens, caught in traps from January through September, ranged from 1.5 to 1.7 inches in length, with the average size approximately 2 inches. Collection of threespine stickleback was secondary to collection efforts for other species, and these numbers do not represent population trends or estimates.

Lewis (1999) caught one threespine stickleback in the Round Butte Dam forebay in 1998. Reports by Schulz and Lewis (1999) confirm the presence of threespine stickleback in Lake Billy Chinook. The abundance of threespine stickleback is low in Lake Billy Chinook.

Lake Simtustus

D. Ratliff (PGE, Madras, Oregon) reports the presence of threespine stickleback in Lake Simtustus and in the Pelton Fish Ladder. The abundance of threespine stickleback in Lake Simtustus is unknown, but numbers are believed to be low.

Lower Deschutes River

J. Newton (ODFW, personal communication, September 1998) has not observed threespine stickleback in the lower Deschutes River. However, C. Zimmerman, (OSU, personal communication, September 1998) has observed threespine stickleback in reaches of the lower Deschutes River from Dizney Riffle at RM 99 to RM 10.4. Zimmerman has noted that threespine stickleback are rare, but can be found in edge habitat with slow to stagnant water around vegetation. The size of these fish ranges from 1.7 to 2.2 inches.

FISHERIES

Threespine stickleback are not a desired fish in fisheries, and it is doubtful that they are used as bait fish in the Deschutes River Basin.

LIMITING FACTOR

Since the introduction of threespine stickleback is relatively recent, populations of these fish might be expanding. The observation made by S. Marx (Assistant District Biologist, ODFW, Bend) that threespine stickleback are displacing trout fry in backwater habitat is cause for concern. Also, observations by scientists in Canada concerning interspecific interactions between sockeye, bull trout, and threespine stickleback are a major factor to consider during development of plans to reintroduce sockeye into the Metolius River and Lake Billy Chinook.

ECOLOGICAL ROLE

Considering the small size of threespine stickleback, they may have limited effectiveness as an upper level predator. Nevertheless, their role as a predator may be more significant than as prey. Predation and/or competition for suitable fry habitat by threespine stickleback could have the effect of reducing populations of more desired salmon and trout. Conversely, the Deschutes River may be on the fringe of suitable habitat for threespine stickleback, and populations of threespine stickleback may never become large.

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