CROOKED RIVER BASIN PLAN

OCHOCO FISH DISTRICT

May 1996

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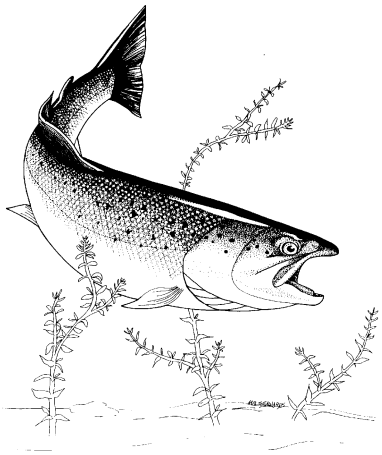

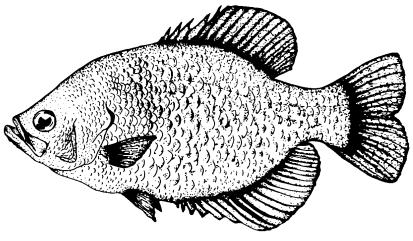

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CROOKED RIVER BASIN
FISH MANAGEMENT PLAN

Introduction

This basin plan covers the Crooked River and its tributaries. The plan consists of twelve sections. These include: this overview, a section on habitat, a section on restoration of anadromous fish, and 9 individual sections on the upper Crooked River and tributaries, the lower Crooked River and tributaries below Prineville Reservoir, Willow Creek, Prineville Reservoir, Ochoco Reservoir, Lake Billy Chinook, Lake Simtustus, Haystack Reservoir, and finally, Crooked River Basin small impoundments, which include Walton Lake, Allen Creek Reservoir, Antelope Flat Reservoir, and Reynolds Pond. Each water body management section is broken into subsections which include an overview, location and ownership, habitat and habitat limitations, access, fish resources, fish stocking history, angling regulations, fish management, management issues and concerns, and a brief description of management direction or alternatives specific to that water body. Following this background is the proposed management direction or a list of management alternatives. These management alternatives give a choice of how the water body might be managed in the future. Any water body section that has wild fish has Alternative 1 as the wild fish alternative. All water body sections have an alternative that describe the present management scenario.

Overview

The Crooked River is the eastern most major tributary to the Upper Deschutes River. Situated in Central Oregon the majority of the basin is located in Crook County with smaller portions in Jefferson, Wheeler, Grant, Deschutes and Harney counties. The total drainage area is approximately 4,300 square miles. Total length from headwaters on the North Fork Crooked River to the mouth at Lake Billy Chinook is approximately 155 miles (Figure 1). Average annual discharge is 1,131,000 acre feet. The highest point in the basin is Lookout Mountain (elevation 6,926 ft) located in the Ochoco Mountains. Elevation drops to 1,900 ft at Lake Billy Chinook where the Crooked River joins the Deschutes River.

The Crooked River flows east to west from headwaters in the North Fork, South Fork and Beaver Creek systems to Prineville Reservoir (RM 70) which was formed by Bowman Dam. The river flows out of the reservoir and joins the Deschutes River at Lake Billy Chinook which was formed by Round Butte Dam at RM 111 on the Deschutes River. Downstream of Prineville Reservoir are 2 major tributaries, Ochoco and McKay creeks that meet the Crooked River at RM 46 and 45, respectively. Another major impoundment in the basin is Ochoco Reservoir, impounded by Ochoco Dam at RM 10 on Ochoco Creek. Below Lake Billy Chinook, is Lake Simtustus, which was formed by Pelton Dam at RM 103 on the Deschutes River. One major tributary, Willow

Creek, flows into Lake Simtustus, and is included in the Crooked River Basin Fish Management Plan. Other smaller, public, reservoirs in the basin include Allen Creek Reservoir, Antelope Flat Reservoir, Walton Lake, Haystack Reservoir, and Reynolds Pond.

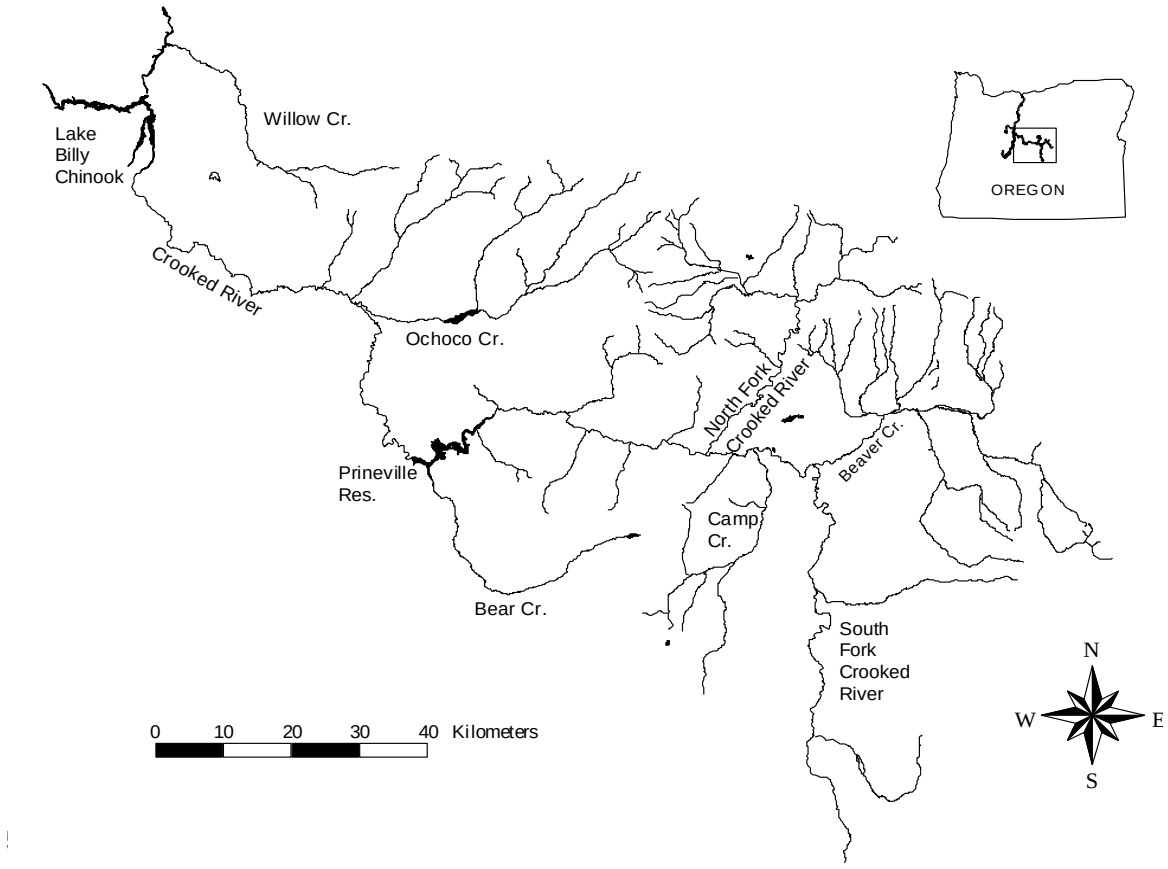

Figure 1. The Crooked River basin.

The climate in the basin is semiarid, characterized by hot dry summers and cold winters. Summer temperatures may exceed 100^{o} F and winter temperatures occasionally drop below -30^{o} F. Annual precipitation averages 10-12 inches per year at lower elevations, and up to 30-40 inches at higher elevations, most of which falls in the form of snow during winter. Occasional high intensity thunderstorms drop significant amounts of rainfall on local areas and may contribute to erosion. Low elevation terraces, flood plains and lower basin valleys are occupied by irrigated croplands. Transition uplands are primarily sagebrush *Artemisia* spp. and western juniper *Juniperus occidentalis*, while upland and high elevation communities are comprised of ponderosa pine *Pinus ponderosa,* lodgepole pine *P. contorta*, and mixed conifers, consisting of Douglas-fir *Pseudotsuga menziesii,* white fir *Abies concolor*, larch *Larix*

occidentalis, and small amounts of Engelmann spruce *Picea engelmannii*. Streamside vegetation communities with deciduous overstory consist of quaking aspen *Populus tremuloides*, mountain alder *Alnus incana*, black cottonwood *Populus trichocarpa*, or willow *Salix* spp.

Soils in the Crooked River basin are a mixture of series derived from the mid-Tertiary Columbia Plateau geology, the early Tertiary clayey tuffaceous sedimentary John Day and Clarno formations, and much older Cretaceous to Paleozoic marine sedimentary formations in the Suplee-Izee area (Silvernale et al. 1976). Some soil associations are on flood plains, terraces, low benches, and alluvial fans and are formed mainly of sediments deposited by streams (USDA 1966). Other soil associations occur on the basaltic plateau and consist of soils with hardpan, formed from pumiceous material, and are shallow and stony. Soils formed on forested highlands are derived from volcanic ash and soft tuffaceous rocks, and are very stony soils over basalt. Soils on uplands and buttes are derived from rhyolite rock and tuff, or basalt. Most of the north facing slopes and drainages are covered with Mount Mazama ash giving rise to higher productivity (Jim David, Ochoco National Forest Soil Scientist, personal communication). Soils in low elevation areas often have calcic horizons and a higher pH than mountain soils. Vegetative cover is 30-40% over much of this area. High intensity, short duration thunder storms have greater potential to erode in shrub steppe and juniper steppe areas. Soils at higher elevations in the Ochoco and Maury mountains are usually better vegetated but are susceptible to erosion during spring runoff when disturbed.

Historic game fish populations included anadromous spring chinook and summer steelhead, resident populations of redband trout and mountain whitefish throughout the basin, bull trout in the lower Crooked River, and sockeye salmon and Pacific lamprey in the Deschutes River. Due to the construction of numerous irrigation and hydroelectric dams, and habitat degradation caused by a combination of land and water management practices, anadromous fish runs have been lost. Bull trout also were extirpated from the basin with the exception of the Crooked River below Opal Springs and lakes Billy Chinook and Simtustus.

Indigenous and introduced species currently present in the Crooked River basin include a diversity of game and non-game species. Game fishes include redband, bull, brown and brook trout, kokanee, mountain whitefish, largemouth and smallmouth bass, bluegill, black crappie, brown bullhead, redear sunfish, crayfish, and bullfrog (Table 1). Nongame species include bridgelip and largescale sucker, northern squawfish, longnose and speckled dace, chiselmouth, redside shiner, and sculpin.

Table 1. Historical and current fish species in the waters described in the Crooked River basin plan.

Common Name	Scientific Name	Origin	Status	Abundance
Pacific Lamprey	*Entosphenus tridentatus*	Native	Extinct	
Summer steelhead	*Oncorhynchus mykiss*	Native	Extinct	
Redband Trout	*Oncorhynchus mykiss*	Native	Present	Moderate
Bull Trout	*Salvelinus confluentis*	Native	Present	Rare
Kokanee	*Oncorhynchus nerka*	Native	Present	Abundant
Chinook Salmon	*Oncorhynchus tshawytscha*	Native	Present	Extremely rare
Mountain Whitefish	*Prosopium williamsoni*	Native	Present	Abundant
Brown Trout	*Salmo trutta*	Introduced	Present	Locally abundant
Brook Trout	*Salvelinus fontinalis*	Introduced	Present	Rare
Rainbow Trout	*Oncorhynchus mykiss*	Introduced	Present	Abundant
Atlantic Salmon	*Salmo salar*	Introduced	Present	Very rare
Brown Bullhead	*Ictalurus nebulosus*	Introduced	Present	Abundant
Largemouth Bass	*Micropterus salmoides,*	Introduced	Present	Moderate
Smallmouth Bass	*Micropterus dolomieui*	Introduced	Present	Abundant
Black Crappie	*Pomixis nigromaculatus,*	Introduced	Present	Locally abundant
Bluegill	*Lepomis macrochirus,*	Introduced	Present	Rare
Redear Sunfish	*Lepomis microlophus*	Introduced	Present	Very Rare
Shorthead Sculpin	*Cottus confusus*	Native	Present	Unknown
Torrent Sculpin	*Cottus rhotheus*	Native	Present	Unknown
Slimy Sculpin	*Cottus cognatus*	Native	Present	Unknown
Mottled Sculpin	*Cottus bairdi*	Native	Present	Unknown
Prickly Sculpin	*Cottus asper*	Native	Present	Unknown
Goldfish	*Carassius auratus*	Introduced	Present	Rare
Longnose Dace	*Rhinichthys cataractae*	Native	Present	Abundant
Speckled Dace	*Rhinichthys osculus*	Native	Present	Abundant
Chiselmouth	*Acrocheilus alutaceus,*	Native	Present	Abundant
Largescale Sucker	*Catostomus macrocheilus,*	Native	Present	Abundant
Bridgelip Sucker	*Catostomus columbianus*	Native	Present	Very abundant
Northern Squawfish	*Ptychocheilus oregonensis*	Native	Present	Moderate
Carp	*Cyprinus carpio*	Introduced	Present	Rare
Redside Shiner	*Richardsonius balteatus*	Native	Present	Very rare
Crayfish	*Pacifastacus leniusculus*	Native	Present	Very abundant

Location and Ownership

The Crooked River is located along the southern edge of the Columbia Basin Plateau and at the northern margin of the High Desert. Portions of the North Fork, South Fork, and mainstem Crooked River carve canyons through the Central Oregon desert, although much of the drainage basin is characterized by rolling hills. The Ochoco Mountains are the major mountain range in the basin, and are a western extension of the Blue Mountains of eastern Oregon; a small mountain range to the south of the Ochoco Mountains is the Maury Mountains, and are entirely drained by tributaries of the Crooked River.

Land ownership is split about evenly between public and private interests. Public lands are administered primarily by the United States Forest Service Ochoco National Forest (USFS) and the Prineville District of the Bureau of Land Management (BLM).

Land use in the Crooked River watershed is approximately 73% range, with grazing as the primary use, 21% forest, and 4% irrigated agriculture (Oregon Water Resources Department (OWRD) 1978). The land around the Crooked River basin has been sparsely populated. The earliest Euroamericans to settle in the basin were ranchers who raised sheep and cattle, beginning in the 1860's (Juris 1975, Crook County Historical Society 1981). Many water rights date back to 1860 to 1920. Low elevation river valleys from Beaver Creek downstream to 50 miles below Prineville on the Crooked River are now devoted to intensive agriculture. Livestock production dominates with irrigated lands primarily used for growing hay and forage crops. Other irrigated crops in the lower Crooked River valley include mint, potatoes, wheat, and onions. Mining for cinnabar was productive until the early 1970's; small mines are still worked for thunder eggs, while some exploration continues for gold and silver. Logging and wood products first became viable products in the county in the 1890's. By 1920, much of the upland timber area came under logging, and continues as a major commodity in the basin. Logging supports a number of sawmills and 2 large molding plants.

Demographics

The city of Prineville is the principal community in the basin. It is located along the Crooked River and is also the county seat for Crook County. Prineville began as a community supported by the livestock grazing and timber harvest activities in the region. It is the oldest town in central Oregon and was incorporated in 1880. Prineville is a growing community with an economy based on timber, agriculture, manufacturing, and tourism. The 1991 labor force was approximately 7,500 with 23% in agriculture, 26% in wood products and manufacturing, 12% in government, and the remaining 39% in trade and services. Two other small communities in the county are Post and Paulina.

Deschutes, Jefferson, and Crook counties are projected for exceptionally large increases in the human population during the next 20 years, well ahead of the statewide average. Crook and Jefferson counties are “bedroom” communities for the Bend-Redmond area. Population growth in Crook and Jefferson Counties is expected to grow 22.3% and 33.7 %, respectively from 1990 to 2000, and 15.5% and 23.7% from 2000 to 2010, respectively (Portland State University 1993). Both Crook and Jefferson counties have populations approaching 15,000, but are expected to reach or exceed 20,000 by 2010. Both Prineville Reservoir State Park on Prineville Reservoir and Cove Palisades State Park on Lake Billy Chinook are ranked in the top 5 state parks for occupancy. Human population growth and increased use at these recreational impoundments has major implications for fish management options.

Access

Crook County's natural resources, including forests, range lands, lakes and streams, and wildlife contribute substantially to recreation and tourism in the region. A significant amount of the Crooked River basin is under public management and is managed by either the BLM or the USFS, including the Crooked River National Grasslands. The USFS Ochoco National Forest estimates an annual use of 350,000 recreation days (USDA 1989a). Most headwater streams of the North Fork Crooked River and Beaver Creek and many tributaries of the mainstem Crooked River begin on USFS lands while several miles of the North and South forks of the Crooked River and the mainstem Crooked River below Bowman Dam pass through BLM lands.

Portions of the North Fork Crooked River and the mainstem Crooked River below Bowman Dam were added to the federal Wild and Scenic Rivers System in 1988. The South Fork Crooked River has been designated for further study as a Wild and Scenic River from near its headwater to its confluence with the Crooked River. It is presently designated as a Wilderness Study Area.

Much of the mainstem Crooked River and lower portions of the major tributaries including the North and South forks and Beaver Creek are in private ownership and inaccessible to the public. Approximately 10 miles of the mainstem Crooked River below Bowman Dam and another 10 miles below Highway 97 are in public ownership, either as BLM lands or Crooked River National Grasslands.

Most of the large impoundments, including Lakes Billy Chinook and Simtustus, which are hydroelectric facilities, and Haystack Reservoir and Prineville Reservoir, built for irrigation storage, have a majority or all of the shoreline in public ownership. Ochoco Reservoir, a private irrigation impoundment, has some public access for boating and shoreline use at the state park. Small impoundments, including Walton Lake, Antelope Flat Reservoir, and Reynolds Pond, have public access around much if not all of the shoreline. Allen Creek Reservoir has only a small portion of the shoreline in BLM ownership which limits access.

Several enhancement projects have focused on improving angler access for shoreline or boating use. Barrier free angling sites have been installed at Lake Billy Chinook, Walton Lake, Haystack Reservoir, and Ochoco Creek to facilitate access for anglers in wheelchairs. Boat ramps have been extended at Prineville Reservoir, Lake Billy Chinook, and an Oregon Department of Fish and Wildlife (ODFW) Restoration and Enhancement project is in progress with the USFS to extend the boat ramp at Antelope Flat Reservoir. Ramps have been extended to provide continued boat access despite drawdown from irrigation, or in the case of Billy Chinook, low winter storage levels.

Fish Resources

Anadromous Fish (Historical)

Prior to construction of dams and water diversions, the Crooked River supported runs of spring chinook and summer steelhead (Nehlsen 1995). Other anadromous species such as sockeye salmon, coho, or Pacific lamprey may have been present but were not documented in any historical accounts. Ochoco and Bowman Dams, completed in 1921, and 1961, respectively, have no fish passage facilities and blocked anadromous fish runs into the Ochoco Creek and upper Crooked River basins. Round Butte Dam was completed on the Deschutes River just downstream of the confluence with the Crooked River in 1964. Fish passage facilities were constructed, but they were not effective and fish passage was terminated in 1968, eliminating spring chinook and summer steelhead from the lower Crooked River.

The historical spring chinook abundance and distribution are largely unknown. Ogden's journals in the 1820's recorded an Indian barrier for taking salmon below the confluence of the North and South forks of the Crooked River (Ogden 1950, Buckley 1992). Spring chinook were known to occur in the basin, possibly as late as the 1940's although they were much more severely impacted by habitat degradation (Frey 1942). Low summer and early fall flows and high temperatures likely contributed to the demise of spring chinook in the Crooked River due to their fall spawning life history. In addition, the Cove Power Plant on the lower Crooked River was a partial barrier to chinook salmon during summer and fall migrations during the early 1900's.

Summer steelhead were historically present throughout much of the Crooked River basin with the exception of the North Fork Crooked River above Upper and Lower Falls. Efforts to document steelhead spawning and distribution were not conducted until the 1950's when plans were well underway for construction of Bowman, Pelton, and Round Butte Dams. Unfortunately, turbid stream conditions, poor access, and a lack of survey effort made observations difficult, sporadic, and frequently unsuccessful. Summer steelhead were documented in Beaver, Twelvemile, Drake, Newsome, Horseheaven, Ochoco and McKay creeks, and in the lower North Fork Crooked River (OSGC 1950-1973). Observations recorded that much of the middle portion of the basin on private lands, where irrigation dams made passage difficult and irrigation withdrawals contributed to extreme low flows and high summer temperatures, made steelhead production unsuitable.

Pacific lamprey probably occurred in the Crooked and Deschutes rivers above the Round Butte-Pelton project. Very little is known about the life history of Pacific lamprey in the Deschutes River basin. These fish were and still are an important food fish for native Americans of the Confederated Tribes of the Warm Springs (CTWS). Lamprey are largely caught as adults at Sherars Falls on the lower Deschutes River in August as they are migrating upstream to tributaries for spawning (Mark Fritsch, CTWS tribal biologist, personal communication). Pacific lamprey also are captured in downstream migrant traps as juveniles and adults in both the Shitike and Warm Springs

rivers, and ammocoetes have been captured while electroshocking. Spawning for lamprey occurs in spring or early summer and adults usually die shortly after spawning. Eggs hatch in 2-3 weeks as ammocoetes. and then spend up to 5-7 years burrowed in the mud as filter feeders. Following transformation, they migrate to the sea and attain a maximum length of up to 30 inches, parasitizing other fish species and marine vertebrates.

Redband Trout

One major fish species of interest, indigenous to the Crooked River basin, is the redband trout. Redband trout are a subspecies of rainbow trout adapted to the arid conditions east of the Cascade Mountains. They are known for their tolerance of high water temperatures. Redband trout are present throughout the basin, except in Haystack Reservoir, Reynolds Pond, Walton Lake and possibly Antelope Flat Reservoir. Historically there were 2 contiguous populations in the basin, separated by a geologic barrier in the North Fork Crooked River. Today there are numerous separate smaller populations, fragmented and isolated by artificial barriers such as reservoir impoundments, irrigation diversion systems, and road culverts. Generally, redband trout populations are thought to be in a depressed status and possibly declining throughout the basin. Redband trout have been listed as a state sensitive species and as a Category 2 sensitive species by the USFS.

Redband trout spawn in rivers and streams during the spring. Eggs are deposited in a nest made in the gravel (redd), and then covered with gravel. Cool, clean, well oxygenated water is necessary for the eggs to survive. Redband trout fry emerge in June and July. For the most part, they live near where they were spawned. Redband trout in most district streams reach about 3 inches at age 1, 4.5 inches at age 2, and 5-6 inches at age three. Very few redband trout exceed 10 inches. Redband trout in the Crooked River below Bowman Dam have considerably faster growth rates. Age at maturity is speculated to be 3 years old, or approximately 5-6 inches. Maturing redband trout migrate up their respective spawning tributary, probably during March, April, or May. Their biology is discussed in detail in that section of the plan.

Bull Trout

Bull trout were historically found and caught by anglers in the lower Crooked River. While there is no historic documentation of bull trout spawning in the basin, bull trout used the lower Crooked River for juvenile rearing and adult holding areas (Frey 1942). Bull trout were caught as recently as the early 1980's up to the city of Prineville (Walt Carter 1992, personal communication). Today, bull trout in the Crooked River basin are confined to Lake Billy Chinook and in the lower Crooked River up to Opal Springs facility, an impassable hydroelectric barrier since 1982. Bull trout are also found in Lake Simtustus and likely pass downstream through the Round Butte dam hydroelectric facility at a small size and rear in the reservoir. Bull trout occur in the

Deschutes River below Pelton reregulation dam and above Lake Billy Chinook up to Big Falls, and in Squaw Creek. All known bull trout spawning occurs in the Metolius River basin. Bull trout are listed as a state sensitive species, and were petitioned as a threatened species to the U.S. Fish & Wildlife Service (USFWS). A recent ruling by the USFWS indicated that bull trout were warranted but precluded for being listed as a threatened species. They were precluded from being listed due to the greater threat of extinction of other species . Lake Billy Chinook, a small portion of the Deschutes River above Billy Chinook, and Lake Simtustus are the only remaining water bodies in Oregon where bull trout are legally harvested.

Bull trout spawn in Metolius River tributaries in the fall (Ratliff et al., in press a; Riehle et al., in press). Like most trout and salmon, they deposit eggs in a redd. Juveniles rear in the small tributary streams for two years and then migrate in the spring to Lake Billy Chinook to rear. After three years in the lake, at age 5 and about 22 inches, they migrate back to their natal tributary to spawn. Bull trout are very piscivorous, eating mostly kokanee. Their life history and biology is discussed in detail in the Lake Billy Chinook section of this plan.

Kokanee

Kokanee are actually landlocked sockeye salmon. Lakes Billy Chinook has the only naturally reproducing kokanee population in this basin. They are also present in Lake Simtustus and Haystack Reservoir where they cannot reproduce. Young kokanee generally emerge from the gravel in late winter and immediately begin their downstream migration to Lake Billy Chinook. Growth of kokanee is quite variable between years and water bodies. In some years, spawners in Lake Billy Chinook average 12 inches or more in length, while in other years the average is much less. Spawning generally takes place during August and September. Most kokanee in Lake Billy Chinook spawn at age 4. As with all Pacific salmon, kokanee die after spawning. Eggs generally hatch in mid-winter.

Mountain Whitefish

Mountain whitefish are members of the Salmonidae family and are closely related to salmon and trout. They are found in the Crooked River below Bowman Dam, Ochoco Creek, Lake Billy Chinook, Lake Simtustus and occasionally in Haystack Reservoir. Whitefish spawn over gravel in the late fall or early winter. No nest is prepared. Juveniles hatch in about March. Whitefish growth rates are similar to those for rainbow trout. Whitefish mature at age 3 or 4. They generally inhabit large rivers or lakes. Mountain whitefish are primarily bottom feeders consuming mostly aquatic insects. As such, they are direct competitors with rainbow trout.

Chinook Salmon

A remnant population of spring chinook salmon is believed to exist in Lake Billy Chinook. Spring chinook salmon were historically present in: the Deschutes River up to Steelhead Falls, in Squaw Creek, and in the Metolius River. Landlocked chinook salmon in Lake Billy Chinook would follow a similar life history pattern as other spring chinook in the Deschutes River (Newton 1973), except they would use the lake for rearing instead of the ocean. Adults spawn in gravel areas of streams or rivers during August and September. Eggs remain in the gravel until late winter when they hatch. Juvenile chinook salmon remain in the streams for approximately 3 months until they begin their seaward migration, or in this case, their migration down to Lake Billy Chinook. Spring chinook salmon reside in the ocean for 2, 3 or 4 years before returning to their natal stream. Upstream migration usually commences in April and May, with adults remaining in large, deep pools until they spawn in August or September.

Brown Trout

Introduced brown trout are present: in the Crooked River below Opal Springs, Haystack Reservoir, Lake Billy Chinook and Lake Simtustus. Brown trout spawn in rivers and streams during the fall. Eggs are deposited in a redd and fry emerge in late winter or early spring. Brown trout reach about 6 inches at age 1, 10 inches at age 2, and 15 inches at age three. Age at maturity is speculated to be 3 years old. Brown trout are very piscivorous and can grow quite large. Brown trout up to ten pounds are caught regularly in Central Oregon.

Brook Trout

Introduced brook trout are present in Allen, Lookout, and Brush creeks, tributaries of the upper North Fork Crooked River above Big Summit Prairie, and Walton Lake. The west fork of Howard Creek also supported brook trout as recently as 1979 but were not observed in surveys in 1992 and 1994. These fish are the naturalized progeny of hatchery fish originally stocked in the 1920's and 1930's.

Brook trout spawn in October or November and redds are typically built in headwater reaches with good flows and temperatures colder than 50^0F. Eggs hatch in approximately 3 months, and juveniles emerge in the spring. Sexual maturity is reached at 2 or 3 years of age. Length frequency distributions of fish sampled in August in Lookout and Brush creeks suggest that young of the year are 0-2 inches, age 1+ are 2-3 inches, age 2+ are 4-6 inches, and the largest fish reach approximately 9 inches. Brook trout are carnivorous and eat a wide variety of organisms including aquatic and terrestrial insects, crustaceans, spiders, molluscs, amphibians and other fish.

Smallmouth Bass

Introduced smallmouth bass are present in Prineville Reservoir, the upper Crooked River and some tributaries, and Lake Billy Chinook. Occasionally they are observed in the lower Crooked River. They spawn on gravel and sandy beaches when the water temperature approaches 65^{o}F. Smallmouth bass have been observed on spawning nests in June. Most spawning appears to be associated with shallow littoral areas (<10 feet) which have pea size gravel. Juvenile smallmouth bass remain near the nest for 5-7 days with the male guarding the young and the nest. After spawning, adult smallmouth bass retreat to deeper water. Juvenile smallmouth bass remain in the protection afforded by boulders, cobble, and talus slopes. Juvenile smallmouth bass eat plankton, immature aquatic insects and crayfish. Adults eat mostly crayfish and fish.

Largemouth Bass

Introduced largemouth bass are present in Prineville Reservoir and Haystack Reservoir. Occasionally they are observed in the upper Crooked River and Lake Billy Chinook. Largemouth bass spawn on sand and mud beaches when the water temperature approaches 62^{o}F. Most spawning is associated with shallow littoral areas (<10 feet) which have aquatic vegetation. Juvenile largemouth bass remain near the nest for 5-7 days with the male guarding the young and the nest. Adult largemouth bass generally inhabit water less than 20 feet deep. They remain in the protection afforded by aquatic vegetation and woody debris. Juvenile largemouth bass eat plankton, immature aquatic insects and crayfish. Adults eat mostly fish and crayfish.

Black Crappie

Introduced black crappie are present in Prineville Reservoir (illegal introduction) and Haystack Reservoir. Occasionally they are observed in Lake Billy Chinook and they probably occur in the upper Crooked River. Black crappie spawn in the spring on sand and mud beaches when the water temperature approaches 66^{o}F. Most spawning occurs in less than 2 feet of water. Juvenile black crappie remain near the nest for a few days with the male guarding the young and the nest. Growth varies tremendously with the size of population and with the productivity of the water. Black crappie are subject to wide fluctuations in abundance and often stunt. Adult black crappie generally inhabit shallow water with aquatic vegetation. Small crappie eat zooplankton and aquatic insect larvae. As such they are direct competitors with trout and juvenile bass. Large black crappie also consume juvenile fish.

Brown Bullhead

Introduced brown bullhead, or “catfish” as they are commonly called, are present in the upper Crooked River, the South Fork Crooked River, the North Fork Crooked

River, Prineville Reservoir, the lower Crooked River, Ochoco Reservoir, Walton Lake (illegal introduction) and Haystack Reservoir. Brown bullhead spawn in the spring when the water temperature reaches 70^{o}F. They spawn in mud or sand in depths from 6 inches to several feet. The eggs are cared for by one or both parents and hatch in 6-9 days. Growth is slow; they may only reach 10 inches at age 5. Sexual maturity is reached at age 3. Brown bullhead feed on or near the bottom, mainly at night. Adults are truly omnivorous eating offal, waste, molluscs, immature insects, leeches, crustaceans, worms, plants, algae, fishes and fish eggs. Juveniles feed primarily on chironomid larvae, cladocerans, ostracods, amphipods, bugs and mayflies. Juvenile brown bullhead are eaten by many fish species.

Other game fish

Redear sunfish and bluegill are rare in the basin. Because they are rare in the basin and do not appear to effect other game fishes, they will not be discussed in detail in this section.

Nongame fish

Many species of nongame fish are present in the basin. Most of the following life history information regarding non-game fish is from Scott and Crossman (1973) and Wydoski and Whitney (1979).

Sculpin species

Sculpins are widely distributed throughout the upper basin and Lake Billy Chinook. They mostly inhabit small streams. Sculpins spawn in spring. They prefer streams having a boulder, cobble, and flat rock bottom. Sculpins grow to a maximum length of only 6-7 inches. They feed primarily on aquatic insect larvae. They are often eaten by other fish.

Bridgelip sucker

Bridgelip sucker are present in the upper and lower basin, Prineville Reservoir, Haystack Reservoir, Lake Billy Chinook, and Lake Simtustus. Scott and Crossman (1973) report that virtually nothing is known about the biology of bridgelip sucker. It probably spawns in late spring. Sexual maturity is reached when individuals are about 5 inches in length. Eggs are probably broadcast during spawning as in other suckers. Maximum adult size is about 17 inches. Electroshocking data collected from Lake Billy Chinook in 1992 suggests that bridgelip suckers reach the following total lengths (inches) at the end of each year of life: age 1, 3.5; age 2, 4.9; age 3, 7.1, age 4, 8.2. The habitat of the species is usually colder water of small, swift rivers with gravel to

rocky bottoms, but it is also found in rivers where current is more moderate and the bottom of sand and mud. Populations in many central Oregon lakes and reservoirs suggest that it adapts well to lake environments. Its food is probably obtained by scraping algae from rocks. As such, it may not compete directly with trout. Its food would include invertebrates taken while feeding on the bottom. This species occurs in an area where large predaceous fishes are not abundant.

Largescale Sucker

Although they are often less abundant than bridgelip suckers, largescale suckers may play a more important role in trout management because of competition for food and their greater biomass than bridgelip suckers. Interestingly, largescale suckers have been reported to hybridize with bridgelip suckers.

Largescale suckers are present in the upper and lower Crooked River, Prineville Reservoir, Haystack Reservoir, Lake Billy Chinook, and Lake Simtustus. Largescale suckers generally mature at 8-12 inches. Largescale suckers spawn in the spring, usually in deeper sandy areas of streams, but at times on gravel or sand shoals in lakes. Spawning takes place from late April to late June depending on stream temperatures. They enter spawning streams when the water temperature is 46-48^{o}F. A female may deposit as many as 20,000 eggs, which are adhesive, demersal, yellow, and average 2.5 mm in diameter. Eggs hatch in about 2 weeks. Fry remain in the gravel or on the surface of the sand for the first few weeks until the yolk is absorbed. The young are pelagic until they are about 0.75 inches in length. As they grow larger, they move toward the bottom and into deeper water. Growth is generally slow. A 12 inch largescale sucker may be 8 or more years old. Maximum size is about 24 inches and 7 pounds. Adults are usually found at depths of only a few feet but have been taken as deep as 80 feet. They often congregate in large numbers in weedy shore areas of lakes, in backwaters, and in stream mouths. Fry move inshore into very shallow water to feed in daylight hours and off into deeper water at night.

Food composition varies with size of individual, time and habitat but in adults is almost exclusively bottom invertebrates such as ostracods, amphipods, Trichoptera, Chironomidae, and molluscs. However, fish eggs, diatoms, algae, and detritus have also been reported. Largescale suckers compete directly with trout species, and probably also prey upon their eggs.

Chiselmouth

Chiselmouth are present in the upper and lower basin, Prineville Reservoir, Haystack Reservoir, Lake Billy Chinook, and Lake Simtustus. They are found throughout the reservoir. Chiselmouth are reported to migrate into streams to spawn. Spawning occurs when water temperatures exceed 62.5^{o}F. Food items include diatoms, surface insects and vegetable matter. Chiselmouth appear to have a

maximum length of about 12 inches. Chiselmouth may be an important food source for piscivorous fish such as brown trout, bull trout, largemouth bass, smallmouth bass and northern squawfish.

Squawfish

Squawfish are present in the upper and lower Crooked River, Prineville Reservoir, Haystack Reservoir, Lake Billy Chinook, and Lake Simtustus. Squawfish spawn from late May to July. Because of its high abundance and its role as a piscivore, the northern squawfish is potentially a major influence on game fish populations. Spawning takes place in gravel shallows, sometimes along a lake shore, sometimes in lakes near a tributary stream, and sometimes a short distance upstream. Lake dwelling forms may spawn in streams only when suitable gravel shallows in lakes are not available. The spawning fish tend to gather in large numbers, but no nest is built. A female may be accompanied by a few to many males, the small eggs and sperm are released close to the bottom. The eggs are adhesive, demersal, and settle in the gavel. Eggs hatch in about 1 week. Sexual maturity is attained in about 6 years when the squawfish are about 12 inches long. A maximum weight of 29 pounds and a length of 25 inches have been reported.

The northern squawfish is typically a lake species, preferring still waters to swift streams. The young inhabit inshore waters in summer months, moving offshore into deeper waters in the fall; the larger fish tend to remain offshore. Squawfish consume shiners, sticklebacks, terrestrial insects, plankton, aquatic insects, and crustaceans while inshore. During fall and winter, squawfish move offshore into deeper water where fish become the major food item. Young squawfish, 1-4 inches, feed heavily on insects but as they grow larger, fish become increasingly important, and very large squawfish feed almost exclusively on other fishes and, sometimes, crayfishes.

Other Nongame Fishes

Other non-game fishes are not very abundant and do not appear to be major influences on the biology and management of game fishes. Tui chub, goldfish and carp are present in the basin in extremely low numbers.

Crayfish

Crayfish are present in most reservoirs and lakes in the basin. They inhabit benthic environments down to 60+ feet. Mating occurs in the summer or fall. Females may spawn twice or more during their life. Females extrude 100 to 300 eggs shortly after mating. Eggs are carried through the winter and hatch in late spring. Young remain with the female for several weeks, molting twice Sexual maturity occurs at 18-30 months and about 2.5 inches. Some crayfish with good growth rates may mate

during their first fall. Juveniles favor shallow weedy areas where they can find protection from predators, and large adults favor deeper areas.

Fish Stocking History

Historic hatchery stocking programs in the Crooked River basin were relatively small compared to other hatchery programs around the state. Small numbers of fingerling rainbow and brook trout were stocked in USFS streams in the late 1920's and early 1930's, while Ochoco Reservoir was stocked regularly once completed in 1918.

With concerns for meeting the Trout and Warmwater Fish Plans, adopted by the Oregon Fish and Wildlife Commission in 1987(ODFWa, ODFWb), and the Wild Fish Policy,(ODFW 1990), all existing hatchery programs are being reviewed for compliance. Many programs are being critically reviewed for potential genetic and disease impacts on indigenous stocks of native fish. Deep Creek and Marks Creek stocking with hatchery rainbow was recently discontinued due to wild fish genetic concerns.

Present day hatchery stocking programs in the basin occur primarily in standing water impoundments, with very few programs in moving waters (Table 2). One exception is the South Fork Crooked River, where major chemical rehabilitation

Table 2. Water bodies in the Crooked River Basin that are stocked annually with hatchery fish. Fingerling fish are 2-4 inches long, while catchable size fish are 6-10 inches long.

Water Body	Species	Size	Number
South Fork Crooked River	Rainbow Trout	Fingerling	15,000
Antelope Flat Reservoir	Rainbow Trout	Fingerling	10,000
Prineville Reservoir	Rainbow Trout	Fingerling	169,000
Walton Lake	Rainbow Trout	Catchable	15,000
Ochoco Reservoir	Rainbow Trout	Fingerling	50,000
Ochoco Creek	Rainbow Trout	Catchable	3,000
Haystack Reservoir	Rainbow Trout	Catchable	5,000
	Kokanee	Fingerling	35,000
	Brown Trout	Catchable	1,000
Lake Simtustus	Brown Trout	Catchable	20,000
	Kokanee	Fingerling	40,000
	Rainbow Trout	Catchable	5,000

programs in the 1970's and 1981 are thought to have eliminated all indigenous redband trout. It receives a small number of Deschutes rainbow fingerling. Spawning habitat is very limited in much of the South Fork Crooked River due to heavy sediment accumulation and a very low quantity of spawning gravel. A small number of legal rainbow trout are stocked in Ochoco Creek through the city of Prineville, primarily used

by juvenile, young adult, and senior citizen residents of Prineville. The last exception is the lower Crooked River below Opal Springs, which is a mitigation site for the Deschutes Valley Water District hydroelectric dam which eliminated resident fish passage. Both legal rainbow trout and a small number of legal brown trout are released, many of which have been found during angler surveys and in spring inventory work, in Lake Billy Chinook.

The Crooked River below Bowman Dam has been managed as a "wild plus hatchery rainbow trout" stream because of the large number of rainbow trout that escape from Prineville Reservoir from the unscreened outlet. Research conducted during the late 1960's and early 1970's indicated that of the angler caught fish from the Crooked River a range of 6 to 50%, with an average of 26%, were hatchery fish. Most emigration from the reservoir appears to occur when the reservoir is drawn down to low levels such as occurred in 1991 and 1992, or during spilling events from a high water year. A three year study was undertaken in 1993 to determine the number of hatchery rainbow trout from Prineville Reservoir that migrate into the Crooked River below Bowman Dam. Preliminary results are indicating that the percent of hatchery fish to be lower than the late 1960's data.

Most standing water bodies in the basin, with the exception of Lake Billy Chinook, Reynolds Pond, and Allen Creek Reservoir, receive an annual stocking of fingerling or legal rainbow trout. Size of fish at release and rate and frequency of stocking vary with size of the water body, intensity of public use, other species present, anticipated drawdown, and available natural production. Other water bodies, including Haystack Reservoir and Lake Simtustus also have a legal brown trout and fingerling kokanee stocking program. Rainbow trout stocked in Simtustus and Haystack are the Deschutes rainbow (66) stock which is resistant to *Ceratomyxa shasta*, a myxosporan parasite lethal to nonresistant stocks. Remaining standing water bodies are stocked with either Cape Cod (72) or Oak Springs (53) domestic stocks of rainbow trout.

Numerous private ponds and reservoirs throughout the Crooked River basin are stocked with a mixture of coldwater and warmwater species, some on an annual basis, some sporadically as requested by the landowner. Each transport permit request is individually reviewed and approved, conditioned, or denied depending on species requested, extent and nature of water facilities, and access of fish to escaping into public water bodies.

Angling Regulations

Angling regulations within the Crooked River basin are generally consistent with statewide regulations, with most streams open to angling between April and November. The two exceptions are: 1) the Crooked River from Bowman Dam to Lake Billy Chinook, where a winter rainbow trout and mountain whitefish fishery has developed with catch and release only regulations, using barbless flies and lures, and 2) the South Fork Crooked River, which has a reduced daily bag limit of 2 trout with artificial flies and lures

only. Most standing water impoundments have regulations which are consistent with the statewide regulations of a 10 trout and 5 bass daily bag limit open year round. Exceptions include (1) Walton Lake, which is consistent with nearby stream regulations for trout; (2) Prineville Reservoir where special bass regulations are in place, including a slot limit for smallmouth bass and a minimum size limit for largemouth bass; and (3) Lake Billy Chinook, which includes both a liberal 25 fish bag limit for kokanee to encourage harvest, and a restricted one fish daily bag limit for bull trout.

Fish Management

Contrary to many fish districts in the state, the Ochoco District is relatively new. The Deschutes District had management responsibility for the various water bodies in the District until 1962. Ochoco Reservoir was the only water body to receive much management until 1951. Fish management at Ochoco Reservoir was centered around eradicating non game fish with rotenone, and stocking hatchery rainbow trout. Intensive fish surveys of the Crooked River Basin did not begin until 1951. Most of the surveys were centered around identifying anadromous fish abundance and distribution in order to evaluate the effects of the proposed Pelton, Round Butte and Bowman dams. Very little effort was expended to study resident fish such as redband trout and bull trout. From 1958 to 1962, intensive efforts were expended documenting runs of anadromous fish over Pelton Dam.

The Ochoco District was formed in 1963, after completion of Bowman Dam, Pelton Dam and the nearly completed Round Butte Dam. Again, major efforts were undertaken to document anadromous fish runs over Round Butte and Pelton dams, and efforts centered maintaining those runs as evidence mounted that the passage facilities were inadequate. A series of studies were also initiated to determine the impacts of nongame fish, the limnology and the best species and strains of trout to stock in Prineville and Ochoco reservoirs and Lake Billy Chinook. Eventually, Lake Simtustus and the Crooked River below Bowman Dam (the Chimney Rock segment) were added to those studies. Studies continued through 1980 and provided much of the knowledge base for the management discussions for the individual sections of this plan.

Chemical treatment to control populations of “undesirable” fish was a widely used management technique and applied in many areas of the Crooked River basin during this 1960’s and 1970’s. Approximately, 90 miles of the Crooked River above Prineville Reservoir were treated with rotenone just prior to completion of Bowman Dam in 1961. The Crooked River was also treated in 1963 from the Rice-Baldwin Dam downstream approximately 32 miles to Smith Rock State Park for nongame fish species including squawfish, suckers, and chiselmouth. The Ochoco Creek system was treated in 1973 including tributaries of Ochoco and Mill Creeks for bridgelip suckers. Virtually, the entire South Fork Crooked River system was treated in 1981 from its headwaters to the mouth.

Standing water bodies in the Crooked River basin were also treated with chemicals for undesirable fish species. Smaller water bodies or reservoirs have usually been treated at extremely low pool due to the high cost of chemicals and implementation. From the 1950's to as recently as 1988, frequent chemical treatments of Ochoco Reservoir during low pool were conducted to reduce and/or eliminate bridgelip sucker populations. Antelope Flat Reservoir was also treated in 1988 and to date, no bridgelip suckers have appeared in any angling or net surveys. In the 1970's, Lake Simtustus was frequently spot treated with Fintrol to control abundant squawfish.

From 1980 to 1988, considerable effort was expended on habitat restoration in the upper Trout Creek watershed. Although not part of this plan, the upper portion of Trout Creek is administered by the Ochoco District. A formidable restoration project was eventually completed to enhance summer steelhead habitat in Trout Creek.

Fish management during the past seven years has focused primarily on habitat protection, Wild Fish Policy implementation, and documenting life history, abundance and distribution of native salmonids. In order to better delineate redband trout gene pools and population characteristics, genetic information is being collected and analyzed. This information is necessary to comply with the Wild Fish Policy (Table 3). Preliminary results indicate that Crooked River redband trout belong to the inland rainbow "redband" trout evolutionary line. However, the occurrence of an unusual allele frequency indicates that they have diverged from other inland rainbow groups (Currens 1994). While overall data for Crooked River redband trout did not show strong evidence of hatchery introgression, populations from below Bowman Dam on the Crooked River, Marks Creek, Ochoco Creek, and McKay Creek showed the greatest effects of hatchery introgression. Samples from tributaries of the North Fork Crooked River including Fox Canyon, Howard, and Lookout creeks comprised a distinct group.

Considerable effort has been expended studying populations of native salmonids, especially redband trout and bull trout. Efforts have been undertaken to complete distribution surveys for redband trout throughout the basin. Bull trout studies have taken enormous time commitments from the District in order to retain the fishery there. Creel surveys, net sampling, and a radio telemetry study have all been conducted at Lake Billy Chinook recently.

Habitat protection has involved commenting on various land use practices and following up on violations of state laws protecting aquatic ecosystems. In addition, instream flows were filed with the OWRD for 35 reaches of 28 streams in May of 1990, where flow measurement and biological data had been collected in the late 1960's and early 1970's with the Oregon Method. The Oregon Method analyzed flows required for critical life history stages of spawning, passage, and incubation. This developed a criteria for depth and velocity. Streams filed include the mainstem, North Fork, South Fork, Beaver Creek, and numerous tributaries (Table 4). To date, none of these requested flows have been certified, pending the large number of applications made throughout the state of Oregon. Because of the large number of out-of-stream appropriations, that often exceed existing streamflows, most impending instream water

rights are unlikely to be fulfilled due to their junior status. All out-of-stream applications are reviewed for their potential impact on native fish populations; general recommendations to the OWRD have been to delay or not approve any additional water rights until the OWRD can demonstrate that instream water rights are met.

Table 3. Wild redband trout populations identified in the Crooked River basin.

	Compliance with Wild Fish Management Policy	
Location/Population	< 10% Hatchery Spawners	> 300 Spawners
Crooked River below Bowman Dam	no	yes
Willow Creek above Madras	yes	unknown
Willow Creek below Madras	unknown	unknown
Ochoco Creek above Ochoco Dam	unknown	yes
Ochoco Creek below Ochoco Dam	unknown	unknown
Marks Creek	unknown	unknown
Bingham Springs/Desolation Creek	yes	unknown
Bear Creek below Antelope Flat Reservoir	unknown	unknown
Bear Creek above Antelope Flat Reservoir	unknown	unknown
Crooked River above Bowman Dam	unknown	unknown
N.F. Crooked River below Lower Falls	Yes	unknown
N.F. Crooked River between Lower Falls and Upper Falls	yes	unknown
N.F. Crooked River above Upper Falls	yes	yes
Deep Creek	yes	yes
Peterson Creek	yes	yes
Allen Creek	yes	yes
Big Summit Prairie tributaries	yes	yes
Horseheaven/Buck creeks	yes	yes
Sheeprock Creek	yes	unknown
Pine Creek	yes	unknown
Drake Creek	yes	unknown
Camp Creek	yes	unknown
S.F. Crooked River	unknown	no
Beaver Creek and tributaries	yes	yes
Rager Creek	yes	unknown
Dry Paulina Creek	yes	unknown

Table 4. Streams and rivers in the Crooked River Basin with Instream Water Right applications on file with the Oregon Water Resources Department.

Stream or River	Tributary Of	Application Date
Allen Creek	McKay Creek	08/29/90
Allen Creek	N.F. Crooked River	08/29/90
Bear Creek	Crooked River	08/29/90
Beaver Creek	Crooked River	08/29/90
Brush Creek	Johnson Creek	08/29/90
Canyon Creek	Ochoco Creek	08/29/90
Crooked River (3)	Deschutes River	05/11/90
Deep Creek	N.F. Crooked River	01/29/93
East Fork Mill Creek	Mill Creek	08/29/90
Gray Creek	N.F. Crooked River	08/29/90
Horse Heaven Creek	Crooked River	08/29/90
Howard Creek	Johnson Creek	08/29/90
Johnson Creek	N.F. Crooked River	08/29/90
Little McKay Creek	McKay Creek	08/29/90
Lookout Creek	N.F. Crooked River	08/29/90
Marks Creek	Ochoco Creek	08/29/90
McKay Creek (2)	Crooked River	08/29/90
Mill Creek	Ochoco Creek	08/29/90
North Fork Beaver Creek	Beaver Creek	08/29/90
North Fork Crooked River (3)	Crooked River	05/11/90
Ochoco Creek	Crooked River	08/29/90
Peterson Creek	N.F. Crooked River	08/29/90
Pine Creek	Crooked River	01/29/93
South Fork Beaver Creek	Beaver Creek	08/29/90
South Fork Crooked River	Crooked River	05/11/90
Sugar Creek	Beaver Creek	08/29/90
West Fork Mill Creek	Mill Creek	08/29/90
Willow Creek	Deschutes River	08/29/90
Wolf Creek	Beaver Creek	08/29/90
Wolf Creek	Ochoco Creek	08/29/90

HABITAT AND HABITAT LIMITATIONS

Historical Habitat Conditions

Early explorers and military expeditions described the Crooked River basin as a rich area with abundant riparian vegetation, adequate supplies of grass, water and firewood, and banks of the Crooked River covered with a dense growth of trees that in some areas had to be cut away to facilitate travel (Buckley 1992). The river and streams were abundant with native fish including rainbow trout, summer steelhead and chinook salmon (Crook County Historical Society 1981). Ogdens' journals of his expeditions up the Crooked River in 1826 described the excellent quality of beaver habitat and noted specifically that all of the tributaries and the mainstem he observed were lined with willows and aspen, and grass as tall as 7 feet (Ogden 1950). Other early explorers noted the abundant grasses and willows and one report describes the Crooked River valley: "the bottom lands of the valley will average from half a mile to mile in width...groves of alder and cottonwood, with dense thickets of willow, exist on its banks... the plains back of the hills are...clothed with a carpet of luxuriant bunch grass" (Buckley 1992). One entry from Steen's military unit that was dispatched to survey a route in July 1860 from Harney Lake to Eugene City described the Crooked River as a "Good running stream 30 ft wide 1 ft deep in middle. Good rocky bottom. Plenty of fish". Ogden also found an Indian fish weir below the junctions of the North and South forks, that was apparently used for capturing anadromous fish.

Present Habitat Conditions and Causative Factors

Streams and Rivers

Streams of the Crooked River basin possess characteristics of a semiarid climate. On an average year, low precipitation produces relatively low runoff, although large variations can be expected on an annual and seasonal basis. Natural flow, except for that resulting from spring snowmelt, and occasional summer rainstorms, is relatively low. Many of these streams once supported abundant aquatic life and native fish populations. However, land and water management practices over the past 130 years have resulted in an overall decline in riparian condition, river channel morphology, water quality and quantity, and subsequent declines or extirpation of native fish populations.

It is imperative to understand that most streams in the Crooked River basin are extremely degraded, and subsequently, that fish habitat and production are severely reduced. Natural habitat in the Crooked River basin has been altered dramatically, and most of the historical fisheries no longer exist. The Crooked River is arguably the most degraded river system in the state. This degradation significantly limits management options. The challenge for fish management has been to create productive fisheries in artificial habitats while preserving remaining indigenous species in less altered habitats.

Good riparian habitat conditions result in cool water, and directly influence instream habitat by maintaining stable streambanks, good water quality, and late season flows. Effects on fish habitat from loss of riparian vegetation include increased stream temperature, loss of cover, increased erosion, a widening and shallowing of the stream channel, and reduction or loss of perennial flow. River and streambanks in many places of the Crooked River basin lack riparian vegetation, cover, and large woody debris and are actively eroding or unstable. Lack of flow during the summer is one of the major concerns, as many streams have become intermittent or dewatered. The 1988 Oregon Department of Environmental Quality (ODEQ) statewide assessment for nonpoint sources of water pollution indicated that many of the streams throughout the Crooked River basin had moderate to severe problems for water quality, fish, and aquatic habitat. Problems included flow alternation, turbidity and sedimentation, stream bank erosion, temperature, nutrient load, sewage pollution, and bacteria. In some stream reaches, low dissolved oxygen, bacteria or viruses, or toxic substances have also been reported (ODEQ 1988).

Of the factors limiting native fish production, the low water, or no water, conditions in streams are probably the biggest factor in the Crooked River basin. Water quantity and quality problems, primarily flow reduction or loss, temperature, sedimentation, and turbidity, limit fish distribution and production (Bottom et al. 1985). Amount of stream flow affects all fish life stages including spawning, incubation, rearing, and migration. Fish abundance is directly related to volume of water available in streams. Sedimentation and turbidity reduces spawning habitat, egg survival, and food production of insects and plankton. Sedimentation affects quality of fish habitat increasing the amount of fines and causing embeddedness of gravel and substrate. This in turn reduces spawning habitat by making gravel difficult to lift, oxygenation to incubating eggs, and cover for rearing fish. Turbidity affects fish production by reducing production of aquatic insects and plankton, and foraging efficiency of fish.

High water temperatures are probably the second largest factor affecting fish in the basin. Optimal stream temperatures for rainbow trout are 54^{o} to 64^{o}F. Many reaches in the Crooked River basin are characterized by low flows and high summer water temperatures. Water temperatures in headwater streams on the Ochoco National often exceed 70^{o}F and have been recorded as high as 83^{o}F, well in excess of state water quality standards for the Deschutes Basin. High water temperatures result in stress or direct mortality to cold water fish species and increases competition from nongame species such as suckers, chiselmouth, and squawfish, which can tolerate higher temperatures.

Abundance and quality of large woody debris also affects food production, rearing, stream flow, and migration of fish species. Large woody debris helps to form pools which provide rearing habitat, traps spawning gravel, provides a refuge for fish during high runoff events, provides cover from predators, stabilizes banks from erosion, and provides structure for aquatic insects.

Many of the headwater streams support native redband trout populations where there is year around flow, instream cover, cobble and boulder substrate, and good streamside vegetation. The best and last good habitat in the basin is on the Ochoco National Forest. However, the amount of good quality habitat is only a small fraction of what it once was. Therefore, it is very important to protect what little habitat is left, and much of the District work effort involves habitat protection on the National Forest.

Land and Water Management Practices affecting Streams and Rivers

The majority of water quantity and quality problems, including flow alteration, temperature and sedimentation, result from nonpoint source pollution activities associated with land use practices. Land use practices most commonly cited for degrading water quality were livestock grazing, timber harvest, irrigated agriculture, and recreation (ODEQ 1988).

Water quality degradation in the Crooked River basin begins in headwater streams from nonpoint pollution sources such as livestock grazing, timber harvest, roading, and areas of heavy dispersed recreation. The most severe degradation of water quality from nonpoint source problems occurs in the lower basin below public land boundaries from agricultural activities. These include livestock grazing, water withdrawal for irrigation, and irrigation return water and natural runoff returning leached sediments, minerals, and manmade chemicals from soils. A lack of stabilizing vegetation, on both upland and riparian areas, contributes to erosion and sedimentation during high runoff events. One of the greatest challenges fisheries managers face, is to recover and rehabilitate these habitats in a cooperative effort with public and private land managers, while sustaining commodity production of agricultural and timber products.

Livestock grazing on fragile streambanks has resulted in excessive cutting and erosion as stabilizing vegetation deteriorates, and streambanks break and slough into the channel from trampling (Chaney et al. 1990; Platts 1991; Kovalchik and Elmore 1992; Nehlsen 1995). Loss of native riparian vegetation increases soil erosion and lessens water storage capacity in watersheds, resulting in greater extremes of high and low water events. Direct damage is caused to riparian vegetation by overgrazing during summer, as cattle are attracted to cool streamside areas. Extreme high flow events cause a stream to incise and a floodplain to widen, lowering the water table and causing eventual death of riparian vegetation.

Irrigation diversions often contribute to instream aquatic problems by disrupting stream flows. Water withdrawal diverts all or major portions of the flow in most streams once they leave headwater streams on the Ochoco National Forest. Streams such as Mill, McKay and Ochoco creeks exit the Ochoco National Forest lands as low as 1 cfs in drought years and are dry within 10 miles from irrigation withdrawal. Low or nonexistent flows during the irrigation season limit fish production. Many diversions do not have head gates, and few have monitoring or measuring devices. In some stream reaches,

habitat occurs only where water must remain instream to satisfy downstream water rights. In many cases, streams have been over appropriated for irrigation; for example, the North Fork Crooked River and tributaries have over 200 cfs of out of stream appropriation, a flow which is rarely met except during spring runoff. With virtually all of the flow appropriated by senior out of stream water rights, instream flow needs for aquatic and fish life are often not met during the irrigation season.

Unscreened diversions can divert fish into irrigation ditches where they become stranded and die. There are over 700 unscreened diversions in the Crooked River basin. Many diversions are gravity fed canal systems which have high evaporation losses and relatively poor efficiency for water delivery. In addition, many diversion dams are seasonally constructed of pushed up gravel and dirt berms. These dams are washed away each spring during runoff causing silting of spawning and rearing habitat. These dams often prevent passage for migrating fish.

Altered streamflow patterns throughout the basin have diminished fish production and distribution. Large and small, public and private reservoirs, constructed for irrigation storage on the mainstem and tributaries of the Crooked River have altered streamflow characteristics in the basin. In some cases, such as the first 12 miles below Bowman Dam, stream flow patterns are reversed from natural flow patterns with high flows during the irrigation season when water is released; low flow occurs while the reservoir stores water for the coming irrigation season.

Impassable barriers at cement irrigation diversion dams, small and large public and private impoundments, and road culverts have severely restricted or eliminated passage for native fish species throughout the Crooked River basin. Existing populations of native fish, such as redband trout, have been isolated and fragmented by impoundment dams on public and private lands, creating small separate gene pools of fish. These smaller populations are subject to "genetic drift" which can lead to extinction.

Most of the forested lands have been extensively harvested and roaded in the past 70 years. Timber harvest can have substantial negative impacts on fish resources (Meehan 1991). Harvesting timber in the riparian zones was a common practice until 1993. Riparian harvest reduces stream shade and leads to higher water temperatures. Riparian harvest also depletes future large woody debris that would enhance the stream. Loss of large woody debris leads to loss of pools, channel complexity, and channel alteration (Sedell and Everest 1991; Thomas et al. 1993). Timber harvest also increases sedimentation due to soil disturbance and alters the timing and quantity of peak flow events (USDA 1989b). Road building associated with timber harvest increases sedimentation by increasing the “hydrologic net” of a watershed, increasing peak runoff and sedimentation. Soil compaction from timber harvest and roading also contribute to reduced infiltration and the problems mentioned above. Dispersed camping and recreation in localized areas has also contributed to loss of riparian vegetation and trampling and compaction of streamside soils.

Artificial Habitats

Reservoirs for irrigation and hydroelectric production have created artificial habitats for native and introduced fish species. Habitat limitations for reservoir fisheries include seasonal and daily water level fluctuation or drawdown, water temperature, low minimum pool levels, turbidity, poor riparian conditions, and a limited amount of fish holding structure. Irrigation reservoirs are drawndown during the irrigation season and store water during the non irrigation season. Drawdown limits natural production of warmwater species by dewatering nests and causing mortality of eggs and young. In extreme cases, low pools limit survival of both cold and warmwater species from extreme temperatures or low dissolved oxygen. Drawdown also limits the establishment of shoreline and riparian vegetation. Turbidity and sedimentation from wave action on barren soil banks and from degraded watershed conditions also limits fish production, spawning and survival. In many cases, artificial impoundments in the basin have allowed nongame fish species such as northern squawfish and suckers to expand their range and compete effectively with preferred game species such as trout or bass.

1. Lakes

Walton Lake is the only reservoir not managed for irrigation or hydroelectric power. The lake was constructed to provide a still water angling site in the Ochoco Mountains and unlike many nearby central Oregon irrigation impoundments, has a stable water level. It is a relatively high elevation lake surrounded by a pine and fir forest. Its major habitat limitations include food availability for fish populations, seasonal water quality problems of blue green algae blooms, low dissolved oxygen, high summer temperatures, and occasional winter dieoffs of hatchery rainbow trout.

2. Irrigation Reservoirs

Prineville, Ochoco, Antelope Flat, Allen Creek, and Haystack reservoirs, and Reynolds Pond were built as irrigation impoundments to store and release water for croplands and livestock production. The reservoirs created habitat that is only fair for game species. The inundated lands provided only a moderate base for fish habitat. In the case of Prineville and Ochoco reservoirs, they were composed of moderately steep, juniper and sagebrush covered canyons, with some irrigated hay fields adjacent to the river. Antelope Flat and Allen Creek reservoirs inundated moderately high elevation grass and sagebrush valleys with surrounding gentle slopes covered with ponderosa pine. Haystack Reservoir inundated a lower elevation canyon with relatively gentle slopes covered with sagebrush and juniper. Reynolds Pond is a low elevation reservoir formed by dikes in a relatively flat area and is surrounded by a semi-arid sparse vegetative community of juniper, sagebrush, rabbitbrush, and bunchgrass. Currently, the habitat for all six reservoirs is characterized by a lack of shoreline vegetation, an

expansive mud flat substrate in the upper end, and mud mixed with boulder and cobble substrate in the lower end.

Habitat limitations for fish in these reservoirs include seasonal and annual water level fluctuations and drawdown, high suspended sediments which limit photosynthesis, only moderate concentrations of nutrients in the water, very low abundance of aquatic vegetation, a lack of structural complexity, and water that is too cold for optimal warmwater fish production and too warm for optimal trout production.

The major habitat limitation for fish production in irrigation reservoirs including Prineville, Ochoco, Antelope Flat, Allen Creek, and Haystack reservoirs and Reynolds Pond, is daily and seasonal drawdown of reservoirs for irrigation. Annual drawdown exposes shallow areas, and as a result, reduces food production for aquatic life, and prevents shoreline vegetation from becoming established. Shoreline species such as willow and sedge are not able to tolerate prolonged periods of drying out as the reservoir level drops and soil moisture is reduced. Drawdown also reduces living space and increases competition for fish living in the reservoir.

Ochoco, Antelope Flat, Allen Creek, Haystack, and particularly Prineville Reservoir, have been impacted by high quantities of suspended sediments, or turbidity. In general, poor watershed condition of the Crooked River basin and tributaries, with wave action from wind and boats, highly erodible soils in the uplands, and poor riparian conditions contribute to fine sediments entering the reservoirs. This turbidity limits light penetration into the water and photosynthesis. The suspended clays and turbidity limit production of benthic and planktonic organisms.

Although nutrient levels in the reservoirs are fair to good, turbidity limits food production for fish. Prineville Reservoir, with its particularly high turbidity levels has very low productivity. While Prineville, Ochoco, Allen Creek and Antelope Flat and Haystack reservoirs may be moderate to nutrient rich, they are only moderately productive due to the turbidity which limits sunlight penetration. Without sunlight penetration, phytoplankton do not grow well. Zooplankton feed on phytoplankton, which are in turn food for fish.

Occasionally, there are large blooms of a blue green algae such as *Aphanizomenon* in Ochoco, Haystack, and Antelope Flat reservoirs which can cause what appears to be a blue green pollution scum along the shoreline. This algae limits light penetration, out competing other phytoplankton species and reducing productivity of zooplankton. In some instances where the outbreak of *Aphanizomenon* has been extensive, fish kills have been observed at Haystack and Antelope Flat reservoirs due to oxygen depletion. Other water quality problems that have been observed that effect fish production and survival are warm temperatures and low dissolved oxygen levels. Fish kills have been observed in recent years at Walton Lake, and Haystack and Antelope Flat reservoirs in the summer from these conditions.

Reynolds Pond has somewhat different habitat problems and limitations in that it is a small, shallow, irrigation reservoir. Approximately 2/3 of the area of the pond is not very well utilized by fish species due to shallow depths of less than 3 feet. Drawdown for irrigation demand intensifies competition for food and space. Fish production in the reservoir is also influenced by the amount of inflow from the irrigation canal and amount of water released for irrigation. Plankton production and spawning and rearing of fish is likely influenced by continual cooling from input of cold irrigation water. Cold water inputs probably disrupt or delay algae and zooplankton production and delay warmwater fish spawning or cause complete failures.

3. Hydroelectric Reservoirs

Lakes Billy Chinook and Simtustus were built for hydroelectric power generation. Habitat in the two reservoirs is characterized by steep shoreline topography, a boulder and cobble substrate, and generally good water quality. Most of the shoreline consists of cobble and boulders. A few sandy beaches are present, mostly near developed recreation areas and in secluded coves. Silt and sand are also present in the deltas created by tributaries. Due to the steep topography and rocky substrate, very little aquatic vegetation is present in these reservoirs. Some woody material has accumulated in the reservoir in recent years. Most of this material is from shoreline alder trees that have fallen into the reservoirs.

Habitat limitations for fish in these reservoirs include only moderate concentrations of nutrients in the water, a very low abundance of aquatic vegetation, a lack of structural complexity, and water that is too cold for optimal warmwater fish production. The steep sides of the reservoirs also greatly limit the abundance and distribution of littoral fish species. Rainbow and brown trout, smallmouth and largemouth bass, black crappie and bluegill are littoral fishes in Lake Billy Chinook, while rainbow and brown trout are littoral fish found in Lake Simtustus. Because of the limited habitat available for these species, their abundance is much lower than would be found in a reservoir with a shallow gradient shoreline.

Zooplankton are a major food source for fish in many reservoirs. As such, they are another important indicator of the reservoir's total potential for fish production. Compared to some other central Oregon lakes, zooplankton densities in Prineville, Ochoco, Billy Chinook, and Simtustus reservoirs are quite low (Figure 2). Haystack has higher zooplankton production more comparable to other Cascade lakes.

Outlet facilities at all reservoirs are unscreened and likely causes losses in fish populations. Unknown numbers of fish emigrate through outlets at Prineville, Ochoco, Antelope Flat, Allen Creek, Billy Chinook, and Simtustus reservoirs, and Walton Lake, to the rivers or streams below. The outlet structure at Haystack Reservoir is unscreened and fish that exit the reservoir become stranded and die in the canal when it is dewatered in the fall.

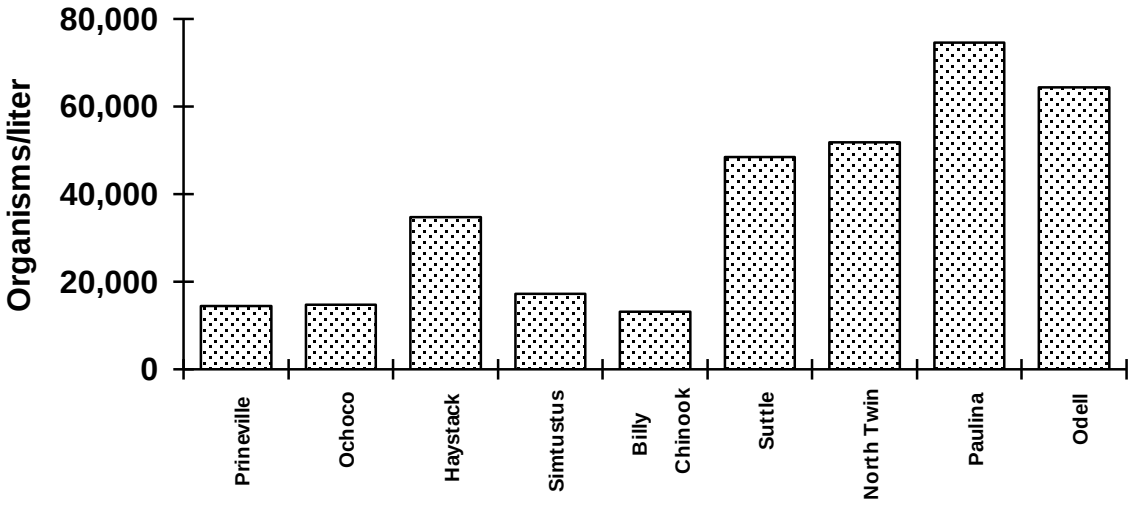

Figure 2. Zooplankton densities of lakes in central Oregon.

Habitat Protection

One aspect of habitat enhancement and restoration is to change or modify the land and water management practices that have degraded riparian and fish habitat and protect remaining habitat for native fish species. The Ochoco District has worked with public agencies and private landowners to improve existing practices through planning processes, and direct habitat improvement projects. Comments are made on federal land use issues through the National Environmental Policy Act process with the USFS, BLM, and Bureau of Reclamation (BOR); and on fish, water, riparian, and wetland issues with state agencies such as OWRD, ODEQ, Oregon Department of Forestry, and Oregon Division of State Lands; and county and city issues with the Crook County Soil and Water Conservation District, Crook County and city of Prineville Planning Departments. In addition, the ODFW Ochoco Fish District coordinates with the Ochoco and North Unit irrigation districts on water withdrawal issues and management of irrigation reservoirs including Prineville, Ochoco, and Haystack reservoirs. On occasion, the District is involved with violations of state regulations and provides inputs where losses or mitigation of fish populations or their habitat is concerned.

Changes in livestock grazing practices probably have the greatest potential to effect improvement in riparian areas and fish habitat in the Crooked River basin. The district provides comments in the scoping process, development of alternatives, and draft environmental assessments on livestock grazing allotment management plans on public lands. Our policy is to encourage early season use, better livestock distribution, and alter duration, timing, and intensity of use. Many livestock grazing allotment management plans date back to the 1960's when riparian areas were recognized as "sacrifice areas" in order to achieve adequate utilization of upland forage. The district has recommended the use of rest rotation pasture systems to improve riparian areas,

and where riparian areas are in an extremely degraded state, recommended riparian pastures or exclosures. The district has received grants from the Restoration and Enhancement program to cost share fencing projects to improve riparian areas and fish habitat on both private and public lands. In the past two years, the district has cost shared fencing projects with thirteen private landowners on approximately 16 miles of streams, and numerous projects with the Big Summit and Paulina Ranger Districts of the Ochoco National Forest.

Some positive steps have been taken in recent years on federal lands to reverse the impacts of timber harvest on fish habitat. Implementation of interim stream side no timber harvest buffers zones of 150' to 300' on Ochoco National Forest streams, depending on whether they are fish bearing or perennial streams, will assist in recovery of streams toward recovery of vegetative potential as future timber sales are designed and implemented (USDA 1995). Adequate buffers will provide shade, streambank stability, and future large woody debris.

The District is working with the Ochoco National Forest and the ODFW Habitat Conservation Division to identify and prioritize passage barriers. Inadequate road culverts on the Ochoco National Forest with velocity or height barriers, or that are undersized, are being replaced with bridges or open arch culverts where possible, and reconstructed to pass 50 year flood events. The District is also assisting the Habitat Conservation District in updating, identifying, and prioritizing existing or potential fish passage barriers in the basin such as private irrigation impoundments and concrete or wooden irrigation diversions.

An active program is underway to screen diversions to prevent fish from being stranded and dying in canals. Fifteen screened diversions presently exist: one at the Crooked River Feed Canal, 12 miles below Bowman Dam where approximately 160-180 cfs is drawn into the Ochoco Irrigation District Canal system, 2 screens at the newly impounded Shady Creek Dam on Big Summit Prairie, and 12 screens on Mill and Ochoco creeks above Ochoco Reservoir. Recently, additional landowners on Mill and Ochoco creeks and the lower mainstem and North Fork of the Crooked River, have expressed interest in the Fish Screening program. Progress is ongoing to cost share and install screens on private lands while funds are available through the 1995-97 state fiscal biennium, through tax credits and a fishing license surcharge.

State legislation passed in 1989 mandated the development of instream water rights to provide for aquatic life, habitat and recreation, for present and future generations. Instream water right applications were filed with the OWRD in 1990 for 35 reaches on 28 streams in the Crooked River basin and Willow Creek (Table 3). These flow recommendations were developed using the Oregon Method from flow data collected in the late 1960’s and early 1970’s. Instream water rights could only be applied for where there was existing flow data on record from a recognized methodology. Recent legislation in 1995 dictated that the OWRD resolve all pending applications for water rights including ODFW instream water rights by October 1996.

Habitat Restoration

A second aspect of habitat restoration and enhancement has been to develop partnerships with other agencies, organizations, and private landowners to enhance riparian areas and fish habitat. The Crooked River Ecosystem Education Council (CREEC) was founded in 1992 to develop watershed level restoration improvement projects and is a consortium of federal and state partners and others including ODFW, USFS, BLM, Ochoco Chapter of Trout Unlimited, Trout Unlimited Bring Back the Natives, Oregon State University Extension Service, Crook County Soil and Water Conservation District, Jefferson County Soil and Water Conservation District, Cove Palisades State Park, the National Fish and Wildlife Foundation, and private landowners. Willow plantings, riparian pasture and exclosure fences, river cleanups, and instream large woody debris projects have occurred on the North and South forks of the Crooked River, mainstem Crooked River, and many tributaries. Watershed demonstration projects are developed and used by CREEC members for education of Crook County School District students. Education is a powerful and long term tool in the watershed recovery process. Through a combination of ongoing restoration projects, and changes in curriculum to include natural resource issues and environmental education, CREEC will foster a greater awareness of the stewardship and benefits of functioning ecosystems. Recently, the CREEC program has expanded to include the Madras and Culver School districts where students will be able to learn about and work on projects in Willow Creek, and on Haystack, Billy Chinook, and Simtustus reservoirs. Numerous opportunities exist throughout the Crooked River and Willow Creek basins to continue these habitat and riparian restoration projects.

The district has also worked with numerous cooperators on enhancing fish habitat in artificial habitats where native fish populations have been replaced with warmwater and other coldwater game species, and hatchery rainbow trout. Projects have included placement of large woody material, and boulders and/or artificial trees to improve juvenile fish production and rearing habitat in Lake Billy Chinook, Prineville Reservoir, Reynolds Pond, and Haystack Reservoir. Cooperators have included the USFS, Portland General Electric Company (PGE), Crook County Parks and Recreation, Ochoco Anglers Association, Central Oregon Bass Club, and BOR.

Management Issues and Concerns

1. The status of redband trout populations is mixed. Redband trout are moderately abundant in the limited amount of headwater tributaries with good habitat and cool water. Redband trout populations are depressed in mainstem rivers and tributaries with degraded riparian zones, poor fish habitat, and warm water. Overall, wild redband trout populations are depressed compared to historical numbers.

2. Much of the basin has fragmented and isolated redband trout populations due to current land and water management practices that have altered flows or created artificial passage or thermal barriers. Passage barriers such as dams, road culverts, and irrigation diversions partially or completely block fish migration. In addition, poor riparian conditions due to timber harvest, livestock grazing, road building practices, and recreation have altered riparian and instream conditions, affecting the quality and quantity of habitat and stream flows.

3. Under the current habitat conditions, the mainstem Crooked River above Prineville Reservoir and the mainstem Crooked River from Highway 97 bridge to the town of Prineville does not support a significant trout fishery, consumptive or otherwise. Low flows, high summer water temperatures, sedimentation, and turbidity limit salmonid production. In some reaches of the mainstem river and tributaries, pesticides, toxic chemicals, elevated nutrients, and bacterial or viral organisms reduce water quality.

4. Unscreened irrigation withdrawals limit instream flows and may cause direct and indirect fish mortality by diverting and stranding fish in canals.

5. Senior out of stream water rights limit flows and dewater stream reaches in much of the basin during the irrigation season. Additionally, illegal withdrawals have been reported.

6. Water quality is limited in reservoirs of the Crooked River basin. Turbidity in some standing water bodies including Prineville, Ochoco, and Antelope Flat reservoirs impairs fish production and limits management options. Occasional high summer temperatures, low dissolved oxygen, and algae blooms have caused dieoffs of game fish species in Ochoco, Haystack, and Antelope Flat reservoirs. In some reservoirs, pesticides, toxic chemicals, elevated nutrients, and bacterial or viral organisms reduce water quality.

7. Riparian vegetation has not become established along the shoreline in most irrigation reservoirs, due to drawdown and dewatering of shorelines and erosion caused by wind and boat waves.

8. Irrigation and hydroelectric reservoirs have unscreened outlets that allow unknown numbers of fish to emigrate into the rivers or tributaries below. Haystack Reservoir has an unscreened outlet that diverts unknown numbers of fish to irrigation canals; fish are stranded and die when the canal is dewatered in the fall.

9. Fluctuating water levels due to irrigation storage and withdrawal reduces habitat and affects spawning and rearing potential for warmwater species. Seasonal drawdown of reservoirs causes increased competition for food and space between game and nongame species. Severe drawdown of irrigation reservoirs to extremely low levels causes loss in production for native coldwater species

and stocked hatchery rainbow trout. These same drawdowns also cause high loss of naturally sustained warmwater fish populations in Haystack and Prineville reservoirs, and Reynolds Pond.

10. Lack of in-reservoir cover and structure, and shoreline vegetation, limits production of fish species in all standing water bodies in the Crooked River basin.

11. Shoreline developments such as docks, housing developments, angler access facility developments, primitive dispersed camping, roads, and dam safety reconstruction work results in loss of fish habitat and deterioration of reservoir water quality.

The following section provides habitat restoration and enhancement objectives that are management actions common to all alternatives presented in each water body section. These include objectives to protect, restore, and enhance habitat, stream flows, water quality, and fish passage throughout the Crooked River and Willow Creek basins.

MANAGEMENT DIRECTION

POLICIES

Policy 1. Work cooperatively with public and private landowners to protect, restore and maintain habitats for natural production of native and introduced fishes in the Crooked River basin.

OBJECTIVES

Objective 1. Protect, restore, and enhance fish habitat in the Crooked River basin, Willow Creek, and reservoirs.

Assumptions and Rationale

1. Protection and restoration of redband trout populations can be achieved principally through habitat protection and restoration. Wild redband trout populations are limited by available habitat.

2. Habitat management is the basis of wild fish management. Management objectives for natural fish production cannot be obtained without all the elements of habitat to support fish production. Habitat protection is more effective than restoration, but habitat that has been degraded should be

restored to return fish production to optimum levels. Habitat restoration can increase natural production, but should not be considered a substitute for habitat protection.

3. Although ODFW does not have regulatory authority over the management of most land and water resources, the Department does influence management of aquatic habitat by federal and state agencies, private landowners, and others.

Actions

Action 1.1 Continue advisory role and support enforcement of existing laws and regulations concerning habitat protection by agencies with enforcement authority such as USFS, Oregon Department of Forestry, Crook, Grant, and Wheeler Counties, ODEQ, BLM, Oregon State Police and Division of State Lands.

Action 1.2 Coordinate and provide technical input to provide management of riparian areas, uplands, and water quality along the mainstem Crooked River and its tributaries to achieve vegetative potential to optimize fish production.

Action 1.3 Plan and implement habitat restoration and enhancement activities in cooperation with USFS, BLM, Crook County Soil and Water Conservation District, CREEC, PGE, Ochoco and North Unit irrigation districts, private landowners, volunteers and sportsman organizations such as Trout Unlimited. Identify habitat deficiencies and sites for habitat restoration projects in steams and reservoirs.

Action 1.4 Negotiate with BOR, private landowners, irrigation districts, and other water management entities to investigate the feasibility of reducing annual reservoir drawdown and seasonal fluctuations in irrigation reservoirs associated with water releases.

Action 1.5 Implement habitat protection and improvement actions listed below under Objectives 2,3, and 4.

Action 1.6 Encourage Crook County to enforce its new 1993 Comprehensive County Land Use Plan and abide by the 100' setback required by the plan for new housing developments.

Objective 2. Maintain or improve instream flow for fish production in the Crooked River and tributaries, and Willow Creek.

Assumptions and Rationale

1. Water quantity is as important as water quality for fish production. Fish production is limited by stream flow in some reaches of the Crooked River and tributaries. Restoration of optimum stream flows will increase the fish production capacity in the drainage.

2. Flow diversions during summer months and water storage in private impoundments in winter months for downstream irrigation use impacts spawning and rearing habitat.

3. Improvement of upland and riparian management practices can increase the watersheds' ability to store and release water.

Actions

Action 2.1 Identify stream reaches that would benefit from instream water rights and apply to OWRD for designations.

Action 2.2 Collect data to evaluate minimum and optimum water flows for fish.

Action 2.3 Encourage irrigators (through education and financial assistance where available) to improve water distribution and application techniques in an effort to use less water more efficiently in order to improve instream flow.

Action 2.4 Investigate the feasibility of purchasing, gifting or leasing water rights to improve instream flows.

Action 2.5 Encourage the OWRD to require legal flow measuring devices on diversions and improved supervision and enforcement.

Action 2.6 Encourage and work with landowners, managers and enforcement agencies to improve upland and riparian management to restore the watershed's ability to store and release water.

Objective 3. Improve the water quality of the Crooked River basin, Willow Creek and reservoirs.

Assumptions and Rationale

1. The water quality in the Crooked River basin and reservoirs does not meet water quality standards for temperature, turbidity, and dissolved oxygen, and in some stream reaches and reservoirs, for pesticides, toxic chemicals, elevated nutrients, and bacterial or viral organisms. It can be

improved through enforcement of existing laws and improvements in land and water management practices.

2. High quality aquatic habitat is necessary for optimum fish production. The aquatic environment must provide requirements for every life history phase of fish. Adequate amounts of clean, cool water, food organisms, cover, and spawning areas for salmonids are components of a high quality habitat.

3. Land and water uses in the watershed can adversely affect water quality. Agriculture, livestock grazing, road building, timber harvest, rangeland practices, urban development and recreation can degrade watershed conditions and decrease water quality.

Actions

Action 3.1 Coordinate with state, county and federal land management agencies to improve monitoring and enforcement of water quality standards.

a. Urge ODEQ, Oregon State Police (OSP), USFS, and BLM to increase water quality monitoring and enforcement, especially in important fish production areas.

b. Determine point and non-point pollution sources.

c. Develop an action plan to address point and non-point source pollution in cooperation with state and federal agencies.

Action 3.2 Promote riparian zone and upland protection as a means of improving water quality for the future.

a. Coordinate with county, state and federal agencies for the establishment and maintenance of quality riparian zones in agricultural, range, urban and forest zones.

b. Coordinate with county, state, and federal agencies to protect upland areas from degrading land management activities.

Objective 4. Prevent fish losses at unscreened diversions and provide adequate upstream and downstream passage for fish at dams, culverts and other artificial obstructions in the Crooked River basin and Willow Creek.

Assumptions and Rationale

1. Unscreened irrigation diversions in the Crooked River and tributaries, and Willow Creek cause fish mortality.

2. Adequate fish passage at dams and diversions is necessary to prevent fragmentation of populations, injury, delay, or loss of fish.

3. Adequate fish passage is necessary at road crossings to provide access to upstream spawning and rearing areas.

Actions

Action 4.1 Inventory irrigation and other water diversions for adequacy of screening to protect trout in the Crooked River and tributaries, and Willow Creek.

Action 4.2 Prioritize unscreened diversions for installation of screens and coordinate this with the screening program (Fish Division, ODFW). Diversions affecting wild trout will have highest priority.

Action 4.3 Install screens in priority order.

Action 4.4 Evaluate suspected upstream passage problems at Peterson Creek Reservoir and Allen Creek Reservoir and various other smaller impoundments or instream diversions. Recommend and implement improvements.

Action 4.5 Inventory road culverts for fish passage problems. Make recommendations to the USFS, BLM or appropriate landowners to improve upstream passage at culverts.

Action 4.6 Work with the ODFW Fish Passage Coordinator to identify and prioritize passage barriers and establish an implementation schedule for installation of fishways on private lands.

RESTORATION OF ANADROMOUS FISH PASSAGE

Overview

Portions of the Upper Deschutes River basin including the Metolius River, Squaw Creek, the Deschutes River below Steelhead Falls, and the Crooked River supported native populations of anadromous spring chinook salmon and summer steelhead. The Metolius River system, including Link Creek and Suttle Lake, also supported sockeye salmon. The entire upper Deschutes River basin supported resident populations of bull and redband trout. Other anadromous species such as Pacific lamprey and coho salmon may have been present in the upper basin but were not documented in any historical accounts.

The Crooked River basin historically supported anadromous runs of spring chinook salmon and summer steelhead (Frey 1942; Ogden 1950; Buckley 1992; Nehlsen 1995). These runs were eliminated by a series of large irrigation and hydroelectric dams on the Deschutes and Crooked rivers. Ochoco and Bowman dams, were completed in 1921 and 1961, respectively, with no fish passage facilities and blocked anadromous fish runs into Ochoco Creek and the upper Crooked River basin. Pelton and Round Butte dams were completed on the Deschutes River downstream of the confluence with the Crooked River in 1958 and 1964, respectively. Although fish passage facilities were constructed by PGE, the licensing company, the facilities were not effective. Fish passage efforts were terminated in 1968, eliminating spring chinook salmon and summer steelhead from the lower Crooked River. Opal Springs dam, constructed in 1921, was a partial barrier to migratory fish. In 1982, it was rebuilt to a larger dam, retrofitted to produce hydroelectric power, and became a complete passage barrier to migratory resident fish.

It is unknown whether Willow Creek, a tributary of the Deschutes River at Lake Simtustus, supported anadromous runs of spring chinook and summer steelhead. It is likely that Willow Creek supported some steelhead and chinook as there are no known geological barriers that would have limited their passage.

Upstream and downstream passage of anadromous and resident salmonids will be evaluated for potential restoration to their historical habitat and reconnection of fragmented fish populations as part of the Federal Energy Relicensing Commission (FERC) relicensing of the Pelton/Round Butte Project. The PGE company has proposed a plan to re-introduce anadromous fish upstream of Round Butte Dam. The intent of the plan is to restore sockeye and spring chinook salmon, and summer steelhead to their historical range in the upper Deschutes River basin including the Crooked River. If introduction of these species occurs, passage would be sought over Opal Springs, Ochoco and Bowman dams and other smaller mainstem and tributary passage barriers in the Crooked River basin.

Anadromous and Resident Fish Resources

Chinook Salmon

The historical abundance and distribution of spring chinook salmon in the Crooked River is largely unknown. Stories and photos of huge catches of salmonids in the lower Crooked River are found in historical records of the early 1900's (USDI 1992). Ogden's journals in the 1820's first documented salmon in the Crooked River when the explorer found an Indian barrier for taking salmon below the confluence of the North and South forks of the Crooked River (Ogden 1950; Buckley 1992). A commercial fishery at the mouth of the Deschutes River occurred from approximately 1880 to 1900 with nets across the river which "practically blocked the ascent of all the fish" (Davidson 1953), and probably impacted escapement of spring chinook to the upper Deschutes River, including the Crooked River.

Almost a century of habitat degradation had occurred by the time the first surveys were conducted for anadromous fish, and therefore do not reflect the historical abundance and distribution of these fish. Spring chinook were still reported by residents of the upper basin in the 1940's although they were much more severely impacted by habitat degradation than steelhead (Frey 1942). Low summer and fall flows combined with high water temperatures probably contributed to the early demise of spring chinook in the Crooked River due to their fall spawning life history. Spring chinook were reported to have used Ochoco Creek extensively for spawning and rearing before Ochoco Dam was completed in 1921. In addition, the Cove Power Plant and Opal Springs Dam on the lower Crooked River, about 2 miles and 7 miles above the mouth, respectively, were partial barriers to spring chinook salmon migrating during low flows of summer and fall in the early 1900's. The Bureau of Commercial Fisheries estimated that about 2,000 spring chinook salmon could spawn in the lower Crooked River if water quantity and quality were suitable (Bureau of Commercial Fisheries 1966). This survey was based on available spawning gravel in the lower 70 miles of the Crooked River from Bowman Dam to the mouth.

Spring chinook salmon may have been in the basin until the completion of Bowman Dam. Correspondence between the OSGC, the USDI, and the BOR, while Bowman Dam was under construction, gives conflicting information on the status of spring chinook in the late 1950's (Nehlsen 1995). Both the OSGC and the USDI indicated that the Crooked River still may have supported a small run of spring chinook, although none had been observed in recent years. Unfortunately, thorough surveys were not conducted to determine their status.

From 1957-1969, approximately 400-800 jack and adult chinook salmon were passed annually over Pelton Dam. However, declining run sizes and poor juvenile fish passage downstream contributed to the demise of the run. Studies to evaluate passage indicated that there were insufficient adults returning to the dam for each adult of the parent run. Therefore, efforts to perpetuate the natural run of spring chinook were abandoned and hatchery mitigation initiated in 1968.

A remnant population of spring chinook salmon is believed to exist in Lake Billy Chinook, although the population is extremely depressed. Anglers reported seeing spring chinook salmon adults in the Deschutes River upstream of Lake Billy Chinook to Steelhead Falls during the mid-1980's, but they have not been reported there in recent years. Juvenile chinook salmon were captured with seine nets in the Deschutes River below Steelhead Falls in 1986 (PGE, unpublished data). One dead adult chinook salmon was found in the Metolius River Arm near the head of the lake in 1988. A few chinook salmon were reported as harvested during creel surveys conducted in 1990-1993. However, these may have been mis-identified by the surveyors. A single 8 inch chinook salmon was captured in trap nets set below the mouth of the Metolius River in 1994. This suggests that the population may still exist.

Summer Steelhead

Crooked River summer steelhead were part of the Deschutes River steelhead stocks, which appeared to have multiple life histories (Nehlsen 1995). The majority of the fish entered the Deschutes River from late July to October. In the early 1950's, however, a few bright adults were found in April and May in creel samples at Cove on the Crooked River that likely would not spawn until the following spring. Most upper Deschutes River steelhead that were passed above Pelton Dam from 1957 to 1969 were 4 years old (Gunsolus and Eicher 1962) and spawned in March and April (Nehlsen 1995).

Summer steelhead were historically present throughout much of the Crooked River basin with the exception of the North Fork Crooked River above Upper and Lower Falls. Steelhead were still present in the Crooked River up until the mid to late 1950's, and were occasionally caught by anglers. Efforts to document summer steelhead spawning and distribution were not conducted until the early 1950's when plans were well underway for construction of Bowman, Pelton, and Round Butte Dams, and populations were severely depressed from historical levels. Unfortunately, turbid stream conditions, poor access, and a lack of survey effort made observations difficult and sporadic, and frequently unsuccessful.

Despite these difficulties, the OSGC reported that salmonids migrated the entire length of the Crooked River during late winter and early spring when flows were suitable (OSGC 1951). In the 2 years that surveys were conducted, 1952 and 1953, summer steelhead were documented in 9 tributaries and the mainstem, and as far upstream as 120 miles from the mouth of the Crooked River. Steelhead were reported passing over Stearns' Dam in the Crooked River 5 miles above Prineville, and spent steelhead were found in Ochoco, McKay, Drake, Horseheaven, and Beaver creeks, and in the lower North Fork Crooked River in 1952 (Montgomery 1952). Steelhead redds or fish were observed in the following year in Twelvemile and Ochoco creeks, and 6 adults moving upstream were captured in a trap in Paulina Creek, a tributary of Beaver Creek. Biologists recorded that much of the middle portion of the basin on private lands, where

irrigation dams made passage difficult and irrigation withdrawals contributed to extreme low flows and high summer temperatures, was unsuitable for steelhead production (OSGC 1951).

From 1957-1969, approximately 270-1,620 summer steelhead were passed annually over Pelton Dam. During 1971, 1972, and 1973 run years, 925, 291 and 50 hatchery adult summer steelhead were passed, respectively. Many more summer steelhead were passed over Pelton Dam from 1957-65 than could be accounted for by spawning counts and observations in Squaw Creek and the upper Deschutes River (Nehlsen 1995). Many of these fish probably spawned in the Crooked River tributaries, but were not observed because of the lack of surveys or turbid river conditions.

The Bureau of Commercial Fisheries estimated that about 3,000 summer steelhead could spawn in the lower Crooked River if water quantity and quality were suitable (Bureau of Commercial Fisheries 1966). This survey was based on available spawning gravel in the lower 70 miles of the Crooked River from Bowman Dam to the mouth and did not include any of the lower tributaries, such as McKay Creek and lower Ochoco Creek.

Pacific Lamprey

Pacific lamprey probably historically occurred in the Crooked and Deschutes rivers above the Round Butte-Pelton project. There were no physical barriers to prevent their movement into the Crooked River. Very little is known about the life history, and historical and present abundance and distribution of Pacific lamprey in the Deschutes River basin. These fish were, and still are, an important food fish for native Americans of the CTWS. Lamprey are harvested as adults at Sherars Falls on the lower Deschutes River in August as they are migrating upstream to tributaries for spawning (Mark Fritsch, CTWS tribal biologist, personal communication).

Sockeye Salmon/Kokanee

Sockeye salmon were historically present in Suttle Lake. Historic wild runs of sockeye salmon entered the Deschutes River from June to September, with spawning occurring from mid-September to November in Suttle Lake and Link Creek. The Metolius Hatchery was operated on Spring Creek from 1947 to 1961 (OSFC 1967) and released approximately 100,000 sockeye fingerling annually (Wallis 1960). Peak counts of returning hatchery sockeye salmon were observed in August during the construction of Pelton and Round Butte dams and likely coincided with the timing of the wild run. Counts of returning adult sockeye salmon at the Pelton trap from 1957 to 1962 ranged from 30 to 330 fish, and included both wild and hatchery fish. The gradual demise of sockeye salmon in the upper Deschutes River basin was attributed to blockage of the spawning run by dams on Lake Creek and Suttle Lake, and ultimately by the completion of Pelton and Round Butte dams.

Sockeye salmon continue to persist at extremely low levels in the Deschutes River (Kostow 1995). A few sockeye salmon continue to return to the base of Pelton Reregulating Dam every year and some are caught in the Pelton trap. A total of fifteen sockeye salmon were captured at the Pelton trap in the past 3 years. These adult sockeye are either progeny from wild or hatchery kokanee in Lake Billy Chinook and Lake Simtustus, or they are strays from elsewhere in the Columbia River basin.

Kokanee salmon are very abundant and found throughout Lake Billy Chinook. They spawn mostly in the Metolius River and its tributaries. However, numerous fish also spawn in the Crooked River upstream to Opal Springs and in the Deschutes River upstream to Steelhead Falls. If passage for anadromous fish is restored over the Round Butte/Pelton Dam complex, some of the kokanee production could be converted to sockeye. Presently, some kokanee that rear in Lake Billy Chinook move downstream through the turbines and residualize in Lake Simtustus. Of those that survive, some emigrate through Pelton and Reregulating Dam turbines to the lower river and may return as adult sockeye salmon to the Pelton fish trap.

Resident Game Fish

Bull trout were historically found throughout the upper and lower Deschutes River basin. They are presently found in the Metolius River system excluding Suttle Lake, upper Lake Creek, and Abbot Creek; in the Deschutes River from Lake Billy Chinook upstream to Steelhead Falls; in the Crooked River upstream to Opal Springs; in Lake Billy Chinook; and in the lower Deschutes River including Warm Springs River and Shitike Creek. Bull trout were caught by anglers in the lower Crooked River up to the town of Prineville (Frey 1942; Walt Van Dyke, personal communication) as recently as the early 1980's. With the renovation of the dam at Opal Springs in 1982, fish passage was deemed impossible, and no bull trout have been observed above Opal Springs since then. Subadult bull trout were found in Squaw Creek in 1995 (Jennifer Burke, ODFW, personal communication).

Redband trout were historically found throughout the upper Deschutes River basin including the Metolius River system, Squaw Creek, the upper Deschutes River, and the entire Crooked River drainage. They are still found in all subbasins of the upper Deschutes River but are much diminished in abundance, and fragmented and isolated into separate populations by numerous manmade barriers.

Irrigation and hydroelectric dams

Pelton and Pelton Reregulating Dams

Pelton Dam is a hydroelectric dam and impounds a 7.5 mile reservoir upstream to the tailwaters of Round Butte Dam. Pelton Reregulating Dam was constructed 2.4

miles downstream of Pelton Dam to maintain the Deschutes River's natural flow and to prevent fluctuations that would severely impair aquatic life; it also has a turbine generator for producing electricity. Pelton and Pelton Reregulating dams are located at approximately RM 103 and 100, respectively, on the Deschutes River.

Fish passage facilities were constructed to maintain anadromous fish runs as part of the original FERC license. An upstream migrant trap and 3 mile long fish ladder were constructed to pass adults upstream. Some problems occurred when adults avoided the trap or when water temperatures increased in the ladder. Juvenile fish were passed downstream with a horizontal skimmer at the east embankment of Pelton Dam. The fish were transferred into the fish ladder to continue their downstream journey. However, shortly after completion of the dam, the OSGC expressed concerns that Pelton Reservoir was a serious problem to downstream migrating juveniles due to the high temperatures in the lower 6 miles of the reservoir forming a thermal block (OSGC 1959). Large schools of young chinook salmon and summer steelhead were observed periodically throughout the summer and fall of 1958 in the Deschutes and Metolius river channels and large numbers were caught by anglers.

Until 1968, when upstream passage of fish was terminated, the management objective was to continue the native runs of anadromous fish. However, fingerling and catchable size rainbow trout and kokanee were stocked in the reservoir to create a sport fishery. Kokanee salmon were also stocked by the OSGC on an occasional basis. Creel studies indicated that several thousand summer steelhead smolts were caught in the reservoir sport fisheries (Gunsolus and Eicher 1962; Korn et al. 1967).

In 1968, attempts to continue upstream passage of adult anadromous fish were abandoned. Remaining runs of wild spring chinook and summer steelhead were observed to spawn naturally below the project and hatchery strains of spring chinook and summer steelhead were developed at Round Butte Hatchery to mitigate for lost passage to upper basin spawning and rearing areas.

Biologists also tried to raise anadromous fish in Lake Simtustus. Starting in 1969, studies were initiated to determine the feasibility of rearing chinook salmon in the reservoir and over 150,000 juvenile salmon were released into the reservoir annually. From 1969 to 1979 juvenile spring chinook salmon were stocked in Lake Simtustus for the purpose of growing them to smolts. Attempts were also made to raise juvenile salmonids in the reregulating Reservoir and in the Pelton Fish Ladder. Spring chinook are now reared in the ladder and emigrate voluntarily in the spring. These ladder reared fish have much higher rates of return then fish released directly from Round Butte Hatchery. From 1973 to 1986, excess grade out summer steelhead from Round Butte hatchery also were stocked in the reservoir. Although these fish were intended to provide a fishery in the lake, some of these hatchery fish may have actually contributed to summer steelhead runs in the Deschutes River.

Round Butte Dam

Round Butte Dam is a large hydroelectric dam completed in 1964 and is located at RM 111 on the Deschutes River. Upstream and downstream fish migration facilities were also constructed at Round Butte Dam. Adult spring chinook salmon and summer steelhead were passed upstream over Round Butte Dam with a tramway system. The system was designed to winch adult fish over the dam with a large gondola-like bucket. From 1963-1966, approximately 400-600 adult chinook salmon and 250-430 summer steelhead were passed annually over Round Butte Dam.

A stationary skimmer at the east embankment of Round Butte Dam and a large floating skimmer were constructed to collect and pass migrating juvenile anadromous fish downstream. Juvenile anadromous fish were captured from Lake Billy Chinook, transported to the base of Round Butte Dam, and released into Lake Simtustus. However, the completion of Round Butte Dam appeared to contribute to the final demise of juvenile fish passage in the upper Deschutes River basin. Fry and fingerling chinook salmon entered Pelton Dam less readily after the Round Butter coffer dam was constructed in 1962 (Korn et al. 1967). Once Round Butte Dam was completed in 1964, studies found that chinook salmon and summer steelhead juveniles tended to wander in the different arms of the reservoir, particularly the Metolius River arm, and did not pass very well through both Billy Chinook and Simtustus reservoirs. Survival of summer steelhead through Pelton Dam, from emigration to returning adults, was estimated at less than 1% prior to completion of Round Butte Dam (Gunsolus and Eicher 1962). Survival of downstream migrating juveniles, from Lake Billy Chinook to the Pelton skimmer, appeared to be less than 1% for experimentally released hatchery fish, after completion of Round Butte Dam.

Opal Springs Dam

Opal Springs Dam is located approximately 1.0 mile upstream of the impounded waters of Lake Billy Chinook at river mile 7 on the Crooked River. Opal Springs Dam was originally constructed in 1921 and was a 6 foot concrete capped rockfill dam that was a partial barrier for migratory fish, particularly at low flows. In 1982, it was replaced by an 18 foot cement capped rockfill diversion dam and retrofitted to produce hydroelectricity. It impounded a 58 acre foot reservoir with a surface area of 5.2 acres. Flashboards were added to the project in 1985 to be seasonally installed, and added 3 feet to the height of the dam and increased the surface area of the reservoir to 5.7 acres. The Deschutes Valley Water District, owner and operator of the dam and facility, is required to have a bypass flow of 50 cfs as part of its FERC license.

With anadromous fish passage blocked by the Pelton/Round Butte dam complex, fish concerns in the early 1980's were primarily for loss of passage for resident fish species and mortality from the turbines. A downstream passage study conducted by CH2M Hill in the spring of 1982, estimated 118 fish were captured of which 48 were trout or kokanee, with an estimated annual mortality of 10 salmonid fish from the

turbines. The study was initiated in April but high water conditions and debris loads caused the trap to wash out after only 1 day. During the 54 days the trap was in place, in May and June, fish species captured included rainbow and bull trout, kokanee, brown bullhead, squawfish, and suckers, and fish size ranged from 1.5 to 16 inches. The capture of a bull trout on a single day of operation in April suggests that there may have been spawning habitat above the project or migratory subadult fish used the area above the project for rearing. On the basis of estimated low fish mortality from fish entering the power facilities, screens or louvers were not required for the diversion.

Ochoco Dam

Ochoco Dam is an irrigation reservoir that blocked fish passage when it was completed in approximately 1921. The dam is located on Ochoco Creek approximately 10 miles above the confluence with the Crooked River.

An early report by Dick Herrig, the first Ochoco District Biologist, included an historical account of Ochoco Reservoir: Much of the history was summarized from conversations with old timers, who said that a majority of the fishing was for brown bullhead and crappie. Prior to rehabilitation of the dam by the BOR in 1949-50, summer steelhead and whitefish could swim over the spillway and into the reservoir during overflow years, and fishing was very good. With the raising of the dam level by the BOR, no upstream passage for migratory salmonids was provided, and annual stocking of hatchery rainbow trout began.

Bowman Dam

Bowman Dam was completed in 1961 and created Prineville Reservoir at RM 70 on the Crooked River. Fish passage was not included in the construction of Bowman Dam even though some steelhead were still in the basin when it was completed. If fish passage is successful over Round Butte dam, passage will be evaluated over Ochoco and Bowman dams to restore anadromous runs into historical spawning and rearing areas of the upper Crooked River and Ochoco Creek basins.

Management Issues and Concerns

1. Restoration of anadromous fish is currently being considered as part of the relicensing of the Pelton Project, including Round Butte and Pelton Dams. If passage is restored over Round Butte Dam, native fish restoration will include summer steelhead, sockeye and chinook salmon, and bull and redband trout. Restoration of these fish into the lower Crooked River basin will provide approximately 100 additional miles of spawning and rearing habitat in the mainstem Crooked River, lower Ochoco Creek, and McKay Creek.

2. Restoration of anadromous fish into the lower Crooked River basin will require passage over Opal Springs Dam.

3. If passage is successful for the Round Butte/Pelton Dam complex and Opal Springs, restoration of anadromous and resident fish in the Crooked River basin where these fish historically occurred will need to be evaluated.

MANAGEMENT DIRECTION

POLICIES

Policy 1. Restore anadromous and migratory resident fish to their historic range in the Crooked River basin by improving upstream and downstream passage over artificial barriers.

Policy 2. Reconnect isolated and fragmented populations of redband trout by restoring and improving passage over manmade barriers.

Policy 3. Require passage over all proposed dams on fish bearing streams.

OBJECTIVES

Objective 1. Determine the feasibility of restoring anadromous and migratory resident fish above Pelton, Round Butte, and Opal Springs hydroelectric dams.

Assumptions and Rationale

1. Spring chinook and summer steelhead were native to the Crooked River. Local stocks of spring chinook and summer steelhead would be suitable as parent stock. The population may need to be started by hatchery methods if habitat constraints cannot be overcome which would conflict with alternatives specifying wild fish only.

2. Bull trout were native to the lower Crooked River.

2. Restoring these fish will improve the diversity of the fish community.

3. These fish may bring in new diseases.

4. Providing downstream fish passage through the Pelton/Round Butte Dam complex is integral to restoration. Upstream passage is probably adequate at the Pelton/Round Butte Dam complex.

5. Fish screening may be necessary at these dams.

6. Restoration would be compatible with Wild and Scenic River designation.

7. Fishing regulations may need to be revised to protect both upstream migrating adults and downstream migrating juveniles.

Actions

Action 1.1 A feasibility study will be conducted to determine if it is physically and biologically possible to restore spring chinook and summer steelhead to their native range above the Pelton/Round Butte Dam complex. Bull trout passage will also be examined to reconnect the Metolius and lower Deschutes River populations.

Action 1.2 If passage is restored, implement restrictive angling regulations in Lakes Billy Chinook and Simtustus and in the lower Crooked River while populations are rebuilding to protect fish stocks.

Objective 2. If passage is restored successfully over Pelton, Round Butte, and Opal Springs hydroelectric dams, evaluate passage over Ochoco and Bowman dams.

Assumptions and Rationale

1. Spring chinook and summer steelhead were native to the upper Crooked River and Ochoco Creek. Local stocks of spring chinook and summer steelhead would be suitable as parent stock.

2. Restoring these fish would improve the diversity of the fish community.

3. These fish may bring in new diseases.

4. Providing downstream fish passage through the Pelton/Round Butte Dam complex will be integral to restoration. Upstream passage is adequate at the Pelton/Round Butte Dam complex.

5. Fish screening may be necessary at these dams.

6. Fishing regulations may need to be revised to protect both upstream migrating adults and downstream migrating juveniles.

Actions

Action 2.1 A feasibility study will be conducted to determine if it is physically and biologically possible to restore spring chinook and summer steelhead above Ochoco and Bowman dams.

Action 2.2 Implement restrictive angling regulations in standing water bodies and the Crooked River and its tributaries while populations are rebuilding to protect fish stocks.

CROOKED RIVER AND TRIBUTARIES ABOVE PRINEVILLE RESERVOIR INCLUDING NORTH AND SOUTH FORKS AND BEAVER CREEK

Overview

This section covers the “upper basin”. It includes the North Fork Crooked River and its headwater tributaries; headwater tributaries and the mainstem of the South Fork Crooked River; tributaries and the mainstem Crooked River above Prineville Reservoir; and tributaries and the mainstem of Bear and Sanford Creeks which drain directly into Prineville Reservoir (Figure 3). Wild populations of indigenous coldwater game fish, primarily redband trout, are the primary fishery management concern.

Land in the upper basin is approximately equally split among federal and private ownership. Land use and water utilization on private lands is primarily for livestock grazing, timber harvest, and irrigation, while public lands are used for livestock grazing, timber harvest, and recreation.

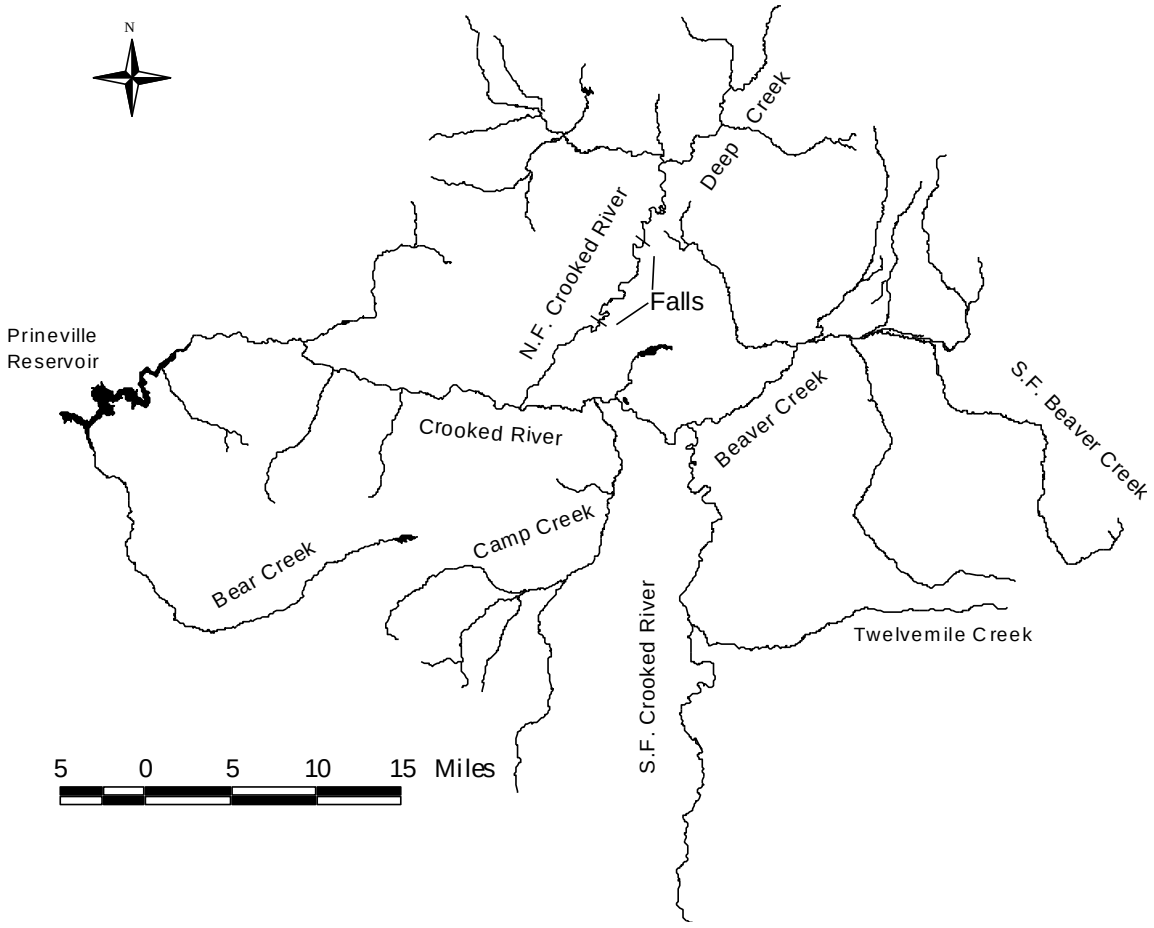

Figure 3. The upper Crooked River basin.

Most of the upper Crooked River and tributaries are characterized by low summer flows and high summer water temperatures. Streams water temperatures often exceed 70°F and have been recorded as high as 83°F (Table 5). Water quality conditions in the upper basin are moderate to severe for water quality, fish, and aquatic life for many streams (ODEQ 1988).

Table 5. Maximum water temperatures recorded in the North Fork Crooked River and its tributaries (USDA 1992).

		% of Time	Maximum Temperature (oF)				
Stream	Year	> 58°F	June	July	August	September	October
North Fork Crooked	91	73	71	83	83	75	
Gray Creek (upper)	91	62	61	75	68	63	56
Gray Creek (lower)	91	96	64	79			
Brush Creek	91	46		63	63	59	52
Lookout Creek	91	83		74	76	70	60
Howard Creek	91	42	53	65	65	59	52
W.F. Howard Creek	91	0	47	50	51	49	47
Porter Creek	91	59		79	77	68	52
Peterson Creek	91	80	68	80	78	69	61
Little Summit Creek	91	52	61	72	70	63	
Jackson Creek	91	50	72	81			
Happy Camp Creek	91	39	60	74	75	68	
Crazy Creek	91	31	56	64	65	60	

Access to rivers and streams on public lands is generally good, while access to the lower portions of the basin is through private land. Opportunities for enhancing recreation on public lands are riparian restoration, trail development, and interpretive work. Opportunities for enhancing recreation on private lands are a long term plan for acquisition of or developing public easements, and riparian restoration.

The Crooked River historically supported native populations of spring chinook salmon, summer steelhead, redband trout, bull trout, mountain whitefish, and many non-game fish. Redband trout are the only native game fish left in the upper basin, and reside primarily in the headwaters of smaller tributaries located on the USFS lands. Most of these populations have been fragmented and isolated due to physical and water temperature barriers. Redband trout populations are generally healthy in streams with year around flow, instream cover, suitable water temperatures, clean spawning gravel, and an intact riparian zone. In streams where these habitat components are lacking, trout populations are significantly reduced in abundance, and nongame species are abundant (except sculpin). Many of the small tributary streams are intermittent or ephemeral and provide extremely limited or seasonal habitat for trout. Throughout the basin, there have been many introduced species and include rainbow trout, brown trout, brook trout, smallmouth bass, largemouth bass, black crappie, and brown bullhead.

Almost all headwater streams and mainstem tributaries of the Crooked River basin are managed exclusively for wild populations of redband trout without any hatchery supplementation. The exception is the South Fork Crooked River which is stocked with hatchery rainbow trout. Continued existence and restoration of healthy populations of indigenous redband trout in all areas where they are now present is the primary management direction. Population health is characterized by high abundance with multiple age classes and genetic fitness of the stock.

Perhaps because of the poor habitat conditions in streams and the subsequent limited fishing opportunities, many anglers have expressed concern over the lack of "flat water" or lake habitat available for angling in the Ochoco Mountains. Walton Lake, Allen Creek Reservoir, Delintment Lake, and Antelope Flat Reservoir provide some lake fishing, but do not meet the growing demand. A group of concerned citizens are currently looking at issues and concerns related to the proposed development of additional reservoirs in the Ochoco Mountains to provide new fishing opportunities.

NORTH FORK CROOKED RIVER

Location and Ownership

The North Fork Crooked River and tributaries comprise approximately 250 miles of river and tributaries, draining an area of about 340 square miles or 13% of the upper basin (Ferry et al. 1979). The North Fork Crooked River headwaters begin in the Ochoco Mountains approximately 75 miles east of Prineville. It originates in the forest meadows of Williams Prairie south of Big Summit Prairie and is fed by snow and spring fed streams. Approximately 75% of the North Fork Crooked River basin lies on USFS, 12% on BLM, and 13% on private lands, the latter on or near the Big Summit Prairie and along the lower North Fork Crooked River. Ownership of lands along the North Fork Crooked River is 26% USFS, 23% BLM, and 51% private (Ferry et al. 1979).

In 1988, the entire North Fork Crooked River with the exception of Big Summit Prairie and the last mile above the confluence with the mainstem Crooked River, was included in the federal Wild and Scenic River system. The Act included 32.3 miles of the North Fork Crooked River for designation and included scenery and recreation as outstandingly remarkable values (ORV's). The North Fork Crooked River Environmental Assessment and Draft Management Plan was released in 1992 and designated 6 segments of the river on USFS and BLM lands as wild, scenic, or recreation (USDI and USDA 1992).

\Habitat and Habitat Limitations

The North Fork Crooked River flows through a variety of geological formations and plant communities, ranging from broad wet prairies to narrow basalt canyons. The upper river and tributaries flow through high elevation areas of rolling broad valleys or

steep v-sided canyons. The lower river below the confluence with Deep Creek flows through a steep impressive canyon, 500 feet in depth, with basalt flows and rimrock formations.

Habitat surveys conducted in 1972 and again in 1978 indicated that the mainstem river is generally open with 10% or less shade, with most shade from old growth ponderosa pine or fir, and sheer rock canyon walls (Ferry et al. 1979). In the lower canyon, large deep pools comprise much of the stream bottom while the remainder is riffles with a cobble substrate. A stream survey was completed in the North Fork Crooked River basin above the mouth of Deep Creek in 1994 and indicated that most streams had low shade and very low large woody debris, although cutbanks were relatively minimal (Johnson et al. 1994).

Most streams have late summer flows of less than 2 cubic feet per second (cfs), although Deep Creek, a major tributary below Big Summit Prairie, and the North Fork Crooked River below the confluence of Deep Creek have generally greater flows of 5 to 10 cfs (Ferry et al.; 1979; Schwartz and Griffith 1980). Flow measurements for the North Fork Crooked River just above Deep Creek averaged from 2 to 6 cfs from July to October, while spring time flows ranged as high as 1,500 cfs.

Over 200 cfs of out of stream water rights have been appropriated from the North Fork Crooked River and tributaries, including Gray, Indian, Stump, Elliot, Johnson, Committee, Allen, Fox, Crosswhite, Brush, Lookout, Shady, Beetle, Yellowjacket, Ross, and Peterson creeks.

Headwater streams are generally located in mixed conifer forests. Depending upon the level of timber harvest, most of these streams have good fish habitat and cool water. As these streams approach Gray Prairie, Big Summit Prairie, and Little Summit Prairie, the impacts of water withdrawal and livestock grazing reduce the quality of fish habitat and flows, and significantly raise water temperature. In addition, it appears that inactive mercury (cinnabar) mines located at the headwaters of Johnson Creek have adversely impacted water quality. Elevated mercury levels have been documented in fish collected in Johnson Creek (Bruce Anderson, USFS Hydrologist, personal communication).

Small impoundments and irrigation diversions have altered much of the flow and isolated some populations of rainbow trout in the upper North Fork Crooked River. In the northeast corner of Big Summit Prairie, Allen Creek Reservoir and its associated irrigation distribution system, and Peterson Reservoir, have isolated populations of redband trout in tributaries of the North Fork Crooked River from the mainstem, since the construction of the impoundments in the 1940-50's.

Access

The upper North Fork Crooked River and its tributaries are located mostly on public lands. Access is very good with a well developed road system. A small percentage of the upper North Fork Crooked River is located on private property.

The lower North Fork Crooked River below Deep Creek offers a remote fishing experience in a rugged, relatively undeveloped canyon, with high scenic values. Fishing success for trout is moderate to fair due to poor water quality and degraded riparian condition, which limit trout productivity. With restoration of riparian conditions, the North Fork Crooked River has a high potential to increase redband trout production and provide a quality outdoor experience for the fishing enthusiast who likes "to get away from the crowds". Below Deep Creek, vehicle access is limited to 3 roads and most recreational access to the canyon is via hiking, horse or llama packing.

The USFS and BLM allocated the North Fork Crooked River Wild and Scenic section into 6 segments ranging from scenic to recreation to wild (USDI and USDA 1992). Annual recreation of the river corridor is estimated to be less than 10,000 visits, with most of the use from Prineville and central Oregon residents. Section 5 of the Wild and Scenic River system has also been designated as a Wilderness Study Area.

Recreational use in the North Fork Crooked River and tributaries includes camping, hiking, photography, wildlife observation, hunting, horseback riding, swimming, fishing, sightseeing, and a limited whitewater float season in the lower North Fork Crooked River canyon (USDI and USDA 1992). Primitive dispersed campsites are located throughout the upper North Fork Crooked River basin, and developed campsites are located at Deep Creek Allen Creek Horse campgrounds.

Fish Resources

Upper Falls (RM 18) and Lower Falls (RM 10) were probably impassable barriers to migrating steelhead and apparently have geologically isolated redband trout in the upper North Fork Crooked River from the remainder of the Crooked River basin. While habitat conditions are less than optimum for redband trout throughout much of the North Fork Crooked River basin, redband trout populations appear to be surviving the best in the North Fork Crooked River and its tributaries, compared to the remainder of the Crooked River basin. Electrofishing surveys indicate that redband trout comprise approximately 20% of the fish population in the Williams Prairie area, with dace accounting for the remainder (Ferry et al. 1979). Sampling downstream, the percentage of rainbow trout drops and the percentage of nongame fish species increases. In the lower North Fork Crooked River, below the confluence with Deep Creek, redband trout comprise less than 1% of the population. This is likely due to increasingly poor water quality characteristics including low summer flows, high water temperatures and turbidity, and poor riparian conditions.

Headwater tributaries of the North Fork Crooked River support moderately abundant populations of redband trout. Where habitat is in relatively good condition, with cool water temperatures, good riparian and instream conditions, redband populations exhibit a mixture of age classes and comprise the bulk of the fish populations. Tributaries with poorer riparian and instream conditions have a higher proportion of nongame fish species, particularly dace and bridgelip sucker. Nongame fish in the North Fork Crooked River include speckled and longnose dace above Upper and Lower Falls, and northern squawfish, bridgelip sucker, largescale sucker, and chiselmouth below the Falls. Allen, Lookout, and Brush creeks also support brook trout, naturalized progeny of hatchery fish originally stocked in the 1920's and 30's.

Fish Stocking History

Historic hatchery stocking was relatively light compared to other hatchery programs in the Deschutes Basin. Small numbers of fry and fingerling rainbow and brook trout were stocked in Ochoco Forest streams in the late 1920's and early 1930's. More recently, hatchery legal rainbow trout were stocked in Deep Creek from 1963 to 1990, but were terminated due to potential concerns for disease and genetic introgression with native redband trout. Brown trout occasionally have been reported by anglers and are probably the progeny of fish originally stocked in Allen Creek Reservoir in the early 1970’s.

Hatchery rainbow and brook trout, stocked in the 1920's and 1930's in selected streams, appeared to have caused little to no hatchery genetic introgression in most of the basin. Preliminary electrophoretic results from fish collected from the North Fork Crooked River tributary streams of Howard, Fox Canyon, and Lookout creeks indicate that these trout appear to comprise a genetic group distinctly different from the remainder of the Crooked River basin (Currens 1994). The exception is Deep Creek which exhibited a moderate level of hatchery introgression from legal rainbow trout released from 1963 to 1990.

Angling Regulations

Angling regulations are consistent with statewide regulations. Stream angling is from late April to the end of October, with a 5 fish daily trout bag, 6 inch minimum, no more than 1 fish greater than 20 inches, and no special tackle restrictions. There have been angling regulation proposals in recent years to limit harvest of redband trout on Ochoco Forest streams to a 2 fish bag limit, due to concerns of low abundance. However, low redband trout abundance appears to be primarily due to poor habitat and stream conditions and not due to overharvest.

Fish Management

The North Fork Crooked River and tributaries are managed for wild fish only, consistent with the wild fish alternative (ODFW 1987a). Hatchery rainbow trout are no longer stocked in any moving waters in the North Fork Crooked River basin. Hatchery rainbow trout have been allowed in Shady Creek Reservoir, a private impoundment on Big Summit Prairie, where screens have been installed above and below the reservoir to prevent escape of hatchery fish. The screens need to be evaluated for effectiveness and stream sampled above and below the reservoir for potential escape and breeding with wild redband trout.

The lower 18 miles of the North Fork Crooked River were treated with rotenone to eliminate abundant populations of suckers and squawfish in 1960 (OSGC 1961). Otherwise, very little intensive fish management occurred in this part of the basin until the late 1970's, when intensive habitat surveys occurred throughout the basin on public lands documenting fish distributions for the first time. Unfortunately, those surveys relied on visual observations of fish to determine presence or absence. Fish management during the past 7 years has focused primarily on habitat protection, Wild Fish Policy implementation, and documenting life history, abundance and distribution of native salmonids. In order to better delineate redband trout gene pools and population characteristics, genetic information is being collected and analyzed. Preliminary information suggests that Crooked River redband trout have diverged from other inland rainbow trout groups and exhibit little introgression from non-native hatchery fish. In addition, redband trout from tributaries of the North Fork Crooked River including Fox Canyon, Howard, and Lookout creeks comprised a distinct group from the rest of the basin (Currens 1994).

Considerable effort has been expended studying populations of redband trout in the North Fork Crooked River. Efforts have been undertaken to complete distribution surveys for redband trout throughout the basin. Additional information has been collected by the USFS. From these surveys, we know that streams in this basin vary in habitat quality from excellent to poor. Those stream with good habitat exhibit redband trout densities greater than $1/yd^2$, whereas those with poor habitat have redband trout densities less than $0.50/yd^2$. Streams with greater effects from commodity management, including livestock grazing, timber harvest, and roading, tend to be warmer, have less pools and complex habitat, and become intermittent sooner in the summer. Surveys also indicated that redband trout utilize intermittent streams when they have water, and that they readily recolonize those habitats when water re-occurs. During drought years, an entire year's juvenile production may be lost in some streams. Surveys conducted in 1994 indicated that very few fish born in 1992 or 1993 survived.

Management Issues and Concerns

1. The status of redband trout populations is mixed. Redband trout are moderately abundant in tributaries with good habitat and cool water. Redband trout are

depressed in tributaries with degraded riparian zones, poor fish habitat, and warm water. The overall status of the wild redband trout population is currently unknown, but likely depressed compared to historical numbers.

2. Much of the basin has fragmented and isolated populations due to current land and water management practices that have altered flows or created artificial barriers. In addition, poor riparian conditions due to timber harvest, livestock grazing, and road building practices have altered riparian and instream conditions, affecting the quality and quantity of habitat and stream flows.

3. Genetics information is being collected to delineate redband trout populations. Preliminary information suggests that Crooked River redband trout may have diverged from other inland rainbow trout groups, and fish in the North Fork Crooked River may comprise a distinct group.

4. Unscreened irrigation withdrawals limit instream flows and may cause direct and indirect fish mortality.

5. Hatchery introgression appears to be limited in most populations except for Deep Creek where a 30 year hatchery program may have altered the stock. No future hatchery stocking is recommended.

6. Private hatchery stocking occurs on Shady Creek Reservoir although emigration is presently protected by screens upstream and downstream of the reservoir. Surveys and occasional checking of screens is recommended to avoid potential impacts of hatchery fish on wild trout populations.

SOUTH FORK CROOKED RIVER

Location and Ownership

The South Fork Crooked River comprises approximately 36 miles of river and numerous miles of tributaries and drains an area of about 800 square miles or 32% of the upper basin. Approximately 290 square miles of the South Fork Crooked River sub-basin do not contribute runoff in most years and are essentially internally drained basins. The South Fork Crooked River headwaters begin as springs and ponds in the high desert of the GI Ranch, northeast of Brothers, Oregon. One major tributary, Twelvemile Creek, flows into the South Fork Crooked River at RM 19.5. Many streams in the basin are unnamed and intermittent or ephemeral.

Land ownership along the South Fork Crooked River is approximately 1/3 BLM and 2/3 private lands (Gomes 1975). The upper South Fork Crooked River flows through several large ranches which limit public access, including the GI Ranch, Cold

Springs Ranch, and Westmoreland Ranch. The lower portion is mostly in a narrow rimrock canyon which is largely managed by BLM with some sections of private lands. The last mile where the river joins the mainstem Crooked River is also private land and is a broad canyon with irrigated hay meadows.

In 1979, the South Fork Crooked River was included as a wilderness study area and has not been designated to date by Congress. The South Fork Crooked River has also been included as an area meeting criteria for an Area of Critical Environmental Concern, with special values of riparian, fishery, recreation, and scenery (USDI 1987).

Habitat and Habitat Limitations

The river flows through a mixture of narrow, steep, rimrock canyons and areas of wider rimrock canyons and irrigated hay meadows. Vegetation throughout much of the basin is comprised of high desert sagebrush, rabbitbrush, juniper, and upland grass species including fescues, bunchgrasses, cheatgrass and crested wheatgrass. The riparian community is dominated by grass and sedge species, with very few willows or other woody species.

Habitat surveys conducted in 1975 and again in 1977 indicated that the mainstem river is generally open with little to no shade, with streamside vegetation of primarily grasses, some sedges, and an occasional willow. Summer flows ranged from 2 to 9 cfs with numerous irrigation dams diverting much of the flow throughout the private lands. The South Fork Crooked River has a relatively high pool:riffle ratio ranging from 50:50 to 80:20 characterized by long slow moving pools with long glides. Much of the river has a substrate of fine sediments, occasional riffles of cobbles and boulders, and spawning gravel is very limited. Over 100 cfs of out of stream water rights have been appropriated from the South Fork Crooked River.

Access

The South Fork Crooked River on BLM lands offers a remote fishing experience in a rugged, relatively undeveloped canyon, with high scenic values. Fishing success for trout is moderate to fair due to poor water quality and a degraded riparian condition, which limit trout productivity. With restoration of riparian conditions, the South Fork Crooked River has a much higher potential to provide a quality outdoor experience for the fishing enthusiast who likes "to get away from the crowds".

Public vehicle access is primarily from Congleton Hollow from the Post Paulina Highway. Recreational use is primarily from fishermen, hunters, hikers and campers. Primitive dispersed camping is available at Congleton Hollow but no improved facilities are present. Some limited 4 wheel drive access is also available to the western rim of the canyon, from the Camp Creek Road. Primitive dispersed camping also is available on the rim. The BLM has designated the South Fork Crooked River as a Wilderness

Study Area and an Area of Critical Environmental Concern. Final designation of the Wilderness Study Area may limit vehicle access on the western rim.

Fish Resources

Presently, hatchery rainbow trout of Deschutes River origin comprise the bulk of game fish caught in the South Fork Crooked River. Despite poor riparian conditions, hatchery rainbow trout demonstrate moderate to good growth with trout reported by anglers up to 20 inches in length. Some smallmouth bass and brown bullhead are occasionally caught by anglers and observed in surveys. Smallmouth bass are likely naturalized progeny from fish originally stocked in Prineville Reservoir or from ponds on the GI Ranch. Brown bullhead were observed in the Crooked River prior to the impounding of Prineville Reservoir and likely originated from a farm pond.

Electrofishing surveys indicate that nongame fish comprise the vast majority of the fish population, consisting of northern squawfish, chiselmouth, largescale and bridgelip sucker, and longnose and speckled dace. This is likely due to poor water quality characteristics including low summer flows, high temperatures and turbidity, and poor riparian conditions. Electroshocking surveys in the South Fork Crooked River from 1993, 1994 and 1995 failed to capture any juvenile salmonids, suggesting that there is no natural production. All rainbow trout fingerling stocked in the South Fork Crooked River in 1993, 1994, and 1995 were adipose fin clipped. All rainbow trout captured in surveys in September of 1994 and 1995 were hatchery origin fish, again suggesting no natural production in the reaches sampled or production and emigration from headwater reaches.

Fish Stocking History

Both legal and fingerling hatchery rainbow trout have been planted in the South Fork Crooked River since 1947, with legal releases of up to 10,000 catchable and 100,000 fingerling fish Most fish have come from Oak Springs hatchery with a few releases from Wizard Falls, Fall River, or Klamath hatcheries. Kokanee were released in 1970, and spring chinook in 1985, but apparently did not survive. The present day program is a late summer or early fall release of 15,000 Deschutes (66 stock) rainbow trout fingerling from Oak Springs Hatchery. The purpose of using this strain of rainbow trout is to use a river adapted trout rather than the traditional Cape Cod or Oak Springs domestic stocks, which appear to do better in lakes and reservoirs.

Smallmouth bass were stocked in 1983 in the South Fork Crooked River; smallmouth and largemouth bass were stocked in the 3 ponds on the GI ranch and have escaped through unscreened outlets. Smallmouth bass appear to have established and are occasionally caught by anglers. Brown bullhead have also been observed in sampling surveys.

Angling Regulations

In 1988, angling regulations were implemented to limit harvest to a 2 fish daily bag limit, barbless flies and lures only, with angling open from late April to the end of October.

Fish Management

The South Fork Crooked River is managed for hatchery rainbow trout, and naturalized populations of smallmouth bass. Since 1982, the South Fork Crooked River has been stocked only with Deschutes river rainbow trout. All fingerling trout released in the past few years have been marked and sampling surveys have indicated that all rainbow caught are hatchery fish. The emphasis has been to manage the trout population to provide a quality fishing experience in a rugged and remote landscape.

As with most areas of the upper basin, very little intensive fish management has occurred in the South Fork Crooked River. In the early 1950's, upstream migrant traps were placed in some tributaries and spawning surveys conducted to determine summer steelhead use (Montgomery 1953; OSGC 1955). Two miles of the South Fork Crooked River were treated in 1960 to eliminate nongame species (OSGC 1961). A physical and biological stream survey was finally completed on the mainstem South Fork Crooked River in 1975 (Gomes 1975). In August 1995, 3 sites were sampled on Twelvemile Creek. Nongame fish including speckled dace, bridgelip sucker, and chiselmouth were found at the lowest site, approximately 1 mile above the mouth. The other two sites at 5 and 10 miles above the mouth were dry. No other surveys have been conducted in tributaries to the mainstem South Fork Crooked River. Virtually, the entire South Fork Crooked River system was treated with rotenone to remove nongame fish in 1981. Unfortunately, the side result of this chemical treatment project was that any remaining indigenous redband trout appear to have been eliminated.

Electroshocking surveys have been conducted in the upper South Fork Crooked River in 1993, 1994, and 1995 to evaluate hatchery stocking programs. Only marked hatchery rainbow trout have been observed. With the limited spawning potential and the likely loss of native strains of rainbow trout from chemical treatment, trout production is dependent on stocking of hatchery fish. Low abundance of, and poor quality, spawning gravel combined with high summer temperatures, low flows, and high turbidity limit trout natural production potential. However, the South Fork Crooked River is a tough environment for any trout. Almost the entire 1992 stocking did not survive in the river, as none were captured in 1993. When hatchery rainbow trout survive in the system, they grow well. Fingerling stocked in the fall of 1993 were observed to reach 9-10 inches by the fall of 1994. Anglers often report catches of "quality" sized rainbow trout, fish between 15 and 16 inches; and occasionally, fish up to 20 inches.

An opportunity for consideration would be the development of a Crooked River broodstock of redband trout for stocking the South Fork Crooked River, rather than

using the Deschutes River stock. Recently, the BLM has placed a greater emphasis on protecting riparian habitat along the South Fork Crooked River and some vegetation is starting to take hold. Hopefully streamside vegetation will be restored and water temperature reduced. Future management will focus on habitat protection and restoration.

Management Issues and Concerns

1. Native redband trout appear to have been eliminated by a rotenone treatment project in the early 1980's. A hatchery rainbow trout program and naturalized smallmouth bass and brown bullhead populations support the current fishery.

2. The South Fork Crooked River does not appear to support a naturally reproducing stock of trout. As such, it cannot support a trout fishery, consumptive or otherwise, without hatchery stocking.

3. Much of the basin has poor riparian conditions due to livestock grazing, and has altered riparian and instream conditions, affecting the quality and quantity of habitat and stream flows.

4. Streams on private lands for the large part have not been surveyed for aquatic life.

5. Unscreened irrigation withdrawals on both tributaries and mainstem limits instream flows and may cause direct and indirect fish mortality.

BEAVER CREEK

Location and Ownership

Beaver Creek and its tributaries comprise several hundred of miles of river and tributaries and drain an area of about 540 square miles or 22% of the upper basin. Beaver Creek headwaters begin from springs and snowmelt fed streams on the Paulina and Snow Mountain Districts of the Ochoco National Forest, and from intermittent streams on plateaus of moderate elevation. The mainstem Beaver Creek and lower elevation tributaries are along valley bottoms with irrigated alfalfa and grass fields. Approximately 21% of the Beaver Creek basin lies on USFS lands, 15% on BLM lands, the latter of which is mostly scattered parcels, and the remainder on private lands. Ownership of lands along the mainstem and north and south forks of Beaver Creek is almost exclusively private with very small amounts in BLM public ownership.

Habitat and Habitat Limitations

The river and its tributaries flow through a variety of plant communities, ranging from wet meadows and forested communities, to arid sagebrush and juniper uplands, to irrigated pasture hay fields.

Limited habitat surveys indicated that much of the mainstem river and tributaries is generally unshaded, with streamside vegetation of primarily grasses, some sedges, and an occasional willow or cottonwood (Carter 1979a). Summer flows on the mainstem and lower tributaries range from 0 to 5 cfs with numerous irrigation dams diverting much of the flow throughout the private lands. Beaver Creek has a relatively low gradient with a high pool:riffle ratio characterized by long slow moving shallow pools with long glides. Much of the river has a substrate of fine sediments in pools and glides with occasional riffles of cobbles and boulders. Spawning gravel is very limited in much of the mainstem.

Over 160 cfs of out of stream water rights have been appropriated from Beaver Creek and its tributaries. Diversions creating low instream flows and corresponding high summer water temperatures are the primary limiting factors affecting fish production in the mainstem Beaver Creek.

Access

A vast majority of the Beaver Creek drainage is on private lands and offers limited opportunity for public recreation. The exception is along the South Boundary area of USFS Paulina Ranger District and the northwestern portion of USFS Snow Mountain Ranger District where tributary streams offer fair fishing success for anglers. Opportunities for enhancing recreation include riparian restoration, trail development, and interpretive work.

Fish Resources

Native redband trout comprise the only species of fish observed in many headwater tributaries of Beaver Creek on the USFS and BLM lands including but not limited to Paulina, Sugar, Wolf, Dippingvat, Roba, Widow, the North Fork of Wolf Creek, Dobson, Freeman, and Tamarack creeks. The lower portions of tributaries have an increasing percentage of nongame fish species such as dace, bridgelip sucker, and sculpin. Downstream, as flows decline due to irrigation withdrawal, and summer water temperatures increase, nongame species such as largescale sucker, northern squawfish, and chiselmouth comprise the vast bulk of fish biomass. Other game fish species observed while sampling the mainstem of Beaver Creek include smallmouth bass and brown bullhead. Smallmouth bass likely became established with the stocking

of the South Fork Crooked River in 1983 or from stocking of bass in Prineville Reservoir in the early 1960's.

Fish Stocking History

Legal and fingerling hatchery rainbow trout were planted in Beaver Creek in 1946 and 1947, and single plantings of rainbow trout fingerling were stocked in Sugar, Wolf and Heisler creeks in the mid 1940's. Summer steelhead were also stocked in Beaver Creek in 1972. The Beaver Creek system is now managed for wild fish only. No hatchery fish are stocked in any moving waters in the Beaver Creek drainage. A small quantity of 200 hatchery rainbow trout are stocked in Cottonwood Pit, a small gravel pit pond with no drainage, located on the USFS Paulina Ranger District.

Angling Regulations

Angling regulations are consistent with statewide regulations, with stream angling allowed from late April to the end of October, a 5 fish daily trout bag, one fish over 20 inches, and no special tackle restrictions.

Fish Management

The mainstem Beaver Creek and tributaries are managed for wild trout and warmwater fish (ODFW 1987a, ODFW 1987b). Hatchery fish are stocked in the South Fork Crooked River and may emigrate out of that system into the Beaver Creek. Otherwise, no hatchery stocking occurs in flowing public waters.

Very little intensive management has occurred in this portion of the basin. Like the South Fork Crooked River, some tributaries had upstream migrant traps placed during the early 1950's to sample summer steelhead presence (Montgomery 1952, OSGC 1955). A physical and biological stream survey was completed in 1979 (Carter 1979a, Carter 1979b). The South Fork Beaver, Grindstone, Trout, Camp, Freeman, and Dobson creeks were surveyed for fish presence in 1995, and in Swamp Creek in 1996. Redband trout were found in the South Fork Beaver, Freeman, Dobson creeks, and Swamp creeks. Only nongame species were found in the sites sampled in Grindstone, Trout, and Camp creeks.

Hatchery rainbow trout plantings have been allowed in private impoundments. Grindstone Lake, a private reservoir owned by the GI Ranch is located in the Beaver Creek system and is famed for its quality sized brook and rainbow trout. It is managed as a private fee fishing resort facility. None of these private impoundments have screens to prevent egress of hatchery rainbow or brook trout into the mainstem Crooked River and other tributaries.

Management Issues and Concerns

1. Redband trout populations are generally depressed compared to historical times because many streams have poor riparian conditions and relatively low trout abundance. Some tributaries such as Roba and Dippingvat creeks have such reduced flow conditions due to poor habitat conditions that trout have been restricted to stream reaches of only a 1/4 mile length on USFS lands in drought years.

2. Much of the basin has fragmented and isolated redband trout populations due to current land and water management practices that have altered flows or created artificial barriers. In addition, timber harvest, livestock grazing, and road building practices have negatively impacted riparian and instream conditions. The arid nature and lack of good habitat in the Crooked River basin indicates that native redband trout populations are highly vulnerable to any further habitat degradation.

3. Unscreened irrigation withdrawals on tributaries and Beaver Creek limit instream flows and may cause direct and indirect fish mortality.

4. A hatchery stocking program at private reservoirs on several ranches is allowed although emigration may cause introgression affects on wild redband trout. The outlets are unscreened, although extremely low to nonexistent flows may limit the potential for downstream movement.

5. Very few streams on private land have been surveyed for aquatic life.

MAINSTEM CROOKED RIVER BELOW THE CONFLUENCE OF THE SOUTH FORK CROOKED RIVER AND BEAVER CREEK

Location and Ownership

The mainstem Crooked River below the confluence of the South Fork Crooked River and Beaver Creek includes the major tributaries of Camp and Horseheaven creeks, and numerous tributaries that drain the north and south sides of the Maury Mountains. It comprises approximately 40 miles of the mainstem Crooked River and several hundred miles of tributary streams and drains an area of approximately 560 square miles or 23% of the upper basin. Headwater tributaries pass through a mixture of private, USFS and BLM lands as they flow to the mainstem Crooked River. Ownership of lands along the mainstem is almost exclusively private with very small amounts in public ownership.

Habitat and Habitat Limitations

Small tributaries to the mainstem originate on USFS lands and flow through a variety of plant communities, including wet meadows and forested communities. Lower portions of tributary streams and the mainstem Crooked River flow through wider valleys with sagebrush and juniper communities in the uplands and irrigated meadows and hay fields along the stream bottoms. Camp Creek arises in the arid Price Valley and historically was a wet meadow with abundant grass, willow, and aspen (Buckley 1992). Desertification of the Camp Creek drainage and the gradual transition to its present day condition of dry canyons and severely eroded streambanks occurred from the mid 1880's to 1905. Livestock grazing was documented as a major cause of this change.

Limited habitat surveys indicate that much of the mainstem river and tributaries are generally open with little to no shade (ODFW 1973; Carter 1979c; Carter 1979d). Summer flows range from 1 to 7 cfs with numerous temporary irrigation dams, mostly earth and gravel, diverting much of the flow throughout private lands. The mainstem Crooked River has a relatively low gradient with long slow moving shallow pools and long glides (ODFW 1973). Severely eroded cutbanks with very little riparian vegetation occur along much of the river, and several portions have been channelized. The river has a substrate of fine sediments in pools and glides with occasional riffles of cobbles and boulders. Spawning gravel is very limited.

Eroding soils surrounding the Maury Mountains have also contributed to poor water quality and degraded fish habitat. A study of the upper Crooked River watershed indicated that Camp, Eagle, Lost, and Conant creeks and the mainstem Crooked River contribute to turbidity and sediment loads in Prineville Reservoir (Silvernale et al. 1976). Soils in this area are highly erodible. Improper land management has resulted in sparse ground cover in the uplands, and degraded to nonexistent riparian vegetation. These conditions allow soils to erode and transport downstream during intensive rain events.

Access

Most of the mainstem Crooked River and its tributaries are on private lands and offer limited opportunities for public recreation. The exception is on USFS lands of the Big Summit Ranger and Prineville Ranger districts, and on BLM lands, where headwater tributary streams offer fair fishing success for anglers.

Fish Resources

Native redband trout are the principal fish species observed on many headwater tributaries on USFS lands including but not limited to Horseheaven, Wickiup, Pine,

Sheeprock and Drake creeks. Redband trout have been reported, but not recently observed in Camp Creek. Many of the tributary streams are intermittent or ephemeral and provide extremely limited or seasonal habitat for redband trout.

Downstream, on private lands and in the mainstem Crooked River and Camp Creek, flows decline significantly due to irrigation withdrawal and water temperature increases dramatically. During drought years, the mainstem Crooked River has a very low flow or becomes intermittent during the summer months, rendering it unsuitable for salmonid production. Nongame species comprise the bulk of the fish populations and include dace, largescale and bridgelip sucker, northern squawfish, and chiselmouth. Other game fish species observed while sampling the mainstem Crooked River are smallmouth and largemouth bass, and brown bullhead. Bass likely became established with the stocking of the South Fork Crooked River in 1983 or from plants of bass in Prineville Reservoir in the early 1960's.

Low abundance and poor quality spawning gravel combined with high summer temperatures, low flows, and high turbidity limit trout production potential, particularly in lower portions of the tributaries and in the mainstem Crooked River during summer time. In 1967, pools were sampled with rotenone for fish populations in the Crooked River (Newton 1967). Fin clipped rainbow trout comprised 50% of the fish observed in the river at the first site, approximately one to two miles immediately above Prineville Reservoir, and one fin clipped rainbow trout was observed in the river 22 miles above the reservoir. These fin marked fish apparently emigrated upstream from Prineville Reservoir. In recent years, private landowners along the river have reported good sized rainbow trout in the river above the reservoir, in the spring and fall when flows and temperatures are suitable to support trout, and good angling for brown bullhead and smallmouth bass in the spring.

Fish Stocking History

Very little fish stocking has occurred in this part of the basin. Fry and fingerling hatchery rainbow trout were planted in the mainstem Crooked River and in Tom Vaughn, Sherwood, Poison, Newsome, Maury, Lodgepole, Indian, Little Horseheaven, Drake, Camp, Cottonwood, and Double Cabin creeks, and in Reams, Miller, and Double Cabin ponds. Most plantings occurred from 1947 to 1957 and were a single event in each stream although some streams received a total of 2-4 plantings in that time period. Miller Pond, which is located in the Maury Mountains and drains into Keeney Creek, was stocked in the early 1980's with a mixture of brown and rainbow trout. Surveys have not been conducted in recent years to determine if these fish survived and produced progeny.

Private impoundments, such as the 3 reservoirs located on the Gutierrez Ranch, located upstream of the Camp Creek Road, are stocked occasionally with hatchery rainbow and brook trout.

Angling Regulations

Angling is open year round on the mainstem Crooked River from Prineville Reservoir up to the South Fork Crooked River with a 5 fish daily bag limit for trout, 5 fish bag limit for bass, and no limit for brown bullhead.

Fish Management

The mainstem Crooked River system is now managed as a basic yield "wild plus hatchery rainbow trout" river. Although hatchery rainbow trout are not directly stocked into the river, fish stocked in Prineville Reservoir move upstream. A survey in 1967 documented the capture of fin clipped hatchery rainbow trout at 2 out of 3 sites sampled in the mainstem Crooked River, one site approximately one mile above the reservoir, and the second site below the confluence of the North and South forks of the Crooked River (Newton 1967).

Very little intensive management has occurred in this portion of the basin. Like the South Fork Crooked River, some tributaries had upstream migrant traps placed during the early 1950's. Approximately, 90 miles of the Crooked River above Prineville Reservoir were treated with rotenone just prior to completion of Bowman Dam in 1961 to encourage trout production and survival as the reservoir was filled (OSGC 1961). Treated areas included this entire reach of the mainstem Crooked River, 2 miles of Camp Creek, 2 miles of Lost Creek, 2.5 miles of Horseheaven Creek, and 0.25 miles of Deer Creek. Physical and biological stream surveys were completed in 1973 and 1979 (ODFW 1973; Carter 1979c, Carter 1979d). The mainstem, Middle and South forks of Camp Creek were sampled for fish presence in 1995 on private lands (Jennifer Burke, ODFW, personal communication). Only bridgelip suckers were found.

Management Issues and Concerns

1. Redband trout populations are depressed compared to historical abundance because the Crooked River and its tributaries have poor riparian and instream conditions.

2. Under the current habitat conditions, the mainstem does not support a significant trout fishery, consumptive or otherwise, except for very limited times of the year.

3. Much of the basin has fragmented and isolated redband trout populations due to current land and water management practices that have altered flows or created artificial barriers. In addition, timber harvest, livestock grazing, and road building practices have altered riparian and instream conditions, affecting the quality and quantity of habitat and stream flows. The lack of good quality habitat and the arid

nature of this area of the Crooked River basin indicate that native redband trout populations are highly vulnerable to any further habitat degradation.

4. Unscreened irrigation withdrawals limit instream flows and may cause direct and indirect fish mortality.

5. Many streams on private lands have not been surveyed for aquatic life.

BEAR AND SANFORD CREEKS

Location and Ownership

Bear Creek begins above Antelope Flat Reservoir on the south side of the Maury Mountains and empties into Prineville Reservoir. Bear Creek and its numerous tributaries drain approximately 260 square miles or 10% of the basin upstream of Prineville Reservoir. Bear Creek and its tributaries pass through a mixture of private, USFS, and BLM lands.

Sanford Creek arises in the northwest corner of the Maury Mountains on USFS lands, flows through a mixture of BLM and private lands, and into upper Prineville Reservoir on BOR lands. The basin comprises an area of approximately 20 square miles, most of which is primarily private lands with some BLM ownership.

Habitat and Habitat Limitations

Bear Creek and most of its tributaries originate in the Maury Mountains and flow through a variety of plant communities, including wet meadows and forested communities. Lower portions of tributary streams and the mainstem flow through wider valleys with sagebrush and juniper communities in the uplands and irrigated meadows and hay fields along Bear Creek. Much of Sanford Creek flows through sagebrush and juniper lands.

Limited habitat surveys indicate that much of Bear and Sanford creeks are generally unshaded, with streamside vegetation primarily grasses, sedges, and an occasional willow. Eroded cutbanks occur along much of Bear and Sanford creeks. High summer water temperatures, low flows, and high turbidity limit trout production.

The Bear Creek sub-basin is composed of the same highly erodible soils as the Camp Creek sub-basin. Bear Creek often carries the greatest sediment load per volume of flow, although overall discharge is far less than the Crooked River (Silvernale 1976). Highly erodible soils, sparse ground cover in the uplands, and poor riparian vegetation are the primary cause of this erosion.

Access

Portions of Bear and Sanford creeks are on private lands and offer limited opportunity for public recreation. The headwaters of Bear Creek and its tributaries are on public lands offer fair angling success. Opportunities for recreation on private lands include developing access along Bear Creek and its tributaries and on private reservoirs such as Klootchman Reservoir. Much of the latter is presently managed for private fee fishing, hunting, and camping.

Fish Resources

Native redband trout are the principal fish species in headwater tributaries including but not limited to Bear, Klootchman, Shearing Spring, and Deer creeks. A 1967 survey indicated that squawfish and suckers were the principal species in the mainstem of Bear Creek (Newton 1967). Redband trout, speckled and longnose dace, and bridgelip suckers were captured in Bear Creek in 1978 below the junction of Little Bear Creek, with nongame fish species comprising the vast bulk of the fish population. Redband trout were reported in Sanford Creek in 1977 at river mile 8.0.

Fish Stocking History

Fry and fingerling hatchery rainbow trout were planted in Bear and Little Bear creeks in 1947 and 1952, respectively. Klootchman Reservoir was stocked in 1952 with rainbow trout fry, and again from 1977 to 1981 with legal sized trout, when public access was available. With closure of public access in 1982, it has been periodically stocked with hatchery rainbow trout by the private landowner. Antelope Flat Reservoir, at the headwater of Bear Creek has an annual stocking of up to 10,000 hatchery rainbow trout fingerling. Both Klootchman and Antelope Flat reservoirs have unscreened outlets that probably allow escapement of hatchery trout into the Bear Creek system. No hatchery fish are stocked in any moving waters, although some hatchery rainbow trout may move upstream from Prineville Reservoir.

Angling Regulations

Angling regulations are consistent with statewide regulations, with stream angling allowed from late April to the end of October, a 5 fish daily trout bag, and no special tackle restrictions.

Fish Management

Bear and Sanford creeks are now managed for wild fish only (ODFW 1987a). No hatchery fish are stocked in any moving waters, although some hatchery rainbow trout

from Prineville, Antelope Flat, or Klootchman reservoirs may emigrate through uncreened outlets.

Very little intensive management has occurred in this portion of the basin. Approximately 0.25 miles of Sanford Creek and 4.5 miles of Bear Creek were treated with rotenone along with the mainstem of theta Crooked River above Prineville Reservoir were treated just prior to completion of Bowman Dam in 1960 (OSGC 1961).

Management Issues and Concerns

1. Redband trout abundance is depressed in Bear Creek because of poor riparian conditions, low flows and high summer water temperatures. The overall status of the redband trout population is currently unknown in Bear Creek, but likely depressed compared to historical numbers. Sanford Creek and many of the Bear Creek tributaries have not been surveyed for aquatic life.

2. Much of the basin has fragmented and isolated populations due to current land and water management practices that have altered flows or created artificial barriers. In addition, timber harvest, livestock grazing, and road building practices on both public and private lands have altered riparian and instream conditions, reducing quality and quantity of habitat, and stream flows. The arid nature of this area of the Crooked River basin indicates that trout populations are highly vulnerable to any further habitat degradation.

3. Unscreened irrigation withdrawals on both tributaries and mainstem limits instream flows and may cause direct and indirect fish mortality.

MANAGEMENT DIRECTION

POLICIES

Policy 1. **Wild redband trout in the Crooked River and tributaries above Prineville Reservoir will be managed for natural production consistent with the Wild Fish Management Alternative for trout (ODFW 1987a).**

Policy 2. **Naturalized brook and brown trout in the Crooked River and tributaries above Prineville Reservoir will be managed for natural production consistent with the Basic Yield Alternative for trout (ODFW 1987a).**

Policy 3. **The South Fork Crooked River above Prineville Reservoir will be managed for natural and hatchery production consistent with the Trophy Fish Management Alternative for trout (ODFW 1987a).**

Policy 4. **Releases of hatchery rainbow trout in the South Fork Crooked River will be confined from RM 0 to RM 22.**

Policy 5. **Smallmouth bass and brown bullhead will be managed for natural production consistent with the Basic Yield Alternative for warmwater fish (ODFW 1987b). Hatchery warmwater species will not be stocked.**

OBJECTIVES

Objective 1. Protect the genetic diversity, adaptiveness and abundance of wild redband trout in the Crooked River and tributaries above Prineville Reservoir.

Assumptions and Rationale

1. Redband trout, and introduced brook and brown trout, are self sustaining in the upper Crooked River basin above Prineville Reservoir. Redband trout populations have been identified on the Department's provisional list of wild fish populations and are the highest priority species for management.

2. Upper Crooked River redband trout have been identified as inland rainbow trout and are classified as a sensitive species under the state sensitive species act, and as a Category 2 candidate species under the federal Endangered Species Act. Their abundance is unknown but likely at depressed levels

3. Monitoring distribution and abundance of wild redband trout and introduced brook trout and brown trout will provide an indication of stock health and adaptiveness.

4. Due to past chemical treatment projects, wild redband trout appear to have been extirpated from the South Fork Crooked River. Extensive numbers of non-native hatchery rainbow trout have been stocked into the South Fork Crooked River since 1947.

5. Interbreeding of hatchery rainbow trout with wild redband trout may decrease genetic fitness of wild trout populations. Streams with both redband and brook trout need to be evaluated for possible interspecific competition or other detrimental impacts by brook trout to native redband trout.

6. Special angling regulations may be needed to protect stock fitness and life history characteristics and to maintain healthy redband trout populations.

7. Smallmouth bass and brown bullhead are present in small numbers in the mainstem Crooked River and lower reaches of the South Fork and Beaver Creek. Competitive social interactions between warmwater fish and trout are largely unknown.

Actions

Action 1.1 Monitor population trends of redband trout and warmwater fish in selected index reaches of the North and South forks, and mainstem Crooked River, Beaver, Bear and Sanford creeks, and tributaries.

Action 1.2 Verify and document distribution, abundance, and upper limits of rainbow trout, brook trout, brown trout, smallmouth bass, and brown bullhead in the North Fork and South Fork Crooked River, Beaver Creek and tributaries. Assess the status of sensitive redband trout populations in the upper Crooked River basin.

Action 1.3. Determine the need for additional or modified angling regulations to protect populations of wild redband trout by monitoring production, harvest, and catch rate in upper Crooked River basin fisheries.

Action 1.4 Establish baseline data and continue periodic sampling of genetic characteristics of redband trout with the use of biochemical (electrophoresis) and meristic parameters.

Action 1.5 Monitor presence and interaction between hatchery and wild rainbow trout according to provisions in the Wild Fish Management Policy (ODFW 1990) by sampling trout composition in rearing and spawning areas. Modify the numbers, locations, frequency, timing and types of hatchery rainbow trout stocked in Prineville and Antelope Flat reservoirs and private impoundments, if necessary to protect the genetic resources of wild fish. Construct screens where feasible to prevent egress of hatchery rainbow trout into streams with wild redband trout.

Action 1.6 Monitor presence and interaction between introduced brook and brown trout and native redband populations. Consider angling regulations or feasibility of removing introduced species if necessary to protect wild redband trout.

Action 1.7 Work with USFS, BLM, CREEC, private landowners, conservation groups, and other interested publics, in the development of a redband trout recovery plan for the upper Crooked River basin

complex. Determine and prioritize future work on limiting factors such as instream habitat, harvest, migration barriers, and interactions with introduced species.

Objective 2. Provide angling opportunities for wild trout in the mainstem Crooked River, North Fork Crooked River, Beaver, Bear and Sanford creeks and tributaries.

Assumptions and Rationale

1. The upper Crooked River can provide a diversity of angling opportunities including non-consumptive and consumptive uses, in different settings including easy access and remote terrain.

2. Lack of suitable salmonid habitat as a result of poor land and water-use management practices limits the ability of the South Fork and mainstem Crooked River, and Beaver, Bear, and Sanford creeks to maintain a fishery.

Actions

Action 2.1 Evaluate angling pressure and harvest rates of wild redband trout through creel surveys on key stream reaches to determine harvest effects on populations.

Action 2.2 Develop an information and education program to enhance angler awareness of the sensitive status and life history requirements of wild redband trout.

Action 2.3 Develop information brochures of flowing water bodies to highlight diverse angling and recreation opportunities.

Objective 3. Provide angling opportunities for smallmouth bass and brown bullhead in the Mainstem Crooked River and tributaries where populations of these fish currently exist.

Assumptions and Rationale

1. Smallmouth bass were stocked in South Fork Crooked River and the GI Ponds in the early 1980's and in Prineville Reservoir in the early 1960's. Brown bullhead probably were introduced into the Crooked River from a farm pond.

2. Populations of brown bullhead and smallmouth bass have colonized reaches of lower Beaver Creek and the mainstem Crooked River downstream to Prineville Reservoir.

3. Competitive social interactions between warmwater fish and trout are largely unknown.

Actions

Action 3.1 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Objective 4. Provide harvest and angling opportunities for quality size hatchery rainbow trout in a semi-remote setting along the South Fork Crooked River.

Assumptions and Rationale

1. The South Fork Crooked River can provide a unique angling opportunity, including non-consumptive use and consumptive use of trout, in a rugged, scenic, canyon setting.

2. Lack of suitable spawning and juvenile rearing habitat as a result of poor land and water-use management practices limits the South Fork Crooked River's ability to produce a fishery without annual supplementation of hatchery fingerlings.

3. Hatchery trout can grow to an average size that satisfies angler demand for a large, quality-size fish, i.e. fish from 15-16 inches. Anglers have indicated a high interest in managing this section of the river for quality size fish in a semi-remote setting.

4. Harvest and hooking mortality of trout by anglers using bait may reduce the potential abundance and catch rate below the optimum. Special harvest restrictions may be necessary to distribute the harvest over a larger number of anglers.

Actions

Action 4.1 Continue to release 15,000 rainbow fingerling at 40/lb. upstream of the confluence of Twelvemile Creek (RM 20) during summer or early fall.

Action 4.2 Evaluate optimum size, stock and time of release of hatchery rainbow trout to better meet this objective.

Action 4.3 Monitor abundance, size, and age composition of rainbow trout in South Fork Crooked River by conducting periodic angler creel and electrofishing surveys.

Action 4.4 Continue angling restrictions (i.e., 2 fish limit, exclusive use of flies, and artificial lures with barbless hooks) that allow a greater percentage of the population to reach 15 inches, optimize catch rate, and minimize hooking mortality of fish released.

Action 4.5 Investigate feasibility of developing a Crooked River redband trout strain for stocking the South Fork Crooked River.

Action 4.6 Continue to monitor the trout population for potential production of native fish.

Objective 5. Provide additional angling access and angling opportunities along the Crooked River and tributaries above Prineville Reservoir.

Assumptions and Rationale

1. Approximately 98% of the land adjacent to the mainstem Crooked River is in private ownership.

2. Approximately 51% of land adjacent the North Fork Crooked River is in private ownership.

3. Approximately 67% of the land adjacent to the South Fork Crooked River and 100 % of Beaver Creek is in private ownership.

4. There is an increasing demand for flat water or lake fishing opportunities on Ochoco Forest lands.

Actions

Action 5.1 Evaluate opportunities to develop access to private land.

Action 5.2 As opportunities become available form, partnerships with landowners or managers to provide access sites or purchase easements throughout the Crooked River and tributaries above Prineville Reservoir.

Action 5.3 Evaluate opportunities to develop public access at Upper Falls; Grays, Little Summit, Big Summit and Antler Prairies, and Peterson Creek, Shady Creek, and Allen Creek Reservoirs.

Action 5.4 Evaluate opportunities for purchase of private lands with high public fishery and riparian values for management by state or federal entities.

Action 5.5 Evaluate feasibility and opportunity to construct additional impoundments on headwater tributaries for lake fishing opportunities.

CROOKED RIVER AND TRIBUTARIES BELOW PRINEVILLE RESERVOIR INCLUDING OCHOCO AND MCKAY CREEKS

Overview

This section covers the "lower basin" which is comprised of the Crooked River from Bowman Dam downstream to Lake Billy Chinook (RM 70 to RM 6), and Ochoco and McKay creeks (Figure 4). The lower 6 miles of the Crooked River was impounded by Round Butte Dam to form Lake Billy Chinook. Ochoco Reservoir and Lake Billy Chinook are covered in separate sections. The lower basin has approximately 70 miles of mainstem river and several hundred miles of tributaries. McKay and Ochoco creeks are major tributaries and arise in the Ochoco Mountains at elevations of 5,000 to 7,000 feet. The drainage area of the entire Crooked River basin at Lake Billy Chinook is approximately 4,300 square miles, while the drainage area at Bowman Dam encompasses approximately 2,700 square miles.

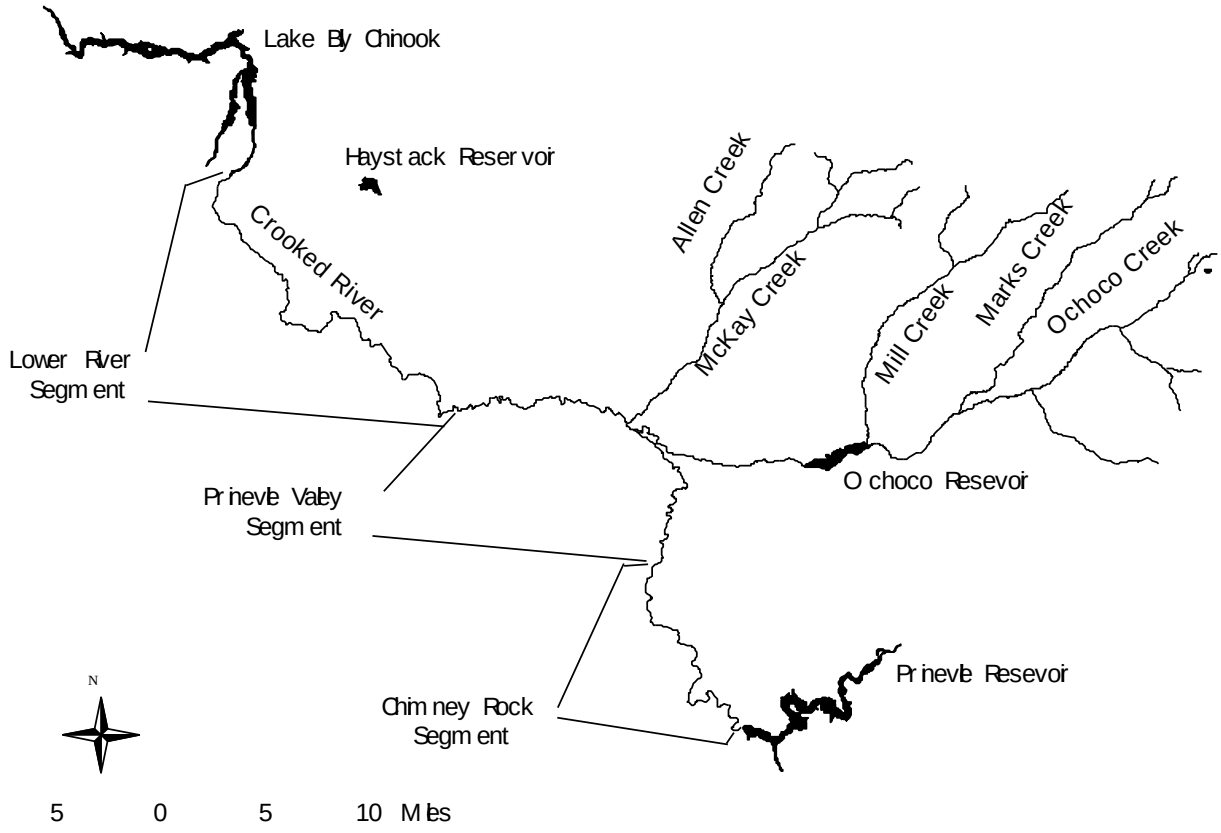

Figure 4. The lower Crooked River basin, including the McKay Creek and Ochoco Creek drainages.

Redband (inland rainbow) trout are the primary native game fish in the lower basin. Hatchery rainbow trout are stocked in Ochoco Creek. Fish populations in the Crooked River below Bowman Dam, and in Ochoco Creek below Ochoco Dam, are a mixture of native redband trout and hatchery rainbow trout, mountain whitefish, and indigenous nongame species. Fish populations in Ochoco Creek above Ochoco Reservoir and in McKay Creek are native redband trout and indigenous nongame species. All reaches of the mainstem Crooked River below Bowman Dam are presently managed for wild rainbow trout with some hatchery trout emigrating from Prineville Reservoir (Table 6). Ochoco Creek above the reservoir and McKay Creek are managed for wild rainbow trout, while Ochoco Creek below the reservoir is managed for hatchery rainbow trout.

Table 6. Rainbow trout fish management in the Lower Crooked River basin.

Water Body	Fishery	Production	Stocking
Lower Crooked River			
Chimney Rock	Consumptive/Non Consumptive	Wild & hatchery	None
Prineville Valley	Consumptive/Non Consumptive	Wild & hatchery	None
Lower River	Consumptive/Non Consumptive	Wild & hatchery	10,000 catchable
Ochoco Creek			
Above Ochoco Res.	Consumptive	Wild	None
Below Ochoco Res.	Consumptive	Hatchery	3,000 catchable
McKay Creek	Consumptive	Wild	None

Many local anglers have expressed concern over the lack of lake habitat available for angling in the Ochoco Mountains. Walton Lake, Allen Creek Reservoir, Delintment Lake, and Antelope Flat Reservoir provide some lake fishing, but do not meet the growing demand. A group of concerned citizens are currently looking at issues and concerns related to the proposed development of additional reservoirs in the Ochoco Mountains to provide new fishing opportunities. The development of additional storage reservoirs in the lower basin may create additional burdens on native fish populations in this portion of the basin.

CROOKED RIVER BELOW BOWMAN DAM

The mainstem Crooked River below Bowman dam is further divided into three sections: the **Chimney Rock section** (RM 70 to 57), the **Prineville Valley section** (RM 57 to 34), and the **lower river section (**RM 34 to 6). Bowman Dam discharges regulated releases of water during the irrigation and non-irrigation season into the river below. Flow releases from Bowman Dam are regulated by the BOR and managed by the Ochoco Irrigation District (OID). The river flows through a variety of geological

formations and plant communities, ranging from narrow basalt canyons to a wide agricultural valley. The upper and lower portions of the river flow through steep impressive canyons with basalt and volcanic ash formations.

Location and Ownership

The BLM administers most of the land adjacent to the **Chimney Rock section**. A small portion is in private ownership. A large portion of the Chimney Rock section was included in the federal Wild and Scenic River system in 1988. Outstandingly remarkable values included scenic, recreation, and fishery values. Environmental Assessment and Management Plans for the Wild and Scenic portion were completed in 1992 (USDI 1992a, 1992b).

The **Prineville Valley section** meanders through a wide flood plain with little confinement by geological formations. Virtually all of the land adjacent to the river is privately owned. Land use and water utilization on private lands through the valley is for livestock grazing and irrigation for crop production. Major crops include alfalfa, mint, wheat, and potatoes. Land use within the urban growth boundary includes residential homes, a city owned golf course, the Les Schwab industrial complex, and the Prineville sewage treatment facility.

The **lower river section** flows through a narrow basalt canyon. Adjacent land upstream of Highway 97 is privately owned with the exception of Smith Rock State Park (RM 23 to 26). The lower river section downstream of Highway 97 is approximately 47% public with a mixture of BLM and USFS ownership. In 1988, a portion of the lower river from the National Grassland boundary below Highway 97 downstream 9.8 miles to Lake Billy Chinook was included in the federal Wild and Scenic River system. Outstandingly remarkable values included scenery, recreation, wildlife, botany, cultural resources, geology, and hydrology. Environmental Assessment and Management Plans were released in 1992 (USDI et al. 1992a, 1992b).

Habitat and Habitat Limitations

In the **Chimney Rock section**, cold water releases from Prineville Reservoir have substantially improved water quantity and fish habitat. Flows are typically 200-250 cfs during the summer irrigation season, and 30-75 cfs during the winter storage season. Flows since construction of the reservoir have been as low as 10 cfs during the winter time during reservoir storage, the minimum flow required by the project, and as high as 3,100 cfs, the legal maximum, during high runoff events.

Average annual discharge at Bowman Dam is approximately 235,000 to 273,000 acre feet. The highest recorded flow in Crooked River was 8,410 cfs in March 1952, and no flow was present during dam construction in August of 1959. The discharge has been reduced to 0 cfs for up to 2 hours annually during inspections of the gate and stilling basin by BOR personnel, which has caused some stranding and mortality of fish and aquatic insects.

The cold water discharged from the reservoir has created a "tailrace fishery" in the Chimney Rock section, similar to that observed in rivers below other major impoundments. Summer water temperatures in this section average 47^{o}F to 50^{o}F with a maximum of 54^{o}F, while winter temperatures average 37^{o}F to 40^{o}F with a minimum of 32^{o}F. Water discharged from the reservoir rarely exceeds 54^{o}F, but is frequently turbid due to sediments suspended in the water at Prineville Reservoir. Studies indicate that the cold, deep layers of water in the reservoir have collected silt and sediments from erosion in the watershed above the reservoir (Silvernale et al. 1976). The water in the Crooked River is generally turbid throughout the lower basin downstream to RM 16 where sufficient spring inflow contributes to good water clarity and cooler river temperatures.

While cold water releases have improved flows, variable discharges at the dam have created problems and issues somewhat unique to the lower Crooked River from the remainder of the basin. One problem is nitrogen supersaturation caused when water is spilled over Bowman Dam or high volumes are released through the outlet structure. In April 1989, during a high water event, gas bubble disease was observed in over 85% of the rainbow trout captured during electrofishing surveys in the Crooked River from Bowman Dam downstream to Prineville. Nitrogen supersaturation in the water, entrained as the water is discharged into the stilling basin, was recorded with a saturometer as high as 109%, 2 weeks after the water had been discharged at this level. One month later, saturation levels were still at 108%, recorded at 0.5, 3, and 5 miles below Bowman Dam. These levels cause mortality in egg and fry stages and cause serious fin erosion and disease in older age classes. Modification of the dam's discharge tube, spillway and stilling basin is recommended to eliminate this problem during high water discharge.

A second issue is the “reverse" flows that occur due to irrigation and the effect on riparian vegetation. While the tailrace discharge from the dam overall has improved flows for the fishery in the lower 12 miles below the dam, the high summer irrigation flows and low winter storage flows are a reverse of natural flows. Typical natural streamflows are high flows in late winter and low flows in summer and early fall. Reverse flows of the lower Crooked River in the Chimney Rock Segment appear to limit growth of streamside vegetation during the growing season. High quality riparian vegetation may never grow in this reach with flows managed for irrigation.

A third issue unique to the lower Crooked River is the potential to allocate uncontracted storage in Prineville Reservoir to improve river flows. In 1992, an Instream Flow Incremental Methodology (IFIM) study on the Crooked River was jointly

funded by the ODFW, BLM, and BOR. The objective of the IFIM study was to determine the incremental value of additional water in the river for improving downstream fisheries and recreation. Uncontracted storage in Prineville Reservoir of 54,700 acre feet may be available to the state of Oregon for purchase, contingent upon Congressional reauthorization of the project, for retention in the reservoir and release into the Crooked River. Results of the study indicated that optimal fish production in the Chimney Rock segment occurs with flows of approximately 75-150 cfs for fry and juvenile redband trout, while optimal production for spawning and adult redband trout occurs at flows exceeding 200 cfs (Figure 5) (Hardin 1993).

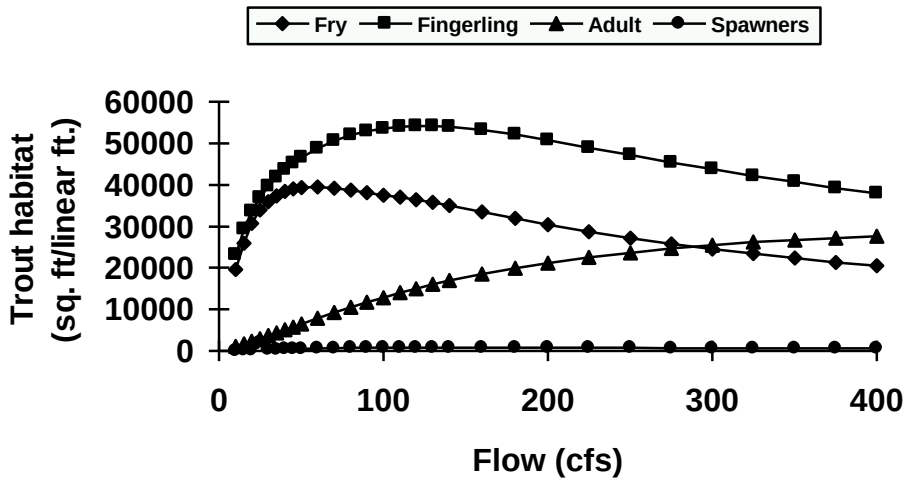

Figure 5. Estimated trout habitat versus flow for riffles in the Chimney Rock segment of the Crooked River as determined through an Instream Flow Incremental Methodology study (adapted from Hardin 1993).

A fourth problem or issue is the very high turbidity levels in the Crooked River. High turbidity and sedimentation result from water discharged from the deep water layers of Prineville Reservoir and consequently limits aquatic life and fish production in the lower Crooked River.

Poor riparian condition, withdrawal of most of the streamflow, and poor water quality characterizes the **Prineville Valley section**. Degraded habitat conditions are exacerbated by withdrawal of most of the flow by the Crooked River Feed Canal (RM 57) which diverts 160 to 180 cfs during the irrigation season. Although the diversion is screened, it is poorly designed and many hours are spent salvaging up to 4,000 rainbow trout and whitefish in the canal annually. Other diversions, which are all unscreened and are partial or complete barriers to fish migration, include the Rice Baldwin Ditch at RM 57, People's Irrigation Ditch at approximately RM 50, and several smaller diversions below the city of Prineville down to approximately RM 18. These diversions remove most of the remaining flow and leave the Crooked River below Prineville with very low flows during the summer. Through the entire valley segment, flow remains low during

the irrigation season and water temperatures are high. Some irrigation return water from Ochoco and McKay creeks augments flows although additional irrigation diversions downstream continue to withdraw water from the Crooked River.

The city of Prineville sewage treatment facility has contributed to poor water quality. Prior to 1992, discharges into the river (RM 47) chronically violated state water quality standards for nitrates, total dissolved solids, and other parameters. The Prineville Meadow Lakes Golf Course was constructed by the city in 1992 with a grant from the Environmental Protection Agency (EPA), and designed to irrigate with diluted sewage water during the growing season. Diluted sewage is still discharged into the Crooked River during the winter months and only meets state water quality standards when the river discharge exceeds 50 cfs. During drought years, winter flows in the river have ranged from 10 to 50 cfs, resulting in chronic water quality violations in the lower Crooked River downstream of the city of Prineville.

From the city of Prineville downstream to the Highway 97 bridge, low flows and low shade have resulted in summer stream temperatures as high as 80^{o}F. Water quality conditions for the entire lower Crooked River were reported to be moderate to severe for water quality, fish, and aquatic life (ODEQ 1988). The river meanders through the valley with little confinement and has a low gradient of 0.1 to 0.2%. The IFIM study suggested that higher flows would be required to obtain optimal production of adult and spawning redband trout in the Prineville valley section.

The reach of the **lower river section** from Forest Crossing down to Highway 97 bridge is a mixture of a boulder strewn riffles and long glides with a low gradient (0.2 to 1.0%). The lower canyon below Highway 97 bridge is a mixture of high gradient boulder reaches and long slow glides.

At RM 28, several miles below Forest Crossing, the North Unit Irrigation District (NUID), withdraws the remaining "natural flow", an average of 70 cfs, with a pump and flume system that diverts water to Haystack Reservoir for delivery in the Culver-Madras area. A minimum flow of 10 cfs is bypassed below the NUID pumps. As with the other two sections, the IFIM study suggested that higher flows would be required to obtain optimal production of adult and spawning redband trout.

In the lower river section below Highway 97, the remote canyon and relatively undisturbed character have resulted in a near pristine riparian condition with a diversity of streamside species including willow, alder, cottonwood, aspen, birch, dogwood, chokecherry, and rose. At Highway 97 (RM 18), springs begin to augment flows and contribute significantly to constant water flow, cooler water temperatures, and water quality. These springs are increasingly larger as the river flows north, with Opal Springs discharging up to 240 cfs, and the river averaging over 1,550 cfs at Lake Billy Chinook. With the addition of spring inflow, water quality and temperatures improve substantially for supporting coldwater fish species.

Opal Springs Dam is a small hydroelectric dam operated by the Deschutes Valley Water District, located approximately 1 mile above Lake Billy Chinook. It has been a complete barrier for migration of game fish including redband and bull trout, and mountain whitefish since the dam was renovated and retrofitted in 1982.

Access

Access is very good in the **Chimney Rock section** because most of the adjacent land is publicly owned. Only a small portion is privately owned with no public access. State Scenic Highway 27 is located in the canyon adjacent to the river and provides easy access for bank angling recreation along the east side of the river. A recent BLM survey indicated that the river receives nearly 30,000 annual visits (USDI 1992a), with fishing comprising the major activity. Several BLM campsites provide camping and day use facilities. While river flows are low much of the time, some boat access is available for a rocky trip down the river during higher spring runoff events. The BLM has issued six commercial permits for guides and outfitters on the river.

Virtually all of the land adjacent to the river in the **Prineville Valley sectio**n is private and lacks public access, with the exception of 2 small county managed parks located along the banks of the river in Prineville, Rimrock and Les Schwab parks. The Prineville Meadows Golf Course, a public owned facility managed by the city, is also adjacent to the river within the Prineville city limits, but is managed as a commercial facility with no public access to the river.

The **lower river section** has limited access due to private ownership upstream of Highway 97. Smith Rock State Park (RM 23 to 26) provides some public access. Downstream of Highway 97, adjacent lands are mostly publicly owned, but access is extremely limited by the sheer canyon walls. The lower canyon is managed as a "natural river area" along the entire corridor with an emphasis on semi-primitive non-motorized experiences between rims, and roaded natural experiences on the rim plateaus (USDI and USDA 1992). Trail access is available from the private facility at Opal Springs, operated by the Deschutes Valley Water District. The Hollywood Trail at Crooked River Ranch also traverses primarily private land to access the canyon floor. There are also several user developed, and often dangerous, rock scrabble trails from the western rim. Private landowners and the Crooked River Ranch have developed three overlooks on the lower Crooked River for scenic viewing.

The lower river section is navigable by expert kayakers during high water flows from New York Rapids (at the NUID flume) to Opal Springs and is extremely rocky and very difficult. This section attracts regional and national use by individuals with expert skills, providing a truly wild and challenging recreational experience (USDI and USDA 1992).

The navigability of the Crooked River below Bowman Dam has not been established. However, the Division of State Lands has determined that there is

sufficient evidence to claim navigability and state ownership for the beds and banks of the Lower Crooked River.

Fish Resources

The **Chimney Rock section** presently supports a mixture of native redband trout, hatchery rainbow trout, and mountain whitefish, and are the principal fishery management concern. Hatchery fish are not stocked in the river, but emigrate from Prineville Reservoir through an unscreened outlet. The river also supports small numbers of smallmouth and largemouth bass, brown bullhead and very low densities of nongame fish.

The **Prineville Valley section** supports several species of indigenous nongame fish including longnose and speckled dace, sculpin, northern squawfish, chiselmouth, and bridgelip and largescale sucker. Redband trout and mountain whitefish are present in very low densities throughout this reach.

The **lower river section** upstream of Opal Springs supports native redband trout and the customary assemblage of nongame fish. Below Opal Springs Dam, kokanee, mountain whitefish, redband, bull, brown, and hatchery rainbow trout are present.

Fish Stocking History

A limited number of hatchery fish were stocked in this portion of the basin during the late 1920's and early 1930's. A total of 20,000 eastern brook trout were stocked in the Crooked River in 1929 and 1932. The exact stocking location is unknown. Most hatchery stocking in the Crooked River occurred after the completion of Bowman Dam. Thereafter, the Crooked River was stocked with up to 90,000 fry and fingerling rainbow trout and up to 10,000 catchable rainbow trout from 1962 to 1970. Catchable sized trout were stocked in 1973 from a salvage project and again in 1975. Over 230,000 kokanee fry were stocked in 1970.

No hatchery fish have been released directly in the Chimney Rock or Prineville Valley sections of the river since 1975. However, fingerling hatchery fish released into Prineville Reservoir appear to emigrate during reservoir drawdown or spill events and provide a substantial portion of the fishery in some years. Fin marking studies conducted on Prineville Reservoir in the late 1960's and early 1970's, combined with creel surveys on the Crooked River, indicated that from 6 to 26% of the fish harvested in the river were hatchery fish from the reservoir.

In 1993, 1994, and 1995, all Prineville fingerling rainbow trout were marked with an adipose clip to assess emigration into the river below. To date, less than 1% of the fish sampled during electroshocking surveys have been fin clipped and none have been

observed in the creel; however, severe drawdown or spill has not occurred since these fish were stocked in the reservoir.

Hatchery rainbow and brown trout have been released by the Deschutes Valley Water District hatchery at Opal Springs since the dam was rebuilt in 1982. These fish are released downstream of the dam. Currently, 10,000 rainbow trout and 1,000 brown trout are released annually. All fish are fin clipped. Spring chinook salmon were occasionally released there in the late 1980's.

Angling Regulations

Until 1980, the trout bag limit was 10 fish per day, over 6 inches, with angling allowed from late April to the end of October. From 1980 to 1988, the trout bag limit was reduced on the Crooked River, along with statewide regulations, to 5 trout per day with a 6 inch minimum.

Current angling regulations from Bowman Dam to Lake Billy Chinook are a 5 trout per day bag limit, 6 inch minimum with no more than 1 over 20 inches, with bait and barbed hooks permitted, during the regular trout season from late April to the end of October. Since 1988, the lower Crooked River has been open to angling in the winter from November 1 to late April for catch and release only with barbless flies and lures and no bait. This winter fishery has become a very popular fishery, particularly with fly anglers from central and western Oregon and provides a scenic winter angling opportunity when most rivers and streams are closed for angling.

In recent years, fly angling groups have expressed interest in more restrictive angling regulations for the 12 mile reach below Bowman Dam, including area, gear, bag limit, and tackle restrictions. Thirty angling regulation proposals were received in October 1992 for changes in harvest regulations on the Crooked River.

Numerous large rivers in central Oregon, including the Deschutes, Metolius, Williamson, and Wood rivers have restricted and special angling regulations. The Crooked River is one of the last remaining large rivers with no special regulations other than the winter fishery. The Crooked River is also very popular for camping and fishing by family groups and provides an opportunity for juveniles to recreate on a big river with a reasonable chance at catching fish.

Fish Management

The Crooked River below Bowman Dam is presently managed as a basic yield "wild plus hatchery rainbow trout" river. Although hatchery fish are not directly stocked into the river, the unscreened outlet at Bowman Dam allows the emigration of substantial numbers of hatchery trout in low water years when the reservoir is drawndown, and during spill events in high water years.

Rotenone projects above and below Prineville Reservoir were conducted in the early 1960's in anticipation of completion of Bowman Dam, to eliminate abundant nongame fish populations of suckers and squawfish. In 1960, 91.5 miles of the upper Crooked River system were treated. In 1963, the lower Crooked River from the Rice-Baldwin Dam (RM 57) to Smith Rock State Park (RM 23), and the lower 4 miles of Dry Creek were treated with rotenone. Following the 1963 treatment project, the river was restocked with hatchery rainbow trout fingerlings and catchables. Native rainbow trout remained in the 12 mile reach of the lower Crooked River between Bowman and the Rice Baldwin dams and in the Crooked River below Smith Rock State Park.

Electrofishing surveys have been conducted in 1989, 1993, 1994, and 1995 in the **Chimney Rock section** to assess rainbow trout abundance. Rainbow trout were the dominant species observed in 1989, comprising 86% of the fish observed. Other species observed in this reach were mountain whitefish, largescale sucker, and brown bullhead. In 1994, mountain whitefish comprised 81% of the sample in the 2 mile reach below Bowman Dam, while redband trout were 14% of the sample, and brown bullhead, sculpin, smallmouth bass, and northern squawfish were the remainder. While mountain whitefish may compete with trout for food resources, particularly immature aquatic insects, both populations of whitefish and trout have shown a dramatic increase in recent years. Rainbow trout abundance was estimated at 826 trout per mile in 1989, 2,289 trout per mile in 1993, 8,228 trout per mile in 1994, and 6,098 trout per mile in 1995. These estimates reflect an 8 to 10 fold increase in abundance since 1989, possibly in response to increased winter flows from a low of 10 cfs in 1988 to flows from 30 to 75 cfs from 1989 to 1995.

Factors that may have introduced error into our trout abundance estimates were sampling area and river discharge. The 1989 sample area was the first 5 miles below Bowman Dam, while the 1993-1995 sample area was the first 2 miles below Bowman Dam. River discharge was approximately 1200 cfs in 1989, 250-350 cfs in 1993, less than 250 cfs in 1994, and 300-350 cfs in 1995. Therefore estimates made in 1989 may not be exactly comparable with those completed afterwards.

High trout abundance in the river may be limiting growth due to competition for food resources and space. Length at age analysis from scale samples collected in 1989 and again in 1994 suggests that fish captured in 1989 had better growth, particularly for fish over 2 years of age (Figure 6). Anglers have complained about the high abundance of 8 to 9 inch fish and the lack of large quality sized fish in 1993 and 1994, prompting the concern for reducing bag limits for trout during the bait season. If trout abundance estimates are reasonably accurate and there is competition for limited food and space resources, reduction of the bag limit could cause further overcrowding and reduction in growth rates.

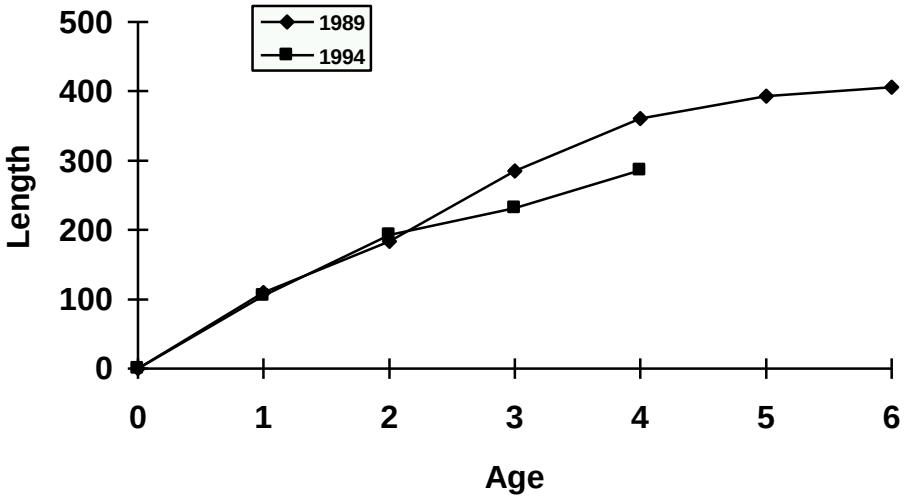

Figure 6. Back calculated total length at annulus formation for rainbow trout captured in the Crooked River (RM 65 to 70).

Preliminary results from ongoing genetics sampling in the Crooked River basin indicate that rainbow trout from the Crooked River belong to the inland rainbow redband trout evolutionary line (Currens 1994). An unusual frequency of one particular allele was found in many of the 21 populations sampled and suggests that they have diverged from other inland rainbow trout groups. While Crooked River basin redband trout do not show strong evidence of hatchery introgression, the population in the Chimney Rock section was among a group of populations in the basin showing the highest introgression effects.

A recent BLM survey identified angling as the number one recreation activity within the Chimney Rock section (USDI 1992a). While the fishery is not in optimal condition, it has the potential to provide "blue ribbon" fishing opportunities. The Crooked River has local and regional acclaim for a quality fishing experience in a scenic canyon with a reasonable chance of landing numerous trout.

Angling surveys were conducted from May to October in 1972 and from late April through June in 1989. The 1972 survey indicated that approximately 16,950 anglers spent over 95,000 angler hours fishing the Chimney Rock section, and landed over 42,000 rainbow trout. The May and April estimates for 1972 were over 7,500 anglers spent nearly 50,000 hours angling, and landed 15,200 trout. This compares to the 1989 survey when an estimated 5,677 angler hours were expended to harvest 2,252 trout from late April through June.

Angler preference surveys were conducted in 1974 and again in 1989 during the creel survey. The 1974 survey surveyed 234 anglers from April 27 to September 15, and indicated that 68% of the anglers had traveled greater than 50 miles to fish the river, 87% were opposed to flies and lures only, 92% were opposed to a 2 trout bag

limit, and 95% were opposed to catch and release angling. The 1989 survey interviewed anglers from opening day in late April through June. The survey revealed that 80% of the anglers were from the Portland area or the westside, 17% from central Oregon, and 3% were from out of state. The anglers indicated a similar preference to the 1972 survey in that 76% favored the present angling regulations, 91% were opposed to a bag limit reduction, and 89% were opposed to flies and lures only. The winter catch and release fishery was opened in 1988 and has gained popularity in the past few years. Fly angling has also grown in popularity. A preference survey that assesses the regular trout season and the winter fishery should be conducted to determine current angler preferences.

Electroshocking was also conducted in the **Prineville Valley section** in 1989 and 1993. A five mile reach from the mouth of McKay Creek downstream to the Sigman Ranch (RM 45 to 40) was sampled in 1989. On the single pass from the mouth of McKay Creek downstream, only 11 rainbow trout were captured. They comprised 20% of the total fish captured. Mountain whitefish were the dominant species observed, and were 55% of the sample, with largescale sucker, bridgelip sucker, northern squawfish, and chiselmouth comprising the remainder. An 0.7 mile reach on the Quail Valley Ranch (RM 56 to 55) was surveyed in 1993. The redband trout population was estimated to be 142 fish per mile. This substantially lower trout abundance occurs because a majority of the water is diverted into the Crooked River Feed Canal (RM 56) during the irrigation season, leaving this section of the river with low flows and high water temperatures.

The most abundant game fish in this section is mountain whitefish, although they are not actively sought by most anglers. Mountain whitefish were the dominant species observed in all sampling areas in 1989 and 1993. In the Quail Valley Reach, trout comprised less than 6% of the fish captured, and mountain whitefish comprised approximately 56% of the fish captured, while largescale sucker, bridgelip sucker, smallmouth bass, chiselmouth chub, and dace species comprised the remainder.

Rainbow trout in the **lower river section** are also managed as a basic yield "wild plus hatchery trout" resource, but likely have a much lower abundance of hatchery rainbow trout. From sampling conducted while collecting fish for genetics analysis, wild redband trout appear to be abundant and natural production appears adequate. *Ceratomyxa shasta*, a myxosporan parasite which is lethal to domestic stocks of hatchery rainbow trout stocked in Ochoco and Prineville reservoirs, may kill any hatchery fish that migrate to this area. *Ceratomyxa* is known to occur in the lower canyon of the Crooked River at Opal Springs. Testing of resistant and non resistant stocks of fish in 1990 at several sites on the Crooked River from the reservoirs downstream to Lake Billy Chinook, indicated that *Ceratomyxa* is endemic somewhere in the river reach below the Highway 97.

The Opal Springs facility has operated a small fish hatchery with a minimum annual release of 1,000 fish as mitigation for lost fish passage and mortality of game fish in the turbines. However, with recent direction to evaluate compliance of fish

hatchery releases in flowing waters occupied by wild fish, the release of hatchery fish into the 1 mile segment of the Crooked River below Opal Springs is probably not in compliance with the Wild Fish Policy. There is also limited public access to the angling area, with a locked gate at the rim of the Crooked River canyon and minimal trail development.

Management Issues and Concerns

1. Habitat issues related to protection and restoration of habitat, restoration of instream flows, water quality, and passage, including Opal Springs and irrigation dams, are addressed in the habitat section of the basin plan.

2. Rainbow trout appear to be abundant in the lower Crooked River in the first 12 miles below Bowman Dam. An unknown number of hatchery rainbow trout emigrate from the reservoir either during spill or low pool drawdown events that contribute to the fishery. It is unknown if the population is in compliance with Wild Fish Policy which limits hatchery fish to no more than 10% of the spawning population.

3. Genetics information is being collected to delineate redband trout populations. Preliminary data suggests that Crooked River redband trout may have diverged from other inland rainbow trout groups. Fish in the Chimney Rock segment show among the highest level of introgression effects, compared to other populations in the basin.

4. Only one diversion on the lower Crooked River is screened. Unscreened diversions, including pumps and ditches cause fish mortality. The Crooked River Feed Canal diverts most of the water from the Crooked River. Although it is screened, the screen is located 1.5 miles below the intake, and is ineffective. An annual fish salvage is conducted on this portion of the canal in the fall. Screening diversions and irrigation dams will be addressed in the habitat section of the basin plan.

5. Uncontracted storage is available in Prineville Reservoir, contingent upon Congressional reauthorization of the Crooked River Project, for improvement of reservoir and downstream fisheries. Negotiations have broken down between irrigation and recreation interests on first in right for refill. Other concerns are cost of acquiring the water and operation and maintenance costs for regulating flows.

6. Nitrogen supersaturation causes disease and mortality during high discharge events both from the outlet and spillway.

7. Diluted sewage is still discharged into the Crooked River during the winter months and only meets state water quality standards when the river discharge exceeds 50 cfs.

8. Annual inspections of the stilling basin and periodic inspections of the gates require discharge to the river be temporarily stopped and cause dewatering of the river and mortality to fish and other aquatic life.

9. Hatchery releases at Opal Springs may not be consistent with Wild Fish Policy and management direction in the lower river.

10. There is interest in restricted angling regulations by fly angling groups to provide a trophy fishery.

OCHOCO CREEK

The Ochoco Creek basin comprises approximately 150 miles of stream, and drains an area of about 360 square miles. Two major tributaries flow into Ochoco Creek, Mill Creek at RM 14, immediately above Ochoco Reservoir, and Marks Creek at RM 20. Ochoco Creek is impounded by Ochoco Dam at RM 11 to form Ochoco Reservoir.

Flow releases from Ochoco Dam into Ochoco Creek are regulated and managed by the OID. A majority of the irrigation season is from early April to mid-October. Most of the flow released from Ochoco Dam is immediately bypassed into the Ochoco Canal system. Some flow is discharged into the creek below for several diversions located downstream of the dam through the city of Prineville. Flows to the creek are typically shut off in mid-October, and consequently the stream goes dry for up to 6 miles below the dam. Seepage and subsurface movement of water has usually restored a small amount of flow near Prineville, and for the remaining 5 miles downstream to the Crooked River. However, with the recent dam repair and reduction in dam seepage, it is uncertain how much of this winter flow will be maintained.

Location and Ownership

Headwaters and tributaries of Ochoco Creek arise on the Ochoco National Forest, with much of the lower reach on private lands. Approximately 75% of the land ownership along Ochoco Creek above the reservoir is private, with the remaining in USFS. Approximately 48% of the Ochoco Creek basin lies on USFS, 1% on BLM lands, and 51% on private lands. Land use and water utilization on private lands along Ochoco Creek above the reservoir are primarily for livestock grazing, timber harvest, and irrigation, while public lands on USFS are used for livestock grazing, timber harvest,

and recreation. Land and water use below Ochoco Reservoir is for crop and livestock production.

Ownership of lands along most of Ochoco Creek below the dam is private. However, Crook County Parks and Recreation manages Ochoco Creek Park and a narrow greenway along the creek through the town of Prineville. Most of the floodplain along Ochoco Creek through the town of Prineville is occupied by residential homes, the Crook County High School, and light industrial buildings.

Habitat and Habitat Limitations

Ochoco Creek and its tributaries flow through a variety of plant communities, ranging from relatively level wet meadows to narrow forested canyons. Upper reaches flow through high elevation areas of narrow valleys or steep v-sided canyons. The lower reaches below the Forest Boundary flow through broader valleys with agricultural lands primarily used for livestock and hay crop production.

Habitat surveys were conducted by USFS and ODFW personnel on Ochoco Creek in 1979, and Marks and Mill creeks in 1977. Ochoco Creek and many of its upper tributaries were in moderate to good habitat condition, although stream shade averaged 33%. Streamflow was continuous and ranged from 0.2 cfs at the outlet of Walton Lake to 10 cfs at the Forest Boundary. Canyon, Fisher and Judy creeks have been impacted by past mining activity. The stream reaches with the best riparian conditions were upper reaches of Canyon and Ochoco creeks. Monitoring of stream temperatures in recent years has indicated many USFS streams exceed state water quality standards of 58^{o}F for the Deschutes River basin (USDA 1992, 1993, 1994).

Surveys on Marks Creek indicated that livestock grazing, irrigation structures, and channelization of the stream have had adverse impacts on water quality, fish habitat, streamside cover, and bank condition. Up to 80% of the banks were eroding and grab sample water temperatures were recorded as high as 73^{o}F, although higher temperatures are likely. Average shade was 10-30% on Ochoco Forest lands and 0-20% on private lands. A small livestock exclosure on portions of Marks Creek has contributed to riparian vegetation and streambank recovery in the past 12 years.

Surveys on Mill Creek also indicated that livestock grazing , irrigation withdrawal and dams, and channel alteration have negatively affected water quality, fish habitat, streamside cover and bank condition. Recorded water temperatures reached 78^{o}F on Mill Creek and 80^{o}F on the West Fork of Mill Creek.

Irrigation diversions on Ochoco, Marks, and Mill creeks below the Forest boundary divert most of the flow. For example, there are over 100 cfs of catchable out of stream water rights for appropriation on Ochoco Creek. Ochoco and Mill creeks are frequently dry before reaching Ochoco Reservoir during July, August and September.

Ochoco Creek was withdrawn from further appropriation in 1915 when it was recognized that the stream was over appropriated.

Elevated mercury levels have been documented in fish collected in Ochoco Creek and Ochoco Reservoir, likely from inactive mercury (cinnabar) mines located at the headwaters of Canyon Creek (Allen-Gil et al. 1995). A two year old fish collected from Ochoco Reservoir had mercury levels exceeding 0.5 mg/l, approaching the state legal limit of 1.0 mg/l. Older age fish typically have greater levels of bioaccumulated mercury, suggesting that 3 to 4 year old fish may reach or exceed the state health standard. Fish collected in 1994 exhibited a mean level of mercury, 61 mg/l, just above the level that would warrant posting signs at the reservoir (ODEQ, unpublished data).

Access

Headwater reaches of Ochoco Creek and its tributaries are on USFS and offer easy public access. Many streams are bordered by gravel or paved roads. Opportunities for enhancing recreation on pubic lands include riparian restoration, trail development, and interpretive work. The majority of lower Ochoco Creek is on private land and offers limited opportunity for public recreation. A greenway which includes Ochoco Creek Park is adjacent to the creek within the city limits of Prineville

Fish Resources

Ochoco Creek basin above the reservoir supports indigenous redband trout. Lower Ochoco Creek, below Ochoco Dam, supports a mixture of wild and hatchery rainbow trout, and mountain whitefish. Some hatchery rainbow trout in Ochoco Reservoir may move upstream into Ochoco Creek and its tributaries above the reservoir. A small spawning run of rainbow trout, coming from the reservoir, has been observed in the spring at the mouths of Mill and Ochoco creeks by anglers and Oregon State Police. Ochoco Creek supports several species of indigenous nongame fish including longnose and speckled dace, sculpin, and bridgelip and largescale sucker. Squawfish were also reported in an early Game Commission Report (OSGC 1950), but have not been observed in recent years.

Brook trout and brown bullhead were recently discovered in Walton Lake at the headwaters of Ochoco Creek. The lake also is stocked annually with up to 15,000 catchable sized rainbow trout. For a majority of the year, there is little to no flow escaping the lake. However, the lake has an unscreened outlet, and during runoff, these non-native fish have the potential to escape to Ochoco Creek below. Once in Ochoco Creek, brook and hatchery rainbow trout have the potential to become established in the stream system and compete with native redband trout for food resources and habitat.

Fish Stocking History

The headwater reaches of Ochoco Creek and some tributaries were stocked sporadically with a mixture of fry, fingerling, or catchable sized hatchery rainbow trout from the late 1940's to the mid 1970's. Ochoco Creek was stocked below the reservoir from 1945 to 1948 with up to 20,000 fingerling or fry. From 1949 to 1958, it was sporadically stocked with 1,000 to 3,000 catchable rainbow trout. From 1963 to 1975, the creek was stocked above and below the reservoir, with up to 8,000 catchable rainbow trout although the majority of the fish went below the reservoir. From 1975 to 1993, 6,000 catchable rainbow trout were stocked below the reservoir. Since then, Ochoco Creek has had an annual stocking below the reservoir of approximately 3,000 catchable rainbow trout. These fish are scattered at several access points in the city limits of Prineville, primarily to provide a fishery for juvenile and senior citizens. The remaining 3,000 fish are now stocked in Walton Lake instead of the creek. Ochoco Creek above the reservoir has not been stocked since 1975.

Other Ochoco Creek tributaries that have been stocked with rainbow trout include Canyon, Wolf, Mill and Marks creeks. Canyon Creek was stocked in 1945 and 1947 with 15,000 to 20,000 rainbow trout fry while Wolf Creek was stocked in 1945, 1948, 1958, and 1962 with up to 6,000 fingerling rainbow trout. Mill Creek was stocked with fry and fingerling rainbow trout in 1947 and 1953. Catchable rainbow trout were occasionally stocked from 1958 to 1981 with up to 2,000 to 4,000 fish. Whiskey Spring Reservoir, in the headwaters of Mill Creek was stocked once in 1952 with 6,000 fry.

Marks Creek was stocked with rainbow trout fry and fingerling from 1945 to 1948, and then a sporadically stocked from 1949 to 1975 with 2,000 to 3,000 catchable sized rainbow trout. Catchable sized trout were stocked on an annual basis with approximately 2,000 rainbow trout until 1992 when the program was terminated due to potential non compliance with the Wild Fish Policy, adopted by the Oregon Fish and Wildlife Commission in 1990 (ODFW 1990). Surveys in the summer of 1992 indicated that hatchery fish comprised 21% of the population 2 months after these fish had been stocked.

While some hatchery introgression is likely within the Ochoco Creek sub-basin, relatively low numbers were stocked in these streams in comparison to other portions of the Deschutes River basin. Domestic stocks of Cape Cod or Oak Springs hatchery fish were used. These domestic stocks of fish are less tolerant of high summer water temperatures than native redband trout, and may have a limited ability to survive and interbreed with native fish. Recent genetic samples verify that hatchery introgression has been minimal within the basin, although Ochoco and Marks creeks populations were among a group that showed the highest effects of hatchery introgression.

Angling Regulations

Ochoco Creek and its tributaries are open to angling from late April to the end of October with a 5 trout per day bag limit, 6 inch minimum with no more than 1 over 20 inches. In October 1992, the Ochoco Chapter of Trout Unlimited proposed a regulation to restrict a reach through the town of Prineville for exclusive juvenile angling. The regulation was not approved by the Oregon Fish and Wildlife Commission. This regulation proposal is likely to be re-submitted at future angling regulation hearings.

Fish Management

Headwater streams of Ochoco Creek are managed exclusively for wild redband trout with no hatchery supplementation. The continued existence or restoration of healthy populations of redband trout in all areas where they are now present is the primary management direction. Population health is characterized by high abundance, multiple age classes and genetic fitness of the stock.

Ochoco Creek below Ochoco Dam is managed as a basic yield "wild plus hatchery rainbow trout" stream. Hatchery rainbow trout are stocked in the city limits of Prineville in the late spring to provide a fishing opportunity for city residents, particularly the youth of Prineville.

Little intensive fish management has occurred in the Ochoco Creek sub-basin. Rotenone projects were conducted above Ochoco Reservoir in 1957 and below Ochoco Reservoir in 1963 to eliminate abundant populations of suckers and squawfish. In 1957, 450 miles of the upper Ochoco Creek system were treated and included Mill and Marks creeks and numerous smaller tributaries. All tributaries were treated upstream until an impassable barrier such as a waterfall or 100 yards of creek was identified with no nongame fish species present. Fish species killed included rainbow trout, suckers, squawfish, and sculpin. Stream habitat surveys were conducted in the Ochoco Creek sub-basin during the late 1970's.

Fish management during the past 7 years has focused primarily on habitat protection and restoration, Wild Fish Policy implementation, and documenting life history, abundance and distribution of native salmonids. Considerable effort has been expended studying populations of redband trout in the Ochoco Creek sub-basin. From these surveys, we know that streams in this basin vary in habitat quality from excellent to poor. Streams with good habitat exhibit redband trout densities greater than 1 fish/yd^2, whereas those with poor habitat have redband trout densities less than 0.50 fish/yd^2. Streams with higher levels of timber harvest, livestock grazing, and an extensive road system, tend to be warmer, have less pools and complex habitat, and become intermittent sooner in the summer. Surveys also indicated that redband trout utilize intermittent streams when they have water, and that they readily recolonize those habitats when flows resume. During drought years, an entire year's juvenile production may be lost.

Management Issues and Concerns

1. Habitat issues including protection and restoration of habitat, restoration of instream flows, water quality, and passage are encompassed in the habitat section of the basin plan.

2. There is interest in a juvenile only angling area on Ochoco Creek within the city limits of Prineville.

3. Annual shutdowns of Ochoco Creek below Ochoco Dam, following the end of the irrigation season causes fish mortality in the first 6 miles of the stream.

4. Elevated mercury levels have been documented in fish from the Ochoco Creek system and may reach or exceed state standards for human consumption.

MCKAY CREEK

The McKay Creek sub-basin comprises over 50 miles of stream habitat and drains an area of about 103 square miles. Two major tributaries flow into McKay Creek, Allen Creek at RM 7, and Little McKay Creek at RM 12.

Location and Ownership

Headwaters of McKay Creek and its tributaries arise on USFS lands, while much of the lower portion is on private land. Approximately 60% of the land ownership along the mainstem of McKay Creek is private, with the remaining in USFS. Approximately 39% of the McKay Creek basin lies on USFS land, 3% on BLM, and 58% on private lands. Land use and water utilization on private lands along McKay Creek is primarily for livestock grazing, timber harvest, and irrigation for crop production, while USFS public lands are used for livestock grazing, timber harvest, and recreation.

Habitat and Habitat Limitations

Habitat condition and limitations in the McKay Creek sub-basin are very similar to those in the Ochoco Creek sub-basin. The upper portions of the sub-basin originate in public and private owned mixed conifer forests. Up to 65% of the stream has been channelized or altered. Shade is typically 0-30% while percentage of pools average less than 10%. Water temperatures have been documented to reach 75^{o}F on McKay and Little McKay creeks (USDA 1992, 1993, 1994). Water quality conditions for McKay

and Allen creeks were moderate to severe for water quality, fish, and aquatic life (ODEQ 1988).

Fish kills have also been observed in the lower 4 miles of McKay Creek and have been traced to various herbicides used to control aquatic weeds in irrigation canals. Several stream-canal crossings provide entrance points for canal water containing pesticides such as acrolein, xylein, and copper sulfate and cause mortality of aquatic life.

Access

Headwater reaches of McKay Creek and its tributaries are on public and private forest land and offer easy public access. Many streams are bordered by gravel or paved roads. Opportunities for enhancing recreation on pubic lands include riparian restoration, trail development, and interpretive work.

The majority of lower reaches of McKay Creek are on private lands and offer limited opportunity for public recreation. Opportunities for recreation on private lands include developing access along the creek and to private ponds.

Fish Resources

The McKay Creek sub-basin supports redband trout and several species of indigenous nongame fish including longnose and speckled dace, sculpin, and bridgelip and largescale sucker. Squawfish were also reported in an early Game Commission Report (OSGC 1950).

Fish Stocking

McKay Creek was stocked in 1964 with 4,600 catchable sized hatchery rainbow trout, and from 1965 to 1972 with 1,000 to 1,500 catchable size rainbow trout.

Angling Regulations

McKay Creek and its tributaries are open to angling from late April to the end of October with a 5 trout per day bag limit, 6 inch minimum with no more than 1 over 20 inches.

Fish Management

McKay Creek and its tributaries are managed exclusively for wild populations of redband trout without any hatchery supplementation. The continued existence or restoration of healthy populations of indigenous stocks of redband trout in all areas where they are now present is the primary management direction. Population health is characterized by high abundance with multiple age classes and genetic fitness of the stock.

Very little intensive management has occurred in the McKay Creek sub-basin. In 1963, the lower 20 miles of McKay Creek were treated with rotenone along with the lower Crooked River to eliminate non-game fish. Stream habitat surveys were conducted in the late 1970's. Like the Ochoco Creek sub-basin, fish management in the McKay Creek sub-basin during the past 7 years has focused primarily on habitat protection and restoration, Wild Fish Policy implementation, and documenting life history, abundance and distribution of native salmonids. Recent genetic samples verify that hatchery introgression has been minimal within the basin, although the McKay Creek population was among a group that showed the highest effects of hatchery introgression.

Management Issues and Concerns

1. All habitat issues including protection and restoration of habitat, restoration of instream flows, water quality, and passage are encompassed in the habitat section of the basin plan.

MANAGEMENT DIRECTION

(wild plus hatchery)

POLICIES

Policy 1. **Wild redband trout, mountain whitefish, and introduced hatchery rainbow trout in the Crooked River and tributaries below Prineville Reservoir (except Ochoco Creek) will be managed for natural production consistent with the Wild Fish Management Alternative for trout (ODFW 1987a).**

Policy 2. **No hatchery fish will be stocked in the mainstem Crooked River and McKay Creek, and Ochoco Creek above Ochoco Reservoir.**

Policy 3. **Rainbow trout in Ochoco Creek shall be managed for hatchery and natural production consistent with the Basic Yield Management**

Alternative for trout. Tainbow trout in a stretch of the Crooked River below Opal Springs shall be managed for hatchery and natural production consistent with the Basic Yield Management Alternative for trout pending an evaluation of the impacts of the hatchery program on wild fish. After completion of this evaluation, this section may be managed for natural production consistent with the Wild Fish Management Alternative for trout. Mountain whitefish shall be managed for natural production consistent with the Wild Fish Management Alternative for trout (ODFW 1987a).

Policy 4. Releases of hatchery rainbow trout in Ochoco Creek will be confined from RM 3 to RM 5.

Policy 5. Smallmouth bass will be managed for natural production consistent with the Basic Yield Alternative for warmwater fish (ODFW 1987b). Hatchery warmwater fish species will not be stocked in the mainstem Crooked River and tributaries below Prineville Reservoir.

OBJECTIVES

Objective 1. Protect or maintain the genetic diversity, adaptiveness, and abundance of wild redband trout in the Crooked River and tributaries below Prineville Reservoir.

Assumptions and Rationale

1. Redband trout are self sustaining in the lower Crooked River basin below Prineville Reservoir. Redband trout populations have been identified on the Department's provisional list of wild fish populations, and are the highest priority species for management.

2. Lower Crooked River redband trout have been identified as inland rainbow trout and are classified as a sensitive species under the state sensitive species act, and as a Category 2 candidate species under the Federal Endangered Species Act. Their abundance is unknown but likely at depressed levels with the exception of the 12 miles below Bowman Dam.

3. Extensive numbers of non-native hatchery rainbow trout, stocked in Prineville Reservoir, periodically pass downstream, rear, and may reproduce in the mainstem Crooked River below Bowman Dam. Hatchery rainbow and brook trout in Walton Lake may exit the lake and rear and reproduce in upper Ochoco Creek and tributaries. Extensive numbers of non-native hatchery rainbow trout stocked in Ochoco Reservoir annually pass downstream, rear, and may reproduce in Ochoco Creek below Ochoco Dam.

4. Due to past chemical treatment projects and current water and land management practices, wild redband trout have likely been substantially reduced or extirpated from Ochoco Creek below Ochoco Dam.

5. Survival and reproduction of catchable size hatchery trout released in Ochoco Creek is unknown, but is likely at low levels.

6. Interbreeding of hatchery rainbow trout with wild redband trout may decrease genetic fitness of wild trout populations. Streams with both redband and hatchery rainbow trout need to be evaluated or monitored.

7. Monitoring the distribution and abundance of populations of wild trout and whitefish will provide an indication of their health and adaptiveness.

8. Special regulations will be necessary to protect stock fitness and life history characteristics and to maintain healthy, wild rainbow trout populations with multiple age classes.

9. Smallmouth bass, largemouth bass, and brown bullhead are present in small numbers in the mainstem Crooked River. Competitive social interactions between warmwater fish and trout are largely unknown, but appear to not affect production of trout in stream environments.

Actions

Action 1.1 Monitor population trends of trout and warmwater fish distribution and abundance in selected index reaches of the mainstem Crooked River and tributaries below Prineville Reservoir, including Ochoco and McKay Creeks.

Action 1.2 Verify and document distribution and upper limits of rainbow trout in the mainstem Crooked River, and tributaries below Prineville Reservoir, including Ochoco and McKay creeks. Assess the status of sensitive redband trout in the mainstem Crooked River, and tributaries below Prineville Reservoir, including Ochoco and McKay creeks.

Action 1.3 Determine the need for additional or modified angling regulations to protect populations of wild redband trout by monitoring production, harvest, and catch rate in the lower Crooked River basin fisheries.

Action 1.4 Establish baseline data sets on the genetic characteristics of redband rainbow trout with the use of biochemical (electrophoresis), DNA and phenotypic parameters.

Action 1.5 Monitor presence and interaction between hatchery and wild rainbow trout according to provisions in the Wild Fish Management Policy (ODFW 1990) through sampling trout composition in rearing and spawning areas. Modify the numbers, locations, frequency, timing and types of hatchery rainbow trout stocked in Prineville and Ochoco reservoirs, Walton Lake and private impoundments, if necessary, to protect the genetic resources of wild fish. Construct screens where feasible to prevent egress of hatchery trout into streams with wild redband trout.

Action 1.6 Determine the feasibility of restoring wild redband trout to Ochoco Creek below Ochoco Reservoir.

Action 1.7 Monitor presence and interaction between introduced hatchery rainbow and brook trout and native redband trout populations. Consider angling regulations or feasibility of removing introduced species if necessary to protect wild redband trout.

Action 1.8 Work with USFS, BLM, CREEC, private landowners, conservation groups, and other interested publics, in the development of a redband trout recovery plan for the lower Crooked River basin complex. Determine and prioritize future work on limiting factors such as instream habitat, harvest, migration barriers, and interactions with introduced species.

Objective 2. Provide angling opportunities for wild redband trout, mountain whitefish and introduced rainbow trout in the mainstem Crooked River and tributaries below Prineville Reservoir.

Assumptions and Rationale

1. The lower Crooked River and tributaries can provide a diversity of angling opportunities for non-consumptive and consumptive use of wild trout in a diversity of settings including easy access and rugged terrain.

2. Cold water releases from Prineville Reservoir maintain good trout populations for a 12-mile reach from Bowman Dam (RM 70) to Crooked River Feed Canal diversion (RM 57). Irrigation withdrawal and increasing water temperatures make habitat substantially less productive for trout from Crooked River Feed Canal diversion (RM 57) to Highway 97 (RM 18).

3. Lack of an adequate instream flow during winter months (October to April) in drought years limits trout survival and production below Bowman and Ochoco dams.

4. There is significant demand for a juvenile only fish area in Ochoco Creek though the town of Prineville.

Actions

Action 2.1 Evaluate angling pressure and harvest rates of wild redband and hatchery rainbow trout through creel surveys on key stream reaches to determine consumptive use and impacts on wild populations.

Action 2.2 Develop an information and education program to enhance angler awareness of the sensitive status and life history requirements of wild redband trout.

Action 2.3 Develop information brochures of flowing water bodies to highlight diverse angling and recreation opportunities.

Action 2.4 Implement a cooperative enforcement, information, and education program with OSP to ensure compliance with regulations.

Action 2.5 Publicize information on the desirable attributes of whitefish as a game fish, and associated angling opportunities in the lower Crooked River and lower Ochoco Creek.

Action 2.6 Evaluate current angling opportunities to provide more catch of abundant species such as mountain whitefish, without affecting sustainability of wild trout.

Action 2.7 Evaluate alternative opportunities for juvenile only fishing areas such as the ponds below Ochoco Reservoir.

Objective 3. Provide harvest and angling opportunities for naturally produced and hatchery supplemented rainbow trout in Ochoco Creek through the City of Prineville.

Assumptions and Rationale

1. Ochoco Creek below Ochoco Reservoir can support a fishery of a general, consumptive nature.

2. Lack of suitable spawning and juvenile rearing habitat as a result of poor land and water-use management practices limits the development of a fishery without annual supplementation of catchable size hatchery trout.

3. Due to past chemical treatment projects and current water management practices, wild redband trout have likely been substantially reduced or extirpated from Ochoco Creek below Ochoco Dam.

4. There is strong public interest for a consumptive fishery on hatchery trout in this reach of stream. Hatchery stocking in Ochoco Creek in the city limits will provide a fishery.

Actions

Action 3.1 Continue to release 3,000 catchable size hatchery rainbow trout from RM 3 to RM 5.

Action 3.2 Monitor angling pressure and harvest of hatchery and naturally produced trout through periodic creel surveys.

Action 3.3 Adjust stocking levels to maintain a return to the angler of at least 40% from hatchery rainbow trout released into Ochoco Creek.

Objective 4. Provide angling opportunities for smallmouth bass, largemouth bass, and brown bullhead in the mainstem Crooked River below Prineville Reservoir where populations of these fishes currently exist at a low abundance.

Assumptions and Rationale

1. Smallmouth and largemouth bass were stocked in Prineville Reservoir by the Department in the early 1960's. Introduced brown bullhead have been in the Crooked River since the 1950's. Small numbers of these fish have colonized areas of the mainstem Crooked River below Bowman dam.

2. Competitive social interactions between warmwater fish and trout are largely unknown, but likely not limiting the production of trout in stream environments.

Actions

Action 4.1 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Objective 5. Maintain or improve instream flows for fish production in the lower Crooked River below Bowman Dam from uncontracted storage in Prineville Reservoir.

Assumptions and Rationale

1. Water quantity is as important as water quality for fish production. Fish production is limited by streamflow in the lower Crooked River below Prineville Reservoir. Restoration of optimum streamflows will increase fish production in the lower river.

2. There is unallocated water in Prineville Reservoir that may be available for purchase by the State to augment downstream flows. Congressional reauthorization of the project is required to approve water for uses other than irrigation.

3. An IFIM study completed in 1992 provides a model for allocating uncontracted storage for downstream flows in the Crooked River.

4. Water allocated to recreation and fish and wildlife from Prineville Reservoir will have an initial purchase cost, and annual operation and maintenance costs.

5. Water to the river is turned off at the dam for up to 2 hours annually for gate and spillway inspections; this results in lowering of the river and causes stranding and mortality of fish and aquatic life.

Actions

Action 5.1 Continue to negotiate with OWRD, BOR, OID, NUID, BLM, CREEC, conservation groups, and other interested publics and state agencies, in the development of a strategy to allocate and manage water jointly from Prineville Reservoir for irrigation, reservoir, and river needs.

Action 5.2 Collect funds to purchase uncontracted storage and for annual operation and maintenance fees assigned to water for recreation and fish and wildlife.

Action 5.3 Encourage irrigators (through education and financial assistance where available) to improve water distribution and application techniques in an effort to use less water more efficiently in order to improve instream flow.

Action 5.4 Once consensus is reached with agencies, publics and irrigation districts, work with elected representative to approve reauthorization of Crooked River Project to provide water for recreation, fish and wildlife.

Action 5.5 Encourage the OWRD to require legal flow measuring devices on diversions and improved supervision and enforcement to ensure water allocated to the river is not appropriated.

Action 5.6 Work with BOR and OID to improve coordination and communication on gate and spillway inspections. Encourage minimum flows of 25-30 cfs during spillway inspections with a minimal shutoff time for gate inspections. Encourage BOR to test alternative methods of gate and spillway inspections that may not require SCUBA diving.

Objective 6. Improve water quality in the lower Crooked River below Prineville Reservoir, specifically for nitrogen supersaturation during high water runoff and sewage releases from the City of Prineville treatment plant. Improve water quality in Ochoco Creek, specifically for elevated levels of mercury.

Assumptions and Rationale

1. Nitrogen supersaturation from gases trapped during high runoff events from Prineville Reservoir causes gas bubble disease if fish. At high levels, it causes mortality in eggs and juvenile fish and disease in older age classes. The outlet structure and spillway can be modified to reduce or eliminate this problem.

2. Sewage releases during the winter from the City of Prineville treatment plant exceed state water quality standards for total dissolved solids, nitrogen, and other parameters.

3. Elevated mercury levels have been documented in fish collected in Ochoco Creek and Ochoco Reservoir, likely from inactive mercury (cinnabar) mines located at the headwaters of Canyon Creek.

Actions

Action 6.1 Continue to work with BOR and OID to design and modify the outlet structure and spillway at Bowman Dam to reduce or eliminate nitrogen entrainment at high discharge flows.

Action 6.2 Continue to work with ODEQ, the City of Prineville, OID, and BOR to regulate flows in the Crooked River to maintain dilution of treatment wastes. Work with management entities to find alternative ways to eliminate discharge into the river.

Action 6.3 Continue to work with the USFS and ODEQ to identify mercury sources and reduce contamination of Canyon and Ochoco creeks.

Action 6.4 Coordinate with state, county and federal land management agencies to improve monitoring and enforcement of water quality standards.

a. Urge ODEQ, EPA, and BOR, and BLM to increase water quality monitoring especially in important fish production and angling areas.

b. Develop an action plan to address point source pollution in cooperation with state and federal agencies.

Objective 7. Provide additional public boat and bank angling access.

Assumptions and Rationale

1. Approximately 70**%** of land adjacent to the mainstem Crooked River below Prineville Reservoir is in private ownership.

2. Approximately 51% of the land adjacent to Ochoco Creek is in private ownership.

3. Approximately 58% of the land adjacent to McKay Creek is in private ownership.

4. There is an increasing demand for flat water or lake fishing opportunities on USFS lands.

Actions

Action 7.1 Evaluate opportunities to develop access to private land.

Action 7.2 As opportunities become available, form partnerships with landowners or managers to provide access or purchase easements for access sites throughout the Crooked River and tributaries below Prineville Reservoir.

Action 7.3 Evaluate opportunities for purchase of private lands with high public fishery and riparian values for management by state or federal entities.

Action 7.4 Evaluate feasibility and opportunity to construct additional impoundments on headwater tributaries for lake fishing opportunities.

Action 7.5 Evaluate opportunities to develop public access through the City of Prineville.

WILLOW CREEK

Overview

This section covers Willow Creek, a tributary to the Deschutes River which enters the river at RM 104.5 (Figure 7). The lower 0.5 mile of Willow Creek was impounded by Pelton Dam to form Lake Simtustus. Lake Simtustus fish management is covered in a separate section. Willow Creek has approximately 34 miles of mainstem river and 12 miles of tributaries. Willow Creek arises in the Ochoco Mountains at an elevation of 4,000 feet.

Much of the Willow Creek basin is characterized by a high desert, arid climate with precipitation ranging from 10 to 20 inches annually. Annual variations in streamflows are strongly affected by snowmelt, and water withdrawal which occurs from February 1 to November 30.

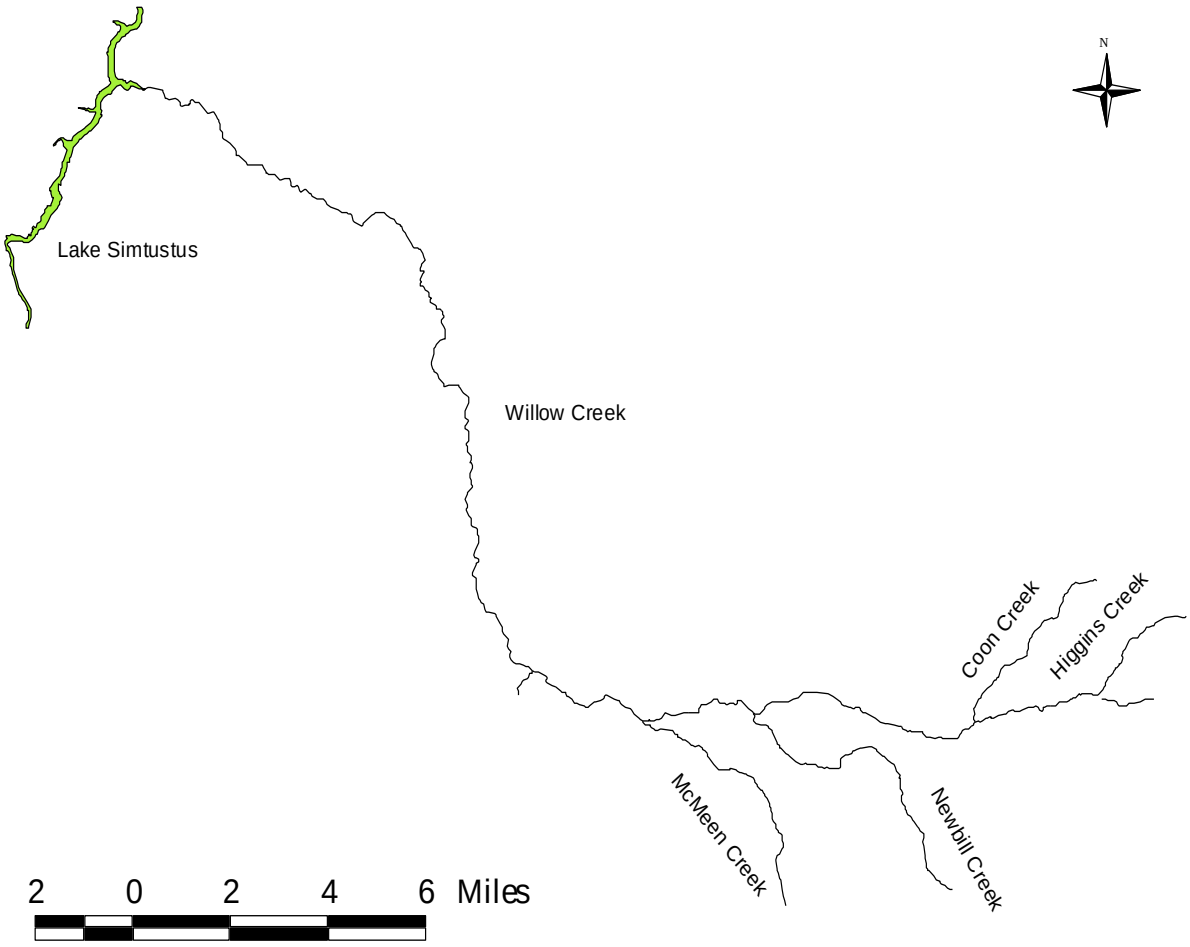

Figure 7. The Willow Creek watershed.

It is unknown whether Willow Creek supported anadromous runs of spring chinook and steelhead. The Metolius River, Squaw Creek, the Deschutes River below Steelhead Falls and the Crooked River supported these fish prior to construction of dams and water diversions. It is likely that Willow Creek supported some steelhead as there are no known geological barriers that would have limited their passage.

Presently, redband trout are the primary native game fish in Willow Creek. Fish populations in Willow Creek upstream and downstream of the City of Madras are a mixture of native redband trout and indigenous nongame species. Mountain whitefish and brown trout, which occur in Lake Simtustus, may also be in lower Willow Creek but their presence has not been documented.

Location and Ownership

The Willow Creek basin comprises approximately 100 miles of streams, and drains an area of about 160 square miles. Headwaters of Willow Creek and its tributaries arise on forested slopes of the Ochoco Mountains, primarily on private lands including those of Ochoco Lumber Company and several livestock ranches. The middle section flows through a narrow basalt canyon on the Crooked River National Grasslands. Below the Grasslands, much of the lower section flows through private lands, including a wide agricultural valley and through the City of Madras. The floodplain along Willow Creek, through the City of Madras, is occupied by residential homes and light industrial buildings. The lower section flows through a narrow basalt canyon from Madras to the mouth and is a mixture of private and BLM lands.

Approximately 34% of the Willow Creek basin lies on Crooked River National Grasslands, 2% on BLM, and 64% on private lands. Land use and water utilization on private lands along Willow Creek are primarily for livestock grazing, irrigated crops, and a small amount of timber harvest, while public lands on the Crooked River National Grasslands are used for livestock grazing and recreation.

Habitat and Habitat Limitations

Willow Creek and its tributaries flow through a variety of geological formations and plant communities, ranging from rugged narrow basalt canyons to a wide agricultural valley. Upper Willow Creek flows begins in a moderate elevation forested valley and then widens into a broader valley dominated by irrigated agriculture with livestock grazing. The middle reach flows through a broad sagebrush and juniper plateau bisected by a narrow basalt canyon. The lower reach flows through a wide agricultural valley and then again into a narrow basalt canyon, where it finally reaches Lake Simtustus. Plant communities are primarily a mixture of ponderosa pine, aspen and a variety of grasses in headwater reaches and juniper, sagebrush, and grasses at lower elevations.

Willow Creek generally supports redband trout where there is year round flow, instream cover, cobble and boulder substrate, spawning gravel, and good streamside vegetation. These habitat components have been severely reduced or modified by water and land management practices, particularly in all reaches except the lower 5 miles, and the trout population is significantly reduced in abundance compared to historical levels, while nongame species are moderately abundant. Access for fish to the headwater area above Higgins Creek has been eliminated by impassable culverts and lack of year round flow. Many of the tributary streams to Willow Creek are intermittent or ephemeral and provide extremely limited or only seasonal habitat for trout.

The redband trout population has been fragmented and isolated into 3 separate populations by physical and water temperature barriers. A mainstem private irrigation dam located above the Grasslands, and intermittent to nonexistent flow and high summer temperatures in the Madras area, have truncated the stream into 3 major segments, of which there is little to no interchange of rainbow trout. Numerous small log and earthen dams, both in the agricultural reaches above and below the Grasslands have further fragmented habitat and created barriers for fish passage.

Habitat surveys were conducted by ODFW in July 1980 (Ferry and Schwartz 1980). Willow Creek and many of its upper tributaries were in poor to very poor habitat condition. Stream shade averaged 17%, with less than 20% shade on public lands and 12% shade on private lands. Stream temperatures ranged from 51^{o} to 88^{o}F. Stream temperatures in Willow Creek exceed the state water quality standard of 58^{o}F for the Deschutes River basin. Water quality conditions for Willow Creek were reported to be moderate to severe for water quality, fish, and aquatic life (ODEQ 1988).

A number of warm springs flow into Willow Creek from RM 4.5 downstream to the mouth. Most were small, averaging less than 0.25 cfs, but 12 contributed an estimated 22.7 cfs at an average temperature of 68^{o}F. The streamflow at the mouth of Willow Creek was estimated at 27 cfs. The majority of the flow in this canyon reach was from springs, with little to none coming from upstream reaches. Despite the warm temperature of the springs, this 5 mile reach appeared to provide the best habitat for trout, with deep pools, spawning gravel, stable banks, good riparian vegetation, and adequate shade.

The habitat survey indicated that streamflow in the upper section was moderate in the forested reaches ranging from 0.5 to 3 cfs, until it reached irrigated farm lands, where flow became intermittent to nonexistent. In the middle section, streamflow was also intermittent to nonexistent, with the exception of the Crooked River National Grasslands, where flows ranged from 0.5 to 3 cfs. Streamflow below the Grasslands once again became intermittent to nonexistent on irrigated agricultural lands. Streamflow was most consistent in the canyon below Madras downstream to Lake Simtustus where access and livestock utilization were minimal. Forty eight springs were

observed in the lower section, contributing to stream flow, ranging in size from 0.1 to 3.5 cfs, and averaging 1.0 cfs.

Highway 26 crosses Willow Creek in the City of Madras and has been the site of a number of fish kills from chemical spills. Due to the speed of traffic and a sharp corner at the bridge over Willow Creek, several chemical spills have resulted, causing fish kills and damage to aquatic life and riparian vegetation.

Access

Headwater reaches of Willow Creek and its tributaries are on private forest and agricultural lands and offer no public access, although the stream is bordered by gravel or dirt roads. Access is very good in the middle section where a majority of the lands are publicly owned Crooked River National Grasslands. Only a small portion is privately owned with no public access. Highway 26 is located adjacent to the canyon and provides easy access for bank angling recreation. Opportunities for enhancing recreation on pubic lands include riparian restoration, trail development, and interpretive work.

A majority of the lower section of Willow Creek is on private lands and offers limited opportunity for public recreation. There are some publicly owned BLM, lands but rugged canyon walls limit access. A primitive gravel trail provides some access along the northern rim of the canyon but occasionally is not accessible due to slumps in the trail.

Fish Resources

The upper section of Willow Creek supports indigenous redband trout. No nongame species have been observed in surveys of the upper section. This section of stream was sampled in August 1980, and only 5 rainbow trout, 4 to 10 inches in length, were observed in an 100 yard section. In July 1989, 6 sites in Willow Creek were surveyed by electroshocker from Higgins Creek downstream approximately 2 miles, each site ranging from 50 to 150 yards in length. Fork lengths of these fish were summarized into a frequency distribution. Peaks in this length frequency distribution suggested that these fish averaged 4.5 inches at age 1+, 5.3 inches at age 2+, and 6.8 inches at 3+, and 8.5 inches at 4+ in length. Fish captured during the survey ranged in size from 4.0 to 8.8 inches in length. In October 1989, a 143 yard reach was sampled by the Madras High School as part of a Salmon Trout Enhancement Program (STEP) project. Only redband trout were observed and ranged in size from 2.6 to 8.3 inches. Young-of-the-year were the most abundant, ranging in size from 2.6 to 3.7 inches, and comprised 65% of the fish observed.

The middle section of Willow Creek through the Crooked River National Grasslands supports a low to moderately abundant population of redband trout and a

very abundant bridgelip sucker population. An 100 yard section of Willow Creek was surveyed in August 1980 at the upper end of the Grasslands and below McMeen Spring; and only bridgelip sucker were observed and appeared to be very abundant. Five sites were surveyed in May 1987 and scales collected from redband trout. Age analysis of the scales indicated that 1+ year old fish were 4 to 5 inches in length, age 2+ fish were 6 to 8 inches in length and one 9.5 fish was likely 3 years of age or older. Hundreds of bridgelip suckers were observed during the survey indicating that these fish comprised a majority of the fish in the stream. A June 1989 survey indicated a similar length at age distribution with 1+ fish 4 to 6 inches in length, 2+ fish 6 to 8 inches in length, and 3 + fish or older 9 to 12 inches in length. Fish ranged in size from 4.2 to 12.6 inches in length. Fish that were 8 inches in larger appeared to be recent spawners. Again, numerous bridgelip suckers were observed and appeared to be the dominant fish species in the stream.

Low flows during the recent drought years, from 1987 to 1992 may have severely impacted rainbow trout in the middle section through the Grasslands. Some sections of Willow Creek through the Grasslands were intermittent in 1992 and some mortality likely resulted. While conducting electrofishing surveys in 1993 to collect fish for genetics work, no trout were found and all of the fish observed in a 200 yard reach were bridgelip suckers.

The lower section supports a mixture of indigenous redband trout, and numerous nongame species including largescale and bridgelip sucker, chiselmouth, northern squawfish, and longnose dace. This reach may also support native mountain whitefish or hatchery brown trout that have moved from Lake Simtustus into Willow Creek. Two 100 yard reaches were sampled in August 1980. No fish were observed at RM 6.0, upstream of the old railroad grade and downstream of Madras, where flow was intermittent and stream temperatures were very high. At a site below the bridge at the mouth of Lake Simtustus, very abundant numbers of squawfish, largescale sucker, chiselmouth, and dace were observed. No redband trout were seen, however.

The lower 2 miles of Willow Creek were sampled in November 1990. Effective sampling was difficult due to the rugged canyon and boulder terrain and the relatively high flows. Moderately abundant numbers of redband trout were observed and ranged in length from 4.5 to 13 inches. Squawfish, suckers, and chiselmouth were also abundant, while longnose dace were observed in small numbers. Several redds and recently spawned out trout were also seen in the survey and suggest that these trout may have a fall spawning life history. It is unknown whether a fall spawning life history may be related to the warm temperature of the springs in the lower creek or hatchery fish stocked in Lake Simtustus.

The most recent chemical spill that occurred in Madras at the Highway 26 bridge at approximately RM 7.75 was in September 1990 when a tanker truck spilled diesel into the creek. Approximately, 380 dead suckers were collected. This reach is frequently dewatered or intermittent with water temperatures inhospitable to redband trout.

Fish production in Willow Creek is limited by poor habitat and water quality. These conditions have likely favored the high abundance of nongame species. Abundant populations of suckers and squawfish likely affect trout production by competition for food and space resources, and also by predation on juvenile classes of rainbow trout. It is unknown whether *Ceratomyxa shasta*, a myxosporan parasite that is present in Lake Simtustus and can kill rainbow trout, is present in Willow Creek.

Fish Stocking History

There are no historical records of hatchery rainbow trout stocked in Willow Creek. However, ranchers reported to the ODFW biologists who surveyed stream habitat in 1980 that some of the impoundments had been stocked with rainbow trout, probably between RM 31.0 and 33.5. Since 1992, the Madras High School Forestry class has raised approximately 200 Deschutes stock rainbow trout from eggs to fry. These fish are stocked in Willow Creek at the mouth, within 50 yards of Lake Simtustus.

Angling Regulations

Until 1980, the trout bag limit was 10 fish per day, over 6 inches, with angling allowed from late April to the end of October. From 1980 to 1986, the trout bag limit was reduced on Willow Creek, along with statewide regulations, to 5 trout per day with a 6 inch minimum.

From 1986 to 1991, Willow Creek within the Crooked River National Grasslands was closed to angling. This proposal was submitted by the USFS and approved by the Oregon Fish and Wildlife Commission. Its intent was to restrict redband trout harvest in Willow Creek, which had just been recently fenced to exclude livestock grazing, while the riparian area was in early recovery. Since 1992, angling has been reopened within the Grasslands from late April to October, but with a restricted catch and release only, with barbless flies and lures regulation.

Current angling regulations with the exception of the Grasslands are a 5 trout per day bag limit, 6 inch minimum with no more than 1 over 20 inches, with bait and barbed hooks permitted, during the regular trout season from late April to the end of October. However, low redband trout abundance appears to be primarily due to poor habitat and stream conditions and not due to overharvest.

Fish Management

Early management focused on attempts to control squawfish and suckers in lower Willow Creek and the Willow Creek arm of Lake Simtustus using a weir and chemical treatments of Fintrol in the 1970's. The weir was installed in 1973 at the

mouth of Willow Creek and operated until 1978 to prevent nongame fish from entering the creek to spawn. When the weir washed out in 1979, it was not replaced. While it was felt to be effective in reducing spawning nongame fish, it was thought that it caused a decline in game fish as well. Fintrol was applied in the lower half mile of Willow Creek in July 1973 and killed several thousand nongame fish. Gillnet data from Lake Simtustus suggests that these methods were not effective in controlling nongame fish.

Management in the early 1980's was focused on inventory of stream habitat and identifying limiting factors affecting trout production. The first inventory was conducted to identify species presence, relative abundance, and size classes.

Fish management during the past 7 years has focused primarily on habitat protection, Wild Fish Policy implementation, and documenting life history, abundance and distribution of native salmonids and nongame fish species. Some effort was expended surveying populations of redband trout in the Willow Creek basin. From these surveys, we know that reaches of Willow Creek vary in habitat quality from good to very poor. Much of the Willow Creek system has extensive habitat alteration of the stream channel, riparian vegetation, and flow for production of livestock and crops. This management has resulted in a stream system with warm water temperatures, few pools and complex habitat, and intermittent to dewatered reaches in the summer. Surveys in portions of the nearby Crooked River basin have indicated that redband trout utilize intermittent streams when they have water, and that they readily recolonize those habitats when good water years occur. This likely occurs in Willow Creek as well. During drought years, an entire year of juvenile production may be lost. However, passage barriers and continued effects of habitat alteration in Willow Creek have resulted in severely depressed and fragmented populations that make it difficult for redband trout to recolonize reaches in years of good flow.

Willow Creek presently is managed for basic yield and is sustained almost entirely by wild populations of redband trout without any hatchery supplementation. Less than 200 rainbow trout of Deschutes stock are stocked by the Madras High School as part of a STEP learning project for students. These fish are stocked at the mouth of Willow Creek where they likely cause little to no impact on wild trout in the stream. The continued existence or restoration of healthy populations of indigenous stocks of redband trout in all areas where they are now present is the primary management direction. Population health is characterized by high abundance with multiple age classes and genetic fitness of the stock.

From sampling conducted during inventories and while collecting fish for genetics analysis, wild redband trout in Willow Creek appear to have low to very low abundance in the upper and middle sections and moderate abundance in the lower section from RM 5 to the mouth.

Redband trout have been collected from the upper section of Willow Creek as part of an ongoing genetics sampling program in the Ochoco District. Fish were collected in 1993 and 1994 and submitted to Oregon State University to determine how

these fish fit in with the evolutionary line of other redband trout in the Deschutes and Crooked River basin. Preliminary results from ongoing genetics sampling in the Ochoco District indicate that redband trout from the Crooked River belong to the inland rainbow redband trout evolutionary line (Currens 1994). Results from fish collected from Willow Creek have not been reported to date.

Management Issues and Concerns

1. Habitat issues related to protection and restoration of habitat, restoration of instream flows, water quality, screening and passage, are addressed in the habitat section of the basin plan.

MANAGEMENT DIRECTION
(wild fish)

POLICIES

Policy 1. Indigenous rainbow trout in Willow Creek and tributaries be managed for natural production consistent with the Wild Fish Management Alternative for trout (ODFW 1987a).

Policy 2. No hatchery trout will be stocked in Willow Creek and tributaries, except for 200 Deschutes stock rainbow trout fry which are released at the mouth of Willow Creek.

OBJECTIVES

Objective 1. Protect or maintain the genetic diversity, adaptiveness and abundance of wild indigenous redband trout in Willow Creek and tributaries.

Assumptions and Rationale

1. Redband trout are self sustaining in Willow Creek and tributaries. Redband trout populations have been identified on the Department's provisional list of wild fish populations and are the highest priority species for management.

2. Willow Creek redband trout have been identified as inland rainbow trout and are classified as a sensitive species under the state sensitive species act, and as a Category 2 candidate species under the federal Endangered Species Act. Their abundance is unknown but likely at depressed levels.

3. Monitoring distribution and abundance of wild redband trout will provide an indication of stock health and adaptiveness.

4. Interbreeding of hatchery rainbow trout with wild redband trout may decrease genetic fitness of wild trout populations.

Actions

Action 1.1 Monitor population trends of redband trout in selected index reaches of Willow Creek and tributaries.

Action 1.2 Verify and document distribution, abundance, and upper limits of redband trout in Willow Creek and tributaries. Assess the status of sensitive redband trout populations.

Action 1.3 Determine the need for additional or modified angling regulations to protect populations of wild redband trout by monitoring production and harvest in Willow Creek basin fisheries.

Action 1.4 Establish baseline data and continue periodic sampling of genetic characteristics of redband trout with the use of biochemical (electrophoresis). meristic parameters, and DNA parameters.

Action 1.5 Monitor presence and interaction between hatchery and wild redband trout according to provisions in the Wild Fish Management Policy (ODFW 1990) through sampling trout composition in rearing and spawning areas. Modify the numbers, locations, frequency, timing and types of hatchery rainbow trout stocked in Lake Simtustus and private impoundments, if necessary to protect the genetic resources of wild fish. Construct screens where feasible to prevent egress of hatchery rainbow trout into streams with wild redband trout.

Action 1.6 Work with USFS, BLM, CREEC, Jefferson County Soil and Water Conservation District, private landowners, conservation groups, and other interested publics, in the development of a redband trout recovery plan for the Willow Creek complex. Determine and prioritize future work on limiting factors such as instream habitat, harvest, migration barriers, and interactions with introduced species.

Objective 2. Provide angling opportunities for wild redband trout in Willow Creek and tributaries.

Assumptions and Rationale

1. Willow Creek can provide a diversity of angling opportunities including non-consumptive and consumptive uses, in different settings including easy access and remote terrain.

2. Lack of suitable salmonid habitat as a result of poor land and water-use management practices limits the ability of Willow Creek to maintain a fishery.

3. Special angling regulations may be needed to protect stock fitness and life history characteristics and to maintain healthy wild redband trout populations.

Actions

Action 2.1 Evaluate angling pressure and harvest rates of wild redband trout through creel surveys on key stream reaches to determine harvest effects on populations. Determine the need for additional or modified angling regulations to protect populations of wild trout.

Action 2.2 Develop an information and education program to enhance angler awareness of the sensitive status and life history requirements of wild redband trout.

Action 2.3 Develop information brochures of flowing water bodies to highlight diverse angling and recreation opportunities.

Objective 3. Provide additional public bank angling access along Willow Creek and tributaries.

Assumptions and Rationale

1. Approximately 55% of land adjacent to Willow Creek is in private ownership.

2. Approximately 68% of land adjacent to tributaries of Willow Creek is in private ownership.

Actions

Action 3.1 As opportunities become available purchase easements for access sites throughout Willow Creek and tributaries.

Action 3.2 Evaluate opportunities to develop public access in the lower reach of Willow Creek from RM 0 to RM 5.

PRINEVILLE RESERVOIR

Overview

Prineville Reservoir is a BOR multi-purpose reservoir on the Crooked River (Figure 8). The project was authorized by Congress in 1956 for irrigation, flood control, and municipal and industrial water. Fish, wildlife, and recreation benefits were not included as project functions, but were viewed as side benefits. Water impounding began December 12, 1960 and the reservoir became operational during the winter of 1960-61. Fish passage facilities were not provided.

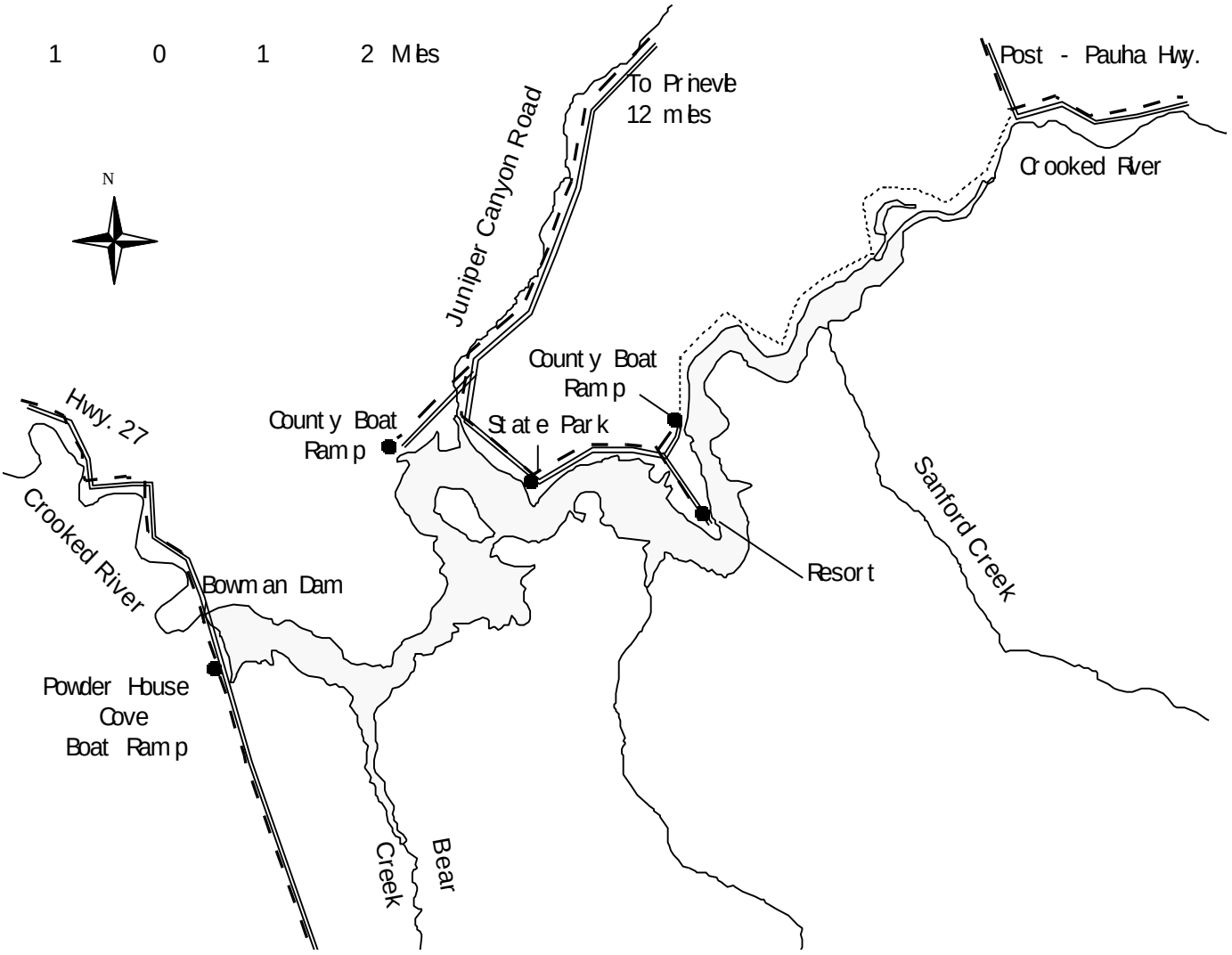

Figure 8. Prineville Reservoir and vicinity.

The Crooked River and other tributaries upstream of the reservoir do not support large enough populations of native redband trout to support a fishery in Prineville Reservoir. We believe that very few of the fish in the reservoir are naturally produced. Prineville Reservoir is currently managed for smallmouth bass, largemouth bass, brown bullhead, and hatchery rainbow trout. Illegally introduced black crappie have become numerous recently and will soon become a major focus for anglers and management.

Prineville Reservoir is open to year-round angling and is popular for both coldwater and warmwater fisheries. A 1992 BOR report indicated that recreation use has increased from an estimated 95,600 recreation days in 1985 to about 331,000 recreation days in 1989 (USDI 1992c, 1992d). It is estimated that over of 50% of the visitors were anglers. Severe drawdown of the reservoir in 1991 and 1992 resulted in boat ramps being unavailable for use after July, and a dramatic drop in boater use and angler participation (Oregon State Marine Board 1983, 1986, 1988, 1993).

Location and Ownership

Prineville Reservoir was formed by the construction of Bowman Dam on the mainstem Crooked River at RM 70. The reservoir is located in Crook County, approximately 17 miles south of Prineville (Figure 8). The reservoir is a locally and regionally popular recreation area, and until severe drought conditions in the early 1990's, Prineville Reservoir State Park was in the top 5 state parks for occupancy in Oregon. This area is characterized by rolling hills and flat plateaus bisected by broad river valleys. Vegetation consists primarily of western juniper intermixed with big sagebrush, bitterbrush, rabbitbrush and a variety of other shrub, grass and forb species. Grass species include native species of Idaho fescue, bluebunch wheatgrass, and wildrye, and exotic species include crested wheatgrass and cheatgrass.

Bowman Dam is an earth filled structure with a height of 245 feet. Prineville Reservoir has a maximum surface area of 3,030 acres and a present storage capacity of 155,000 acre feet. Maximum depth is 230 feet with an average annual drawdown of 25 to 30 feet. The elevation at full pool is 3,235 feet above mean sea level. Lowest recorded level was in 1992 when the reservoir was drawndown 72 feet and only 22,537 acre feet of storage (14% of capacity) remained. Maximum storage occurred in 1993 when the reservoir exceeded the maximum capacity by 15,000+ acre feet. There are 36.0 miles of shoreline, of which 34.5 are in public ownership. Public lands are administered by the BOR.

Irrigation and flood control functions drive the operation of the dam. Irrigation water is released from April 15 to October 15, and the reservoir level is lowered accordingly. The reservoir must be at or below 93,000 acre feet from November 15 to February 15 for flood control purposes. If the reservoir exceeds that level, water is released to lower the level to 93,000 acre feet. After February 15, a majority of the inflow is stored for irrigation needs. During drought years, when water levels are below

93,000 acre feet during the winter storage period, a majority of the inflow is stored to bring the reservoir up to the minimum flood control level.

In addition to irrigation and flood control releases, minimum flows of 10 cfs are authorized for fish and wildlife purposes in the Crooked River below the reservoir. Since 1990, the BOR has administratively released from 30 to 75 cfs of water in the Crooked River during winter, depending on flood and snowpack conditions, to improve flows in the river below. Based on modeling yearly average runoff and inflow patterns from 1961-1994, Prineville Reservoir is expected to fill 3 out of 4 years. Additionally, the probability of refilling the reservoir is nearly equal whether winter flow in the Crooked River is 30 or 75 cfs. Presently, 70,300 acre feet of space in the reservoir are allocated, with the remaining 82,700 acre feet of active space still unallocated. The OID has contracted for the largest share of irrigation water of 59,600 acre feet, and operates the water release facilities at the dam, under the direction of the BOR. During drought years, OID and NUID have requested and received non-contracted water on a one year basis to meet irrigation needs.

Habitat and Habitat Limitations

Prior to inundation, the Crooked River at the site of the reservoir supported a very low abundance of native redband trout and steelhead, brown bullhead and assorted nongame. The riverine ecosystem was extremely degraded by land and water management practices at the time. River temperatures were excessively high and flows were extremely low during the summer months. The riparian zone was degraded and provided little benefit for salmonid production.

Prineville Reservoir habitat is characterized by a lack of shoreline vegetation, an expansive mud flat substrate in the upper end, and a boulder and cobble strewn substrate in the lower end. Like other irrigation reservoirs, Prineville Reservoir suffers from annual fluctuation in water level and the associated impacts. Severe drawdown, such as occurred in 1991 and 1992, limits food production and living space for all fish species. For example, rainbow trout fingerlings stocked in the spring of 1992 were virtually absent in the reservoir during 1993, either due to direct mortality or through outmigration to the Crooked River below. Additional habitat limitations for fish include low to moderate concentrations of nutrients in the water, high suspended sediments which limit photosynthesis, annual water level fluctuations, very low abundance of aquatic vegetation, a lack of structural complexity, and water that is too cold for optimal warmwater fish production and too warm for optimal trout production.

Prineville Reservoir has been severely impacted by high quantities of suspended sediments, or turbidity, since the early 1970's. This turbidity is a result of erosion occurring on the mainstem Crooked River, Camp Creek, Eagle Creek, and Bear Creek, and shoreline erosion of the reservoir itself from wave action from wind and boats (Silvernale et al. 1976). Erodible soils are present along more than 90% of the reservoir shoreline and contribute to turbidity when waves loosen soil on the shoreline. The

watersheds upstream of the reservoir are formed from highly erodible soils, including montmorillinite clay; and upland and riparian areas are in poor condition. These factors result in increased erosion rates. Eroding streambanks from timber harvest, roading, and improper livestock grazing contribute large quantities of sediment to the reservoir during the spring run-off period. As a result, the reservoir is muddy during the spring months and often late into the summer. When washed into the reservoir, the montmorillinite clay stays in suspension for several years, increasing reservoir turbidity and preventing sunlight penetration into the water column.

Prineville Reservoir is probably moderately nutrient rich, but unproductive due to the high turbidity which limits sunlight penetration. Orthophosphate phosphorous was measured at 0.047 mg/l in May of 1982, and 0.025 mg/l in July of 1982. These levels would generally indicate a eutrophic, or productive system. However, without sunlight penetration, phytoplankton do not grow well. This is reflected in chlorophyll a levels (which measures phytoplankton production) which were only 0.7 γg/l in May and 1.5 γg/l in July. These levels are very low and suggest an ultraoligotrophic, or unproductive system. Zooplankton feed on phytoplankton and their abundance is dependent on the abundance of phytoplankton.

Zooplankton densities are generally low in the reservoir and reflect the poor phytoplankton production. Sampling from May to September 1985 showed an average of 14,400 organisms per cubic meters with 55% *Cyclops* and 47% *Daphnia*. The 14,400 organisms per cubic meter compares with observations of 34,100 at Suttle Lake, 33,300 at Paulina Lake, 37,800 at North Twin Lake, and 29,400 at East Lake during the same months a few years earlier (Figure 2, page 28). Zooplankton are the major food item for juvenile fish, rainbow trout in the spring and fall, and black crappie until they reach 8-10 inches. The levels of zooplankton suggests that Prineville Reservoir does not produce an abundant food source for rainbow trout, black crappie and juvenile bass. Competition for this food is probably intense and will become even more intense as the black crappie population grows.

During the late 1970's, public hearings were held in an effort to allocate the uncontracted space. A plan was submitted to Congress in 1980 that would allocate 51,000 acre feet for reservoir recreation, fish and wildlife; 3,700 acre feet to increase the minimum downstream flow above 10 cfs; 95,300 acre feet for irrigation; and 3,000 acre feet for domestic, municipal and industrial water supplies (USDI 1980). The space assigned for joint flood control use would remain at 60,000 acre feet. The recommended minimum stream flows below the reservoir would be changed from the present 10 cfs to 75 cfs, or 30 cfs whenever reservoir storage was 93,000 acre feet or less on the first day of the month. These changes would have created a more stable water level in the reservoir. Unfortunately, there was not local consensus regarding the plan, and it was not approved by Congress.

Access

Shoreline and boat access are good at Prineville Reservoir. Public lands allow access to virtually all of the shoreline, although vehicle access is limited to Prineville Reservoir State Park, Roberts Bay, Bowman Dam, Powder house Cover, Jasper Point, and the county boat ramps. The North Side road runs along the north side of the reservoir from Jasper Point to the Post-Paulina Highway. It is open to vehicles from April 15 to December 15 and accesses several primitive dispersed recreations sites. This area is managed as a state wildlife area by ODFW. The road is closed during the winter to protect mule deer on winter ranges, reduce environmental damage and prevent erosion from motor vehicles. The first 2.6 miles of the road from the Paulina Highway are opened annually on March 15 to allow anglers access to the upper portion of the reservoir.

Boat ramps are located at the State Park, Prineville Reservoir Resort, Jasper Point, and west of Juniper Canyon. The ramps at the Resort, Jasper Point, and Juniper Canyon are gravel and become unusable during low water levels. The boat ramp at the State Park is paved and is functional at all water levels. Primitive boat launching occurs at Powder House Cove. Mooring facilities are available to the Resort and State Park. All areas of the reservoir are accessible to boats, but there is a 10 mph speed limit upstream of Owl Creek. Developed campsites are available at the Resort and the State Park. Dispersed campsites are located all around the reservoir.

The BOR completed the Prineville Reservoir Resource Management Plan in 1992 (USDI 1992d). The Plan provides a 10 year plan and framework to develop site-specific recreation proposals for campsites, improving boat launching facilities, and providing boat-in campsites. It also has management recommendations for off-road vehicle use, grazing, concessions, and the reservoir road system. Opportunities also exist for developing additional shoreline access though the development of trail systems to walk-in areas for additional recreational uses.

Fish Resources

Native game fish species historically included spring chinook, summer steelhead, redband trout, and mountain whitefish; nongame species included northern squawfish, chiselmouth, longnose and speckled dace, redside shiner, largescale and bridgelip sucker, and various sculpin species. Presently, most nongame species are still present along with introduced hatchery rainbow trout, smallmouth bass, largemouth bass, brown bullhead, and black crappie.

Rainbow Trout

Hatchery rainbow trout grow well in Prineville Reservoir and have been the predominate game fish pursued by anglers. Fingerling rainbow trout are stocked in

early to mid-May. They normally enter the fishery in mid-summer when they reach 6-8 inches. Springs catches usually consist of 10-12 inch trout, although 14-16 inch trout are sometimes observed in the creel. Hatchery rainbow trout sometimes emigrate from the reservoir into the Crooked River below Bowman Dam. High emigration rates appear to coincide with either severe drawdown of the reservoir, or when the reservoir is high enough that water flows over the spillway (also known as "spill"). Rainbow trout may also migrate up the Crooked River in the spring and fall. Although these fish may spawn in the river, we believe they do not successfully reproduce due to the high water temperatures and poor habitat conditions that occur there in the summer. Native fish are believed to be very rare in the reservoir.

Outbreaks of diseases are widespread in some years and occasionally cause concern among anglers. In September 1984, in the upper portion for the reservoir, 90.7% of the rainbow trout and 95.5% of the cutthroat trout were infected with a disease called Lernaea, a parasitic copepod. In the lower portion of the reservoir, 68.3% of the rainbow trout and 57.1% of the cutthroat trout were infected. Most trout were also infested with tapeworms. Another disease observed in rainbow trout in recent years was strawberry disease, a rickettsial or bacterial disease which causes red sores on the sides of fish.

Warmwater Fish

Largemouth bass are found mostly in the upper one-half of the reservoir while smallmouth bass are common throughout the reservoir. The shallow mud flat areas, creek mouths, natural coves with stumps and other underwater structures are preferred by largemouth bass. Smallmouth bass prefer rocky shorelines and outcroppings, and deeper water.

Bass reproduction is highly variable and appears to depend on reservoir elevation, rate of drawdown, and cool spring time weather fronts (Shrader 1991). Cold weather, combined with chilling winds, can result in water temperatures that are too cold for good spawning success, or cause bass to abandon their nest. Increased wave action created by strong winds along shallow shoreline areas are also detrimental to bass spawning. Newly born (young-of-the-year) largemouth bass must reach approximately four inches by the end of the summer in order to survive the harsh winter conditions at Prineville Reservoir. Young-of-the-year bass which don't reach this size are subject to heavy mortality during their first winter. Summer conditions in the reservoir vary each year, and the size of young of the year bass varies each fall. Thus, the number of juvenile largemouth bass surviving their first winter also varies. This variation in winter survival appears to be the major factor determining how many juvenile largemouth bass from a specific years spawning (a cohort) will contribute to the bass fishery in later years. Sometimes entire largemouth bass cohorts are missing from the population. These missing cohorts can cause poor fishing during the time they would have been 12-16 inches in length.

Analysis of abundance, diet, and relative weights of both largemouth and smallmouth bass suggest that Prineville Reservoir is a fairly unproductive reservoir for growing quality sized fish (Daily 1994; Shrader 1991). Diet of both bass species included a mixture of crayfish, insects, chiselmouth, squawfish, and stocked rainbow trout, and varied considerably during the sampling season and between up reservoir and down reservoir sites. The slow growth rate and poor condition suggest that the prey base is inadequate to support an abundant population of quality sized bass.

An abundant population of brown bullhead is present in the reservoir. Bullhead average 8-10 inches long, with an occasional fish up to 18 inches. The majority of the population appears to be located in the shallower, upper end of the reservoir, and in the Bear Creek arm; however, they are common throughout the reservoir. During the past several years, large schools of young of the year bullheads have been observed in the shallow areas. Brown bullhead appear to be over-populated and stunted, a common problem with warmwater fish that are prolific in their reproduction. Occasional fish kills occur in some years. Anglers express concern about the fish kills, but there is virtually nothing that can be done to prevent them. Brown bullhead are also found occasionally in the Crooked River above and below the reservoir, and may move in response to spill or severe drawdown in the reservoir.

Black crappie were recently illegally stocked into the reservoir. Spring electroshocking surveys indicate that they have successfully reproduced in the last 2-3 years (T. Shrader, ODFW, personal communication). Black crappie grow slow in Prineville Reservoir (Figure 9), and so far only a small portion of the population has exceeded 8 inches. The number exceeding 8 inches is so low that we have not captured any larger than 8 inches in our sampling (Figure 10). If growth rates do not improve, the black crappie population will probably be dominated by 6-7 inch fish.

Nongame Fish

Nongame fish are abundant in Prineville Reservoir. Sampling with experimental gillnets up to 1985 indicated that 90-95% of the catches consisted of rough fish. The effect of a high nongame fish population on game species within the reservoir is not clearly understood. However, when a group of fish comprises such a large portion of the total biomass in an ecosystem, they are certainly a major influence on the production of other species that we determine to be more desirable. In Prineville Reservoir, nongame fish probably inhibit game fish production through predation and competition for food and space.

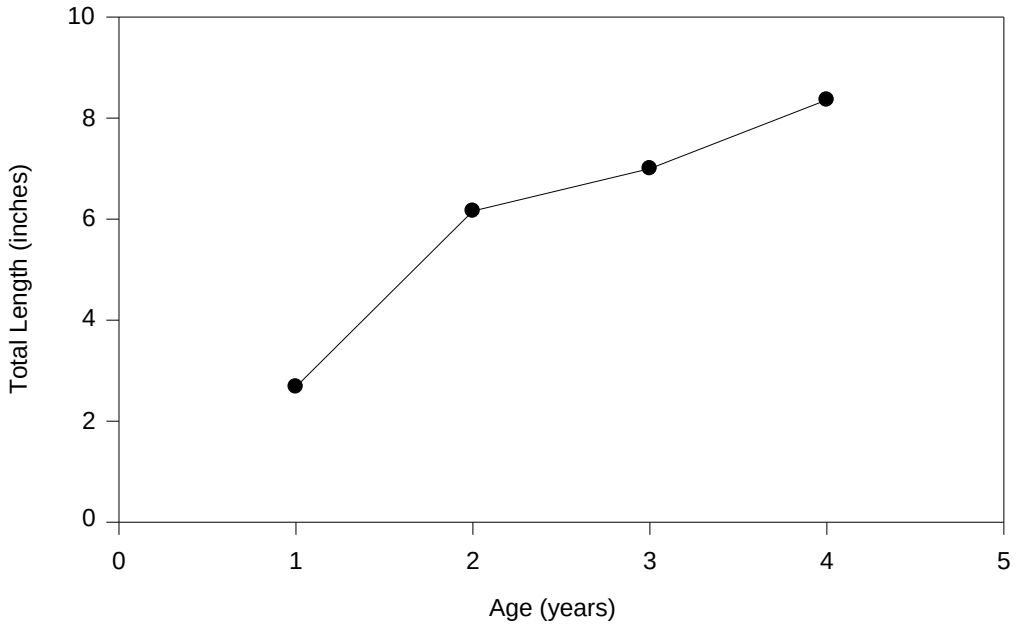

Figure 9. Backcalculated length at annulus formation for black crappie captured by electroshocking in Prineville Reservoir in 1994.

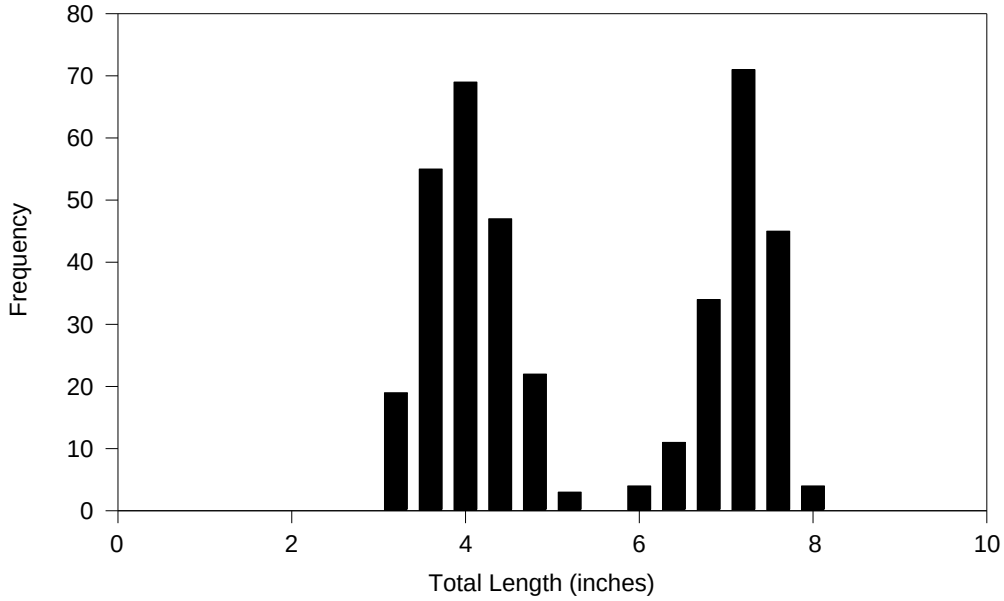

Figure 10. Length frequency distribution of black crappie captured by electroshocking in Prineville Reservoir in 1994.

Gillnet inventories conducted from 1962 to 1980 showed that suckers and chiselmouth were the most abundant nongame fish; they often made up over 70% of the catch. At their present abundance, suckers and chiselmouth are probably a major limiting factor for rainbow trout due to competition for space and forage. From electroshocking data in 1990 and 1991, largescale and bridgelip suckers each comprised about half of the sucker population.

Fish Stocking History

Hatchery rainbow trout fingerlings have been stocked annually since Bowman Dam was completed. Various trout species and strains have been released over the past years including Oak Springs rainbow trout, Eagle Lake rainbow trout, and summer steelhead. Release strategies have also included variations in time of release, size at release, marked fish, and unmarked fish. Up to 260,000 cutthroat trout fingerlings and 500,000 rainbow trout fingerlings were stocked each year. One release of marked steelhead was made in October 1967 when hatchery rainbow trout fingerling were unavailable. Most moved out of the reservoir when the reservoir spilled in the spring of 1969. Eagle Lake rainbow were released in 1974 to see if they would be a better competitor with nongame fish. However, they did not perform better than other rainbow trout strains. Lahontan cutthroat trout fingerlings were stocked sporadically from 1973 to 1977 and annually from 1977 to 1986. Being recognized as one of the more predatory trout species, it was hoped that Lahontan cutthroat trout would do well and provide a fishery when rainbow trout angling was slow. Results were mixed. Growth, survival and catchability were acceptable, but many anglers were dissatisfied with their body condition and fighting ability.

Studies were completed to evaluate the different strains of trout, time of release, number to release, and size at release. Marked rainbow fingerling released into the reservoir during the late 1960's and early 1970's indicated the following:

1. Virtually all trout caught are hatchery produced. There is little natural production.
2. Spring releases of large fingerling have been more successful than late spring releases of smaller fish.
3. Fall releases of both large and small fingerling have shown inconsistent results.
4. Trout growth is good until a length of 12-14 inches is reached. Some rainbow exceed 14 inches.
5. Size of fish at release is far more important than strain of fish.
6. Rainbow trout released into the reservoir comprised most of the trout caught in the Crooked River below the dam.

Continual experimentation with release timing and size eventually resulted in some clear guidelines. Beginning in 1986, the number of rainbow trout stocked was reduced to about 170,000 fingerlings of the Oak Springs strain. They were released at

a larger size (35/lb.) and later in the spring than in the past. This is the current stocking strategy.

Largemouth and smallmouth bass were stocked into the reservoir in 1960 and 1961 shortly after reservoir completion. Bass populations, since initial releases, have been sustained entirely from natural reproduction. Largemouth and smallmouth bass populations have provided a moderate fishery throughout the history of the reservoir. Several bass tournaments are held on the reservoir each year. Incomplete tournament data indicates that since 1979, an average of 1,080 tournament angler hours were expended annually. Black crappie were illegally stocked in the late 1980's.

Angling Regulations

Prineville Reservoir is open to fishing year around with no special tackle restrictions. The daily limit on rainbow trout is 10 per day (no more than 5 over 12 inches and no more than 2 over 20 inches). The daily limit on bass is 5 per day, with only 3 over 15 inches. However, there is a 12 inch minimum length on largemouth bass, and a 10-14 inch protective slot limit on smallmouth bass. All smallmouth bass within the slot must be released unharmed.

Fish Management

Fish management activities at Prineville Reservoir started even before the dam was completed. Approximately, 90 miles of the Crooked River above Prineville Reservoir were treated with rotenone just prior to completion of Bowman Dam in 1961 to encourage trout production and survival as the reservoir was filled. A series of studies were also initiated to determine the impacts of nongame fish, the limnology, and the best species and strains of trout to stock in Prineville Reservoir. Studies continued through 1980 and provide most of the knowledge base for the management discussion.

Rainbow trout fishing was fair shortly after completion of the reservoir. However, catch rates dropped from greater than 0.40 fish/hour in the early 1970's to about 0.25 fish/hour by 1980. This may be due to the fact that the number of nongame fish were increasing in the reservoir. Nongame fish comprised about 6% of the catch in gill nets during the late 1960's, but comprised about 76% by 1980.

Presently, trout anglers catch fish generally throughout the year. Spring catches usually consist of 10-12 inch trout, although 14-16 inch trout are observed in the creel. Fingerling trout, stocked in early to mid May, normally enter the fishery in the mid-summer when they reach 6-8 inches. Trolling and bank angling are both popular. Ice fishing is popular during years when the ice is thick enough to support anglers. Creel surveys were conducted in 1993 and 1994 in conjunction with a warmwater fish study (see below). Total angler hours were 49,309 in 1993 and 81, 659 in 1994 (Tables 7 and 8). The extreme drawdown in 1992 appears to have caused substantial losses of trout,

as very few were harvested in 1993. They may have been lost to predation, competition, or emigration from the reservoir. Game fish harvest in 1994 was up considerably over 1993 (Tables 9 and 10). The rainbow trout catch rate was 0.22 fish/hour in 1994, which is similar to the catch rate in the late 1980's.

Table 7. Estimated angler hours at Prineville Reservoir from April 15 through October 15, 1994.

	Angler Hours		
	Boat	Shore	Total
April	5,866	4,424	10,290
May	18,353	10,003	28,356
June	8,655	6,269	14,924
July	5,113	4,928	10,041
August	5,484	4,807	10,291
September	2,899	3,941	6,840
October	0	918	918
Total	46,370	35,290	81,659

Table 8. Estimated angler hours at Prineville Reservoir from April 15 through October 30, 1993.

	Angler Hours		
	Boat	Shore	Total
April	259	3,073	3,332
May	6,454	10,118	16,572
June	4,845	7,170	12,015
July	4,017	3,825	7,842
August	2,247	1,890	4,137
September	1,983	2,105	4,088
October	393	927	1,320
Total	20,198	29,108	49,306

Table 9. Estimated harvest of game fish at Prineville Reservoir from April through October, 1994.

	Brown Bullhead	Largemouth Bass	Smallmouth Bass	Rainbow Trout	Black Crappie
April	1,038	0	0	3,881	0
May	4,713	20	159	4,701	278
June	6,250	26	53	2,295	868
July	7,371	109	267	1,790	3,553
August	8,258	0	812	1,942	1,248
September	4,475	87	394	2,414	1,221
October	17	0	3	627	16
Total	32,122	242	1,688	17,650	7,184

Table 10. Estimated harvest of game fish at Prineville Reservoir from April through October, 1993.

	Brown Bullhead	Largemouth Bass	Smallmouth Bass	Rainbow Trout	Rainbow Trout (1993 Fingerling)
April	3,917	0	0	42	0
May	9,178	35	0	598	0
June	1,088	0	21	209	0
July	1,431	45	102	556	0
August	754	0	148	324	162
September	488	0	82	507	950
October	21	4	17	162	372
Total	16,877	84	370	2,398	1,484

As warmwater fishing became more popular in the basin, studies were undertaken in 1977 to determine bass movements, growth rates and survival in Prineville Reservoir. Bass were tagged in 1977, 1978 and 1979. Conclusions were that handling mortality was minimal, growth rates were poor during stress periods, smallmouth bass grew faster than largemouth bass, and that angler caught bass returned to the area from which they were caught, even when released a considerable distance away. Because of concerns regarding over-harvest of the bass population , a 10 inch minimum length on bass was put in effect on the reservoir in 1983.

A second bass study was undertaken in 1985. Objectives were:

1. Estimate the percent of the largemouth and smallmouth bass populations harvested each year (exploitation rate).
2. Describe length and age related characteristics of bass populations.

3. Describe the fishery in terms of catch composition and catch rates.
4. Map habitat associations of basses.
5. Describe the diet of bass.

Exploitation was determined to be 13-22% for largemouth bass. This rate is low compared to most other largemouth bass populations. Smallmouth bass had a much higher exploitation rate of 37-60%. This rate is high compared to most other smallmouth bass populations and was felt to be limiting the number of smallmouth bass reaching 16 inches. The populations were characterized by slow growth rates and variable recruitment. The fishery was dominated by trout anglers (40%), followed by brown bullhead anglers (27%) and finally bass anglers at (12%). A 12 inch minimum length limit was put in effect on the reservoir in 1988 to reduce the exploitation rate on bass.

Electroshocking in 1990 and 1991 revealed that smallmouth bass growth rates had declined substantially since 1985 (Figure 11), while largemouth bass growth rates varied around the same levels (Figure 12). In 1992, a regulation was enacted which requires the release of smallmouth bass between 10 and 14 inches to encourage harvest of smaller fish that were stunting and retaining the option to harvest large fish.. This type of regulation is referred to as a "slot limit". We hoped that this regulation would reduce the number of smallmouth bass and allow growth rates to increase.

Further warmwater fish studies were undertaken in 1993 and 1994. Results indicated that the bass community had shifted from a smallmouth bass to largemouth bass ratio of 2:1 in 1985 to 10:1 or more in 1994. Low water levels caused by drought conditions likely contributed to the species shift by changing the habitat to favor smallmouth bass (Daily 1994). Abundance of bass was also relatively low compared to other Oregon water bodies. Electroshocking catch per unit effort (number of fish caught divided by the seconds of electroshocking, multiplied by 1000) for smallmouth bass $\geq$ 8 inches varied from a high of 20 in 1986 and a low of 6 in 1988, and appeared to fluctuate on a three year cycle (Figure 13). Electroshocking catch per unit effort for largemouth bass $\geq$ 8 inches varied from a high of 13 in 1992 to a low of 0.6 in 1993 (Figure 13). We suspect that drought conditions and the subsequent low water levels in the reservoir have caused a substantial drop in bass abundance from 1985 to 1993.

The reduced abundance was particularly evident in larger size bass. Proportional stock density (PSD) measures the percent of bass greater than "stock size" that are greater than "quality size". For smallmouth bass, stock size is seven inches and quality size is eleven inches; for largemouth bass, stock size is eight inches and quality size is twelve inches. Relative stock density 15 (RSD15) measures the percentage of the fish greater than stock size that are greater than 15 inches. For largemouth bass, PSD and RSD15 have both shown a general increasing trend (Figure 14), although RSD15 declined from 1992 to 1994. We believe this trend demonstrates that the 12 inch minimum length limit has increased the percent of the largemouth bass

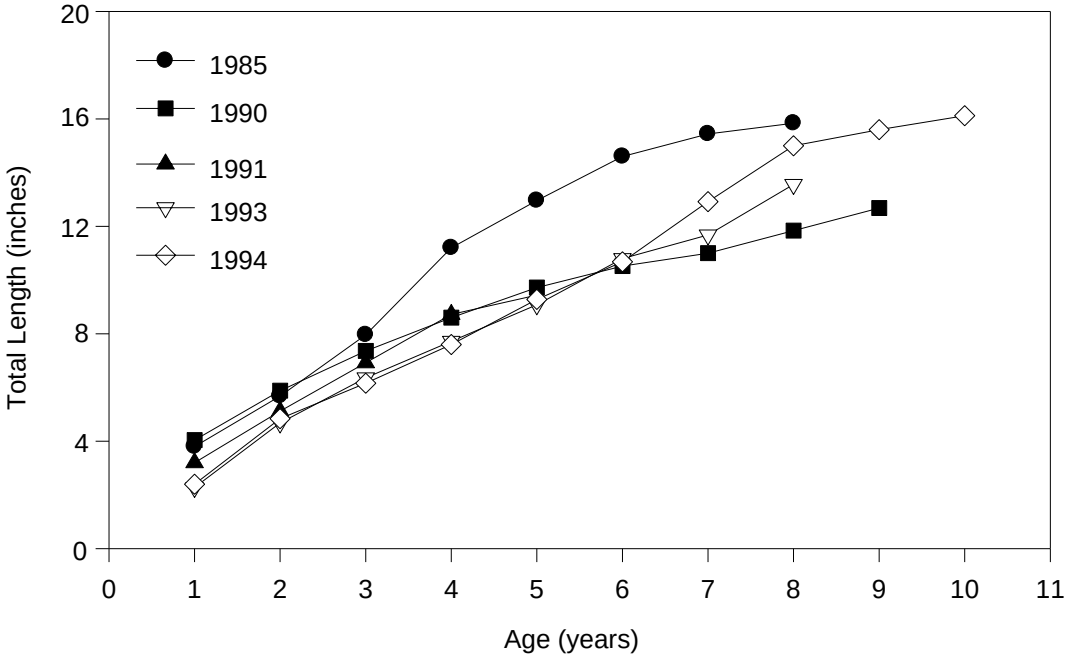

Figure 11. Backcalculated length at annulus formation for smallmouth bass collected by electroshocking in Prineville Reservoir. Lengths previous to 1992 have been converted from fork length to total length.

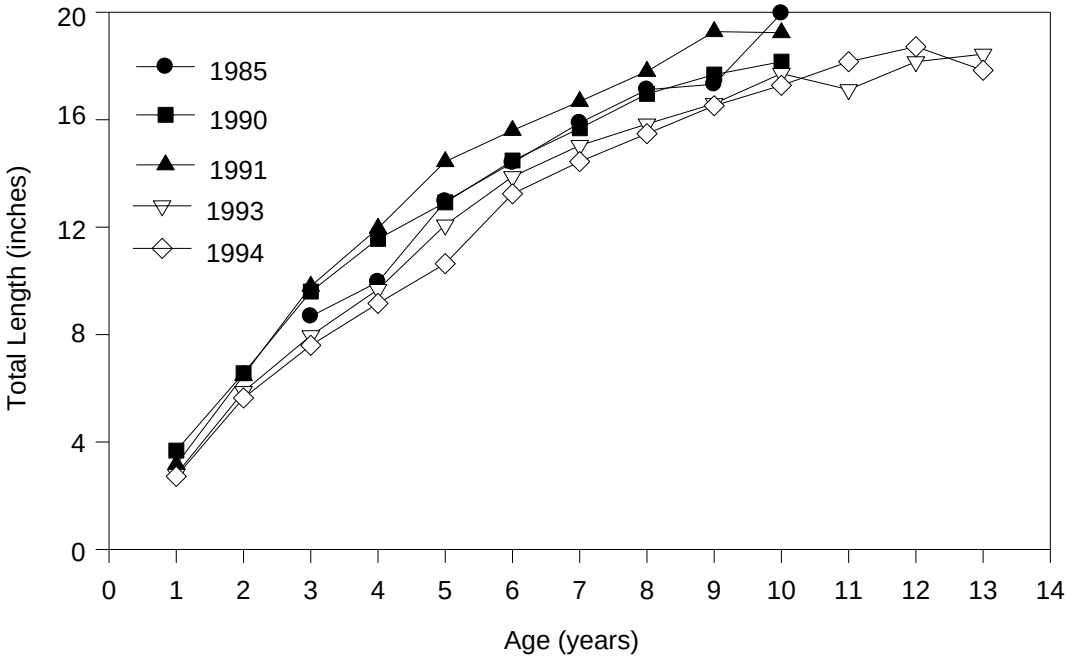

Figure 12. Backcalculated length at annulus formation for largemouth bass collected by electroshocking in Prineville Reservoir. Lengths previous to 1992 have been converted from fork length to total length.

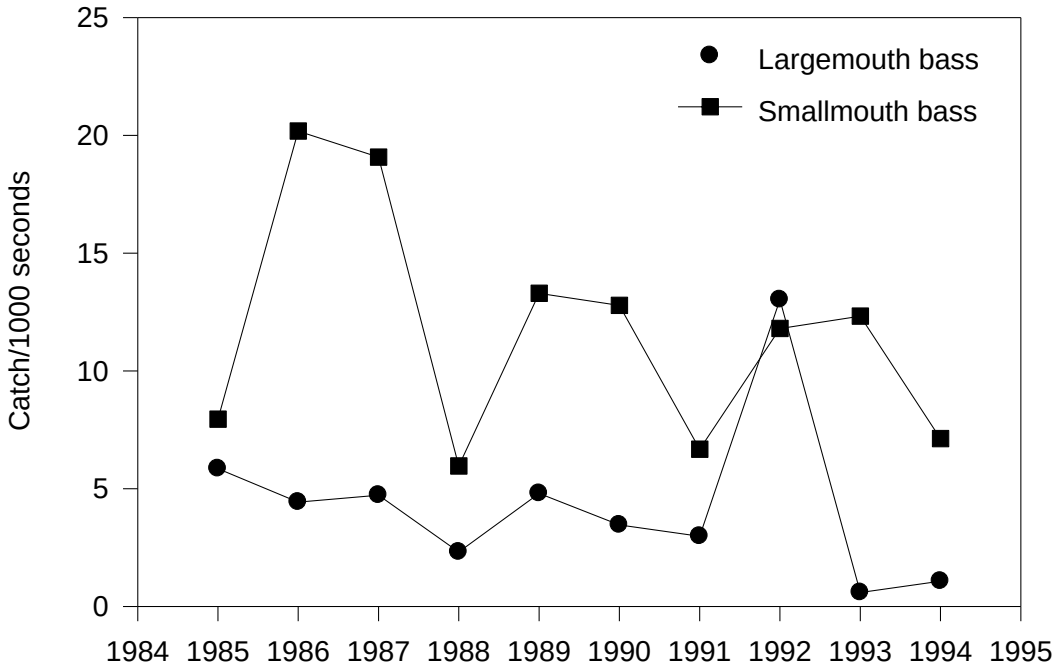

Figure 13. Electroshocking catch per unit effort (X1000) for bass captured during May, 1985-94, in Prineville Reservoir.

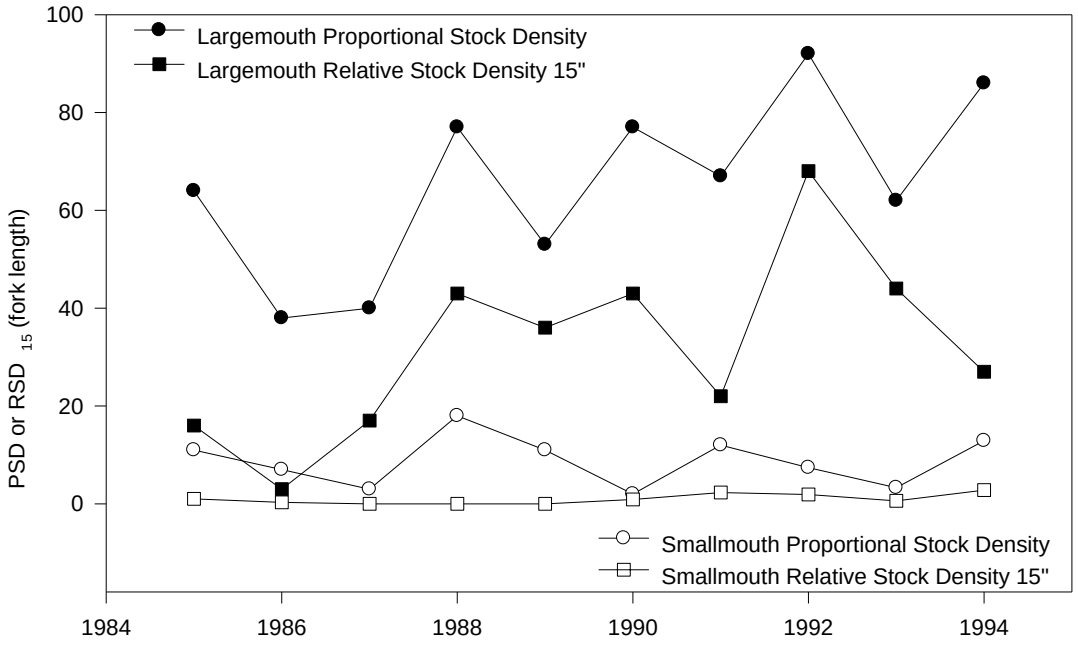

Figure 14. Proportional stock density and relative stock density 15” calculated using total length for smallmouth bass and largemouth bass collected by electroshocking in Prineville Reservoir during May.

population surviving to an older age and larger size. For smallmouth bass, neither PSD nor RSD15 have shown any trend since 1985. This suggests that angling regulations have not increased the percent of older and larger smallmouth bass in the reservoir. Relative weight (a measure of plumpness) was poor for both smallmouth and largemouth bass, and declined as bass got older. Zooplankton abundance was again found to be very low in 1993. However, the reservoir was very high and juvenile bass exhibited some of the highest growth rates observed in recent years. Creel surveys completed in 1993 and 1994 show that brown bullhead and rainbow trout are harvested at much higher rates than bass.

Although much angling effort is directed at trout and bass, the large population of brown bullhead actually attracted more angler effort in 1994. A good fishery occurs at night during late spring and summer months in the upper one-third of the reservoir. In 1993 and 1994, brown bullhead were the predominate species harvested, easily outdistancing rainbow trout.

The newly introduced black crappie will develop a fishery in the years to come if successful natural reproduction continues to occur. Over 7,000 black crappie were harvested in 1994. Black crappie harvested by anglers are generally small. It is difficult to determine whether larger crappie (8-10 inches) will be abundant in the future. Research at other reservoirs suggests that most crappie will not exceed 8 inches in Prineville Reservoir. Hopefully crappie of this size will satisfy angler expectations.

The impact of black crappie on other reservoir fish species is also unknown at this time. From studies in other reservoirs, black crappie may compete with trout for zooplankton in the spring and fall. Rainbow trout in Phillips reservoirs switch to feeding on insects during the summer (Shrader 1994). Because Prineville Reservoir has a low abundance of zooplankton, crappie competition for prey items may reduce growth rates of rainbow trout and juvenile bass. In essence, successful establishment of a large population of black crappie has the potential to lead to detrimental changes to the rainbow trout fishery. To date, we have not been able to detect major changes in rainbow trout growth rates. Length frequency histograms of rainbow trout caught in May with electroshocking equipment appear to have had slightly slower growth rates in 1994 versus 1990 and 1991 (Figure 15), but the difference is fairly small. Rainbow trout condition factor has also been similar since 1985 (Figure 16).

Since largemouth bass and black crappie spawn at approximately the same time, crappie have the potential to out-compete juvenile bass as well. However, both largemouth and smallmouth bass that grow large enough to prey on crappie should exhibit good growth. This may explain the increase in growth rates of older smallmouth bass in 1993 and 1994 (Figure 12). Future monitoring will help establish whether there are changes occurring in trout and bass growth rates.

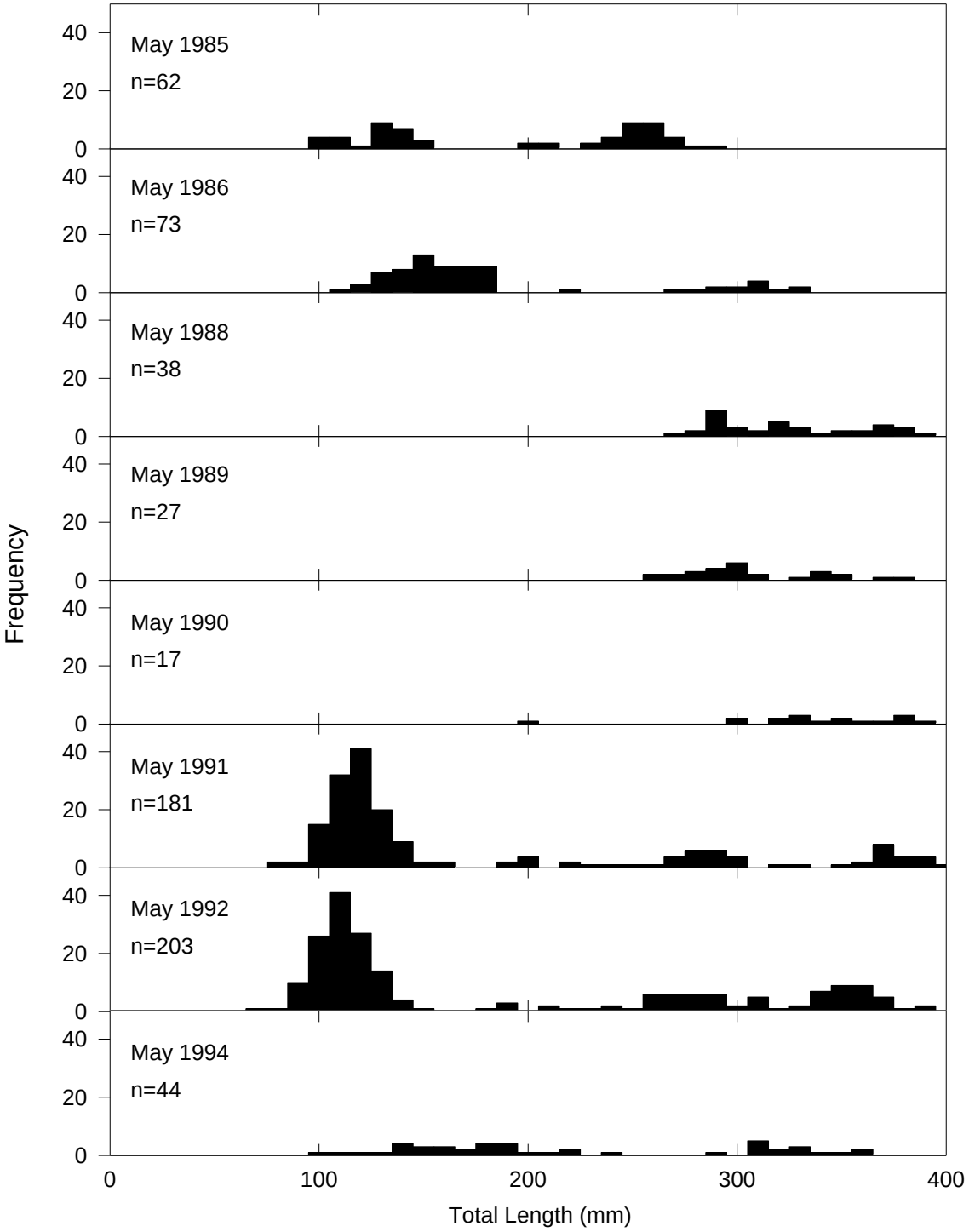

Figure 15. Length frequency distributions of rainbow trout captured by electroshocking in Prineville Reservoir.

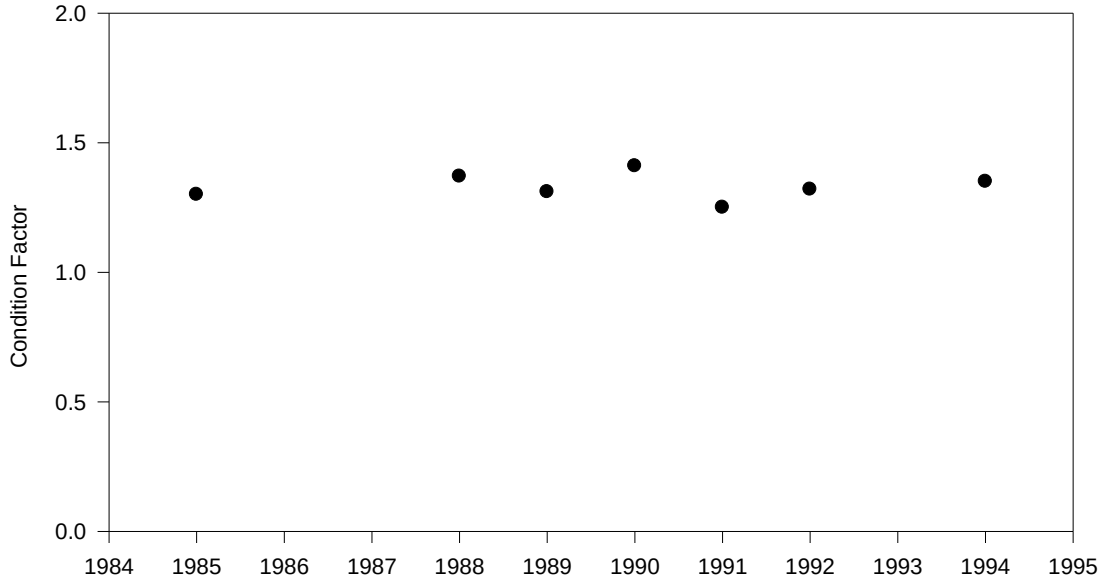

Figure 16. Condition factor (based on total length) of rainbow trout captured by electroshocking in Prineville Reservoir.

A fish management plan for Prineville Reservoir was completed in 1986. Several management alternatives were considered. The selected alternative directed that trout would be managed for intensive use and basic yield, while warmwater fish were to be managed for natural production and basic yield. The intent was to achieve the maximum possible benefits from hatchery trout and to maintain wild production, if possible without restricting the hatchery program. Artificial reservoir conditions and poor watershed and stream conditions upstream of the reservoir severely limit natural production of a wild trout.

The quality of bass habitat in Prineville Reservoir is declining. Siltation is covering rock areas, stumps and other previously used habitat. Organic structure such as stumps are rotting and decreasing in quantity and quality. Extensive habitat work is needed to maintain or improve structure, primarily for largemouth bass. Habitat projects were completed in 1984 and 1986 by Ochoco Bassmasters and ODFW using tire structures near the mouth of Sanford Creek to create artificial reefs. In 1977, 1987, and 1992, the Ochoco Bassmasters, BOR, and ODFW installed artificial bass reefs using junipers and Christmas trees near known spawning areas to provide improved cover and rearing areas for adults and juveniles. Willow shoots were also planted in 1983 and 1985 along much of the shoreline.

Management Issues and Concerns

1. The expanding black crappie fishery may effect trout and bass populations and fisheries, and they may not grow large enough to meet angler expectations.

2. Turbidity continues to impair fish production and may severely limit management options.

3. Riparian vegetation has not become established along the shoreline in most areas, probably due to erosion caused by wind and boat waves. Efforts to establish riparian vegetation will need to continue.

4. Bass populations appear to be declining in abundance and growth rates.

5. Abundant non-game fish compete with game fish for food and space, and may prey on juvenile game fish.

6. Water quality from nonpoint source pollution in the upper watershed is moderately poor due to land and water management practices.

7. Prineville Reservoir has an unscreened outlet that allows an unknown number of fish to emigrate into the Crooked River.

8. Native redband trout in the watersheds above the reservoir may be affected by hatchery fish that may move upstream. Hatchery fish may cause introgression of non-desirable traits that reduce genetic fitness of native stocks or bring diseases into wild fish populations. If tributaries above the reservoir, which are currently managed for wild fish, exhibit a high abundance of hatchery fish, reductions in the number of trout released or termination of the hatchery trout program may be considered.

MANAGEMENT DIRECTION

(quality management for bass)

POLICIES

Policy 1. Rainbow trout will be managed for hatchery production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).

Policy 2. Smallmouth and largemouth bass will be managed for natural production consistent with the Quality Fish Management Alternative for warmwater fish (ODFW 1987b).

Policy 3. Brown bullhead and black crappie will be managed for natural production consistent with the Basic Yield Management Alternative for warmwater fish (ODFW 1987b).

OBJECTIVES

Objective 1. Provide diverse angling opportunities for a consumptive fishery on hatchery rainbow trout.

Assumptions and Rationale

1. This fishery will be of a general consumptive nature.

2. There are unknown numbers of wild rainbow trout entering Prineville Reservoir from Bear Creek and the upper Crooked River; although we believe they are very rare.

3. Catch rates of 0.22 rainbow trout per hour provide an adequate fishery.

4. Extensive numbers of non-indigenous hatchery rainbow trout stocked in Prineville Reservoir periodically pass downstream, rear and may reproduce in mainstem Crooked River below Bowman Dam.

Actions

Action 1.1 Annually stock 169,000 hatchery fingerling rainbow at 35 per pound during April-June at full pool. During years of low water hatchery stocking will be adjusted downward to reflect reduced trout habitat.

Action 1.2 Monitor abundance, size, age-class structure and distribution of Prineville Reservoir rainbow trout by conducting periodic statistical creel surveys and annual inventories using electrofishing and gill nets.

Action 1.3 Periodically evaluate stocking programs through adjustments in size, number and time at release of hatchery trout in Prineville Reservoir to meet catch rate and contribution to angler creel guidelines.

Action 1.4 Periodically monitor hatchery rainbow trout in the Crooked River above and below the reservoir to measure compliance with Wild Fish Management Policy. Modify stocking program if it is determined that the program is not in compliance with Wild Fish Management Policy.

Objective 2. Provide angling opportunities for quality size smallmouth and largemouth bass in Prineville Reservoir.

Assumptions and Rationale

1. Smallmouth bass are moderately abundant and well distributed throughout the reservoir. Smallmouth bass grow slowly in Prineville Reservoir.

2. Largemouth bass abundance is low in Prineville Reservoir and they exhibit moderate growth.

3. During low water years spawning and rearing habitat for smallmouth and largemouth bass is greatly reduced and appears to affect abundance and growth rates.

4. Reservoir fluctuations during spawning periods appears to reduce abundance by reducing egg and juvenile survival of smallmouth and largemouth bass.

5. Competitive interaction between rainbow trout, warmwater fish, and nongame may limit production of all species.

6. Catch rates of 0.023 bass per hour provide an adequate fishery.

7. Productivity is low in Prineville Reservoir and limits the potential of the bass fishery. Restrictive angling regulations may be able to shift the population structure to produce a higher percentage of "quality" size fish, but probably will not increase the abundance of bass.

8. A smallmouth bass three year average PSD $\geq$6, and a largemouth bass PSD of 40-60 and RSD15 $\geq$30, will result in bass population structures which will meet angler demand.

9. Electroshocking catch per unit effort for smallmouth bass $\geq$ 8 inches of at least 2.0 fish/1000 seconds and usually $\geq$5.0, and for largemouth bass $\geq$4.0 , will result in bass abundances which will meet angler demand.

Actions

Action 2.1 Monitor population abundance, distribution, age-class structure and size of warmwater fish in Prineville Reservoir through annual electrofishing, and periodic mark and recapture studies to determine if the following goals are being met: (1) a smallmouth bass three year average PSD $\geq$6, and a largemouth bass three year average PSD of 40-60 and RSD15 >30; and (2) a May

electroshocking catch per unit effort (for fish ≥ 8 inches) of 5.0 smallmouth bass per 1000 seconds and 4.0 largemouth bass per 1000 seconds.

Action 2.2 Monitor angling pressure, exploitation rate, and harvest of smallmouth and largemouth bass through periodic creel surveys.

Action 2.3 Determine the need for additional or modified angling regulations to protect populations of bass by monitoring their reproduction, harvest and catch rates in Prineville Reservoir.

Objective 3. Provide angling opportunities for a consumptive fishery on brown bullhead and black crappie in Prineville Reservoir.

Assumptions and Rationale

1. Brown bullhead and black crappie reproduce naturally and are abundant in Prineville Reservoir.

2. Brown bullhead and black crappie grow slowly in Prineville Reservoir, probably because of low productivity, competition with other fish, and their high abundance.

3. Management options are limited for these species because harvest rates are typically not high enough to effect changes to abundance or population structure.

Actions

Action 3.1 Monitor population abundance, distribution, age-class structure and size of warmwater fish in Prineville Reservoir through annual electrofishing and periodic mark and recapture studies.

Action 3.2 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Action 3.3 Publicize information regarding additional harvest opportunities on abundant brown bullhead in Prineville Reservoir.

Objective 4. Provide better boat and shoreline access at Prineville Reservoir during low water conditions.

Assumptions and Rationale

1. Boat ramps at Prineville Reservoir State Park, the county boat ramps, and Powderhouse Cover are unusable at low water conditions.

2. Access for the early spring bullhead fishery at the head of the reservoir is limited due to a road closure for mule deer winter range and to prevent soil erosion from vehicle use.

Actions

Action 4.1 Coordinate with BOR, Oregon State Parks and Recreation Department, and Crook County to extend boat ramps at Prineville Reservoir.

Action 4.2 Explore further opportunities for additional boat ramps and associated parking facilities to better distribute boat angler use.

Action 4.3 Educate early spring anglers on the importance of limiting vehicle access in the upper portions of the reservoir shoreline for wildlife and water quality protection.

Action 4.4 In cooperation with BOR, Oregon State Parks and Recreation Department, Crook County Parks and Recreation, look at opportunities to develop trails for additional shoreline walk-in access points.

OCHOCO RESERVOIR

Overview

Ochoco Reservoir is a private irrigation reservoir on Ochoco Creek in Crook County (Figure 17). The OID was organized in 1916 and Ochoco Dam completed in 1921, with a capacity of 46,500 acre feet. Although intended to irrigate 22,000 acres of land, only 8,500 acres were serviced until completion of Prineville Reservoir. In 1956, Congress established the Crooked River Project, which incorporated Ochoco Dam with the newly proposed Bowman Dam. In combination with Prineville Reservoir, water released from Ochoco Dam serves a total of about 20,000 acres. Primary crops include grass and alfalfa hay, mint, potatoes, and wheat.

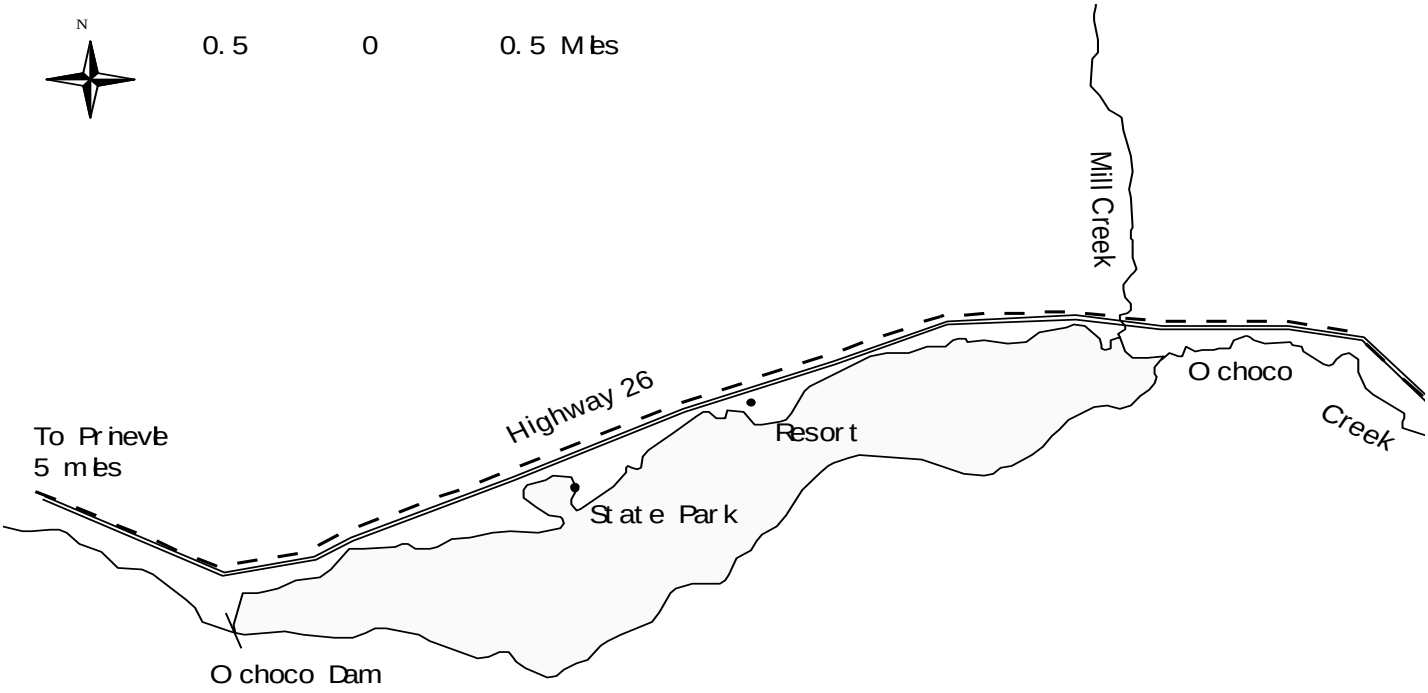

Figure 17. Ochoco Reservoir.

Ochoco Reservoir is open to year round angling and has been popular for rainbow trout fishing. Trolling and casting from boats, and bank angling are both popular at Ochoco Reservoir. Ice fishing is popular during those years when the ice that forms is thick enough to support anglers. Between 8,000 and 10,000 fishing boat use days were spent on the reservoir in the mid 1980's. The reservoir is presently managed for a hatchery rainbow trout program, although some indigenous redband

trout are present. Nongame species include bridgelip sucker and dace. Until the recent drought years and drawdown for dam repairs, the reservoir has been a locally and regionally popular recreation area for fishing, boating, and swimming. Severe drawdown of pool levels since 1990 resulted in boat ramps being unavailable for use after July and a dramatic drop in boater use and angler participation (Oregon State Marine Board 1983, 1986, 1988 and 1993). Less than 1,000 fishing boat use days were recorded in 1992.

Location and Ownership

Ochoco Reservoir was formed by the construction of Ochoco Dam on Ochoco Creek at approximately RM 10. Ochoco Dam is an earth filled dam with a height of 125 feet, a crest length of 1,000 feet, and a storage capacity of 44,500 acre feet. The BOR reconstructed and enlarged Ochoco Dam in 1949-1950. Ochoco Dam was also reconstructed in 1994 to fix internal seepage and erosion of the foundation and embankment, and repair of the outlet works. Additional repairs were made again in 1995 to correct internal seepage.

Ochoco Reservoir is located in Crook County, 6 miles east of the town of Prineville. Ochoco Reservoir lies on the west slope of the Ochoco Mountains in central Oregon, occupying a relatively narrow valley. Below the dam, semiarid irrigated farmlands dominate, while rolling hills with juniper-sage-grassland communities dominate the surrounding uplands. The elevation at full pool is 3130 feet above mean sea level. Maximum surface area of the reservoir at full pool is 1,090 acres and minimum surface area at dead storage is approximately 100 acres. The length of the reservoir is 3.5 miles long with a maximum width of 0.5 miles.

Irrigation demand drives the operation of the dam and consequent drawdown of the reservoir water level. The entire active capacity is allocated for the exclusive use of irrigation. Irrigation releases generally begin around April 1 and extend until early to mid-October, with an annual average water level drawdown of 20 to 50 feet. Outflows during the irrigation season average 6,000 to 8,000 acre feet per month. During high spring runoff, outflow can exceed 25,000 acre feet. From 1990 to 1993, the BOR administratively restricted the maximum pool level to 30,000 acre feet due to safety concerns. Full reservoir storage capacity will be restored in the spring of 1996, following completion of the latest dam rehabilitation.

Habitat and Habitat Limitations

Ochoco Reservoir habitat is characterized by a lack of shoreline vegetation, an expansive mud flat substrate in the upper end, and a boulder and cobble strewn substrate in the lower end. Like other irrigation reservoirs, Ochoco Reservoir suffers from annual fluctuation in water level and the associated impacts. Additional habitat limitations for fish include only moderate concentrations of nutrients in the water, very

low abundance of aquatic vegetation, a lack of structural complexity, and water that is too cold for optimal warmwater fish production and perhaps too warm for optimal trout production.

Drainage area for the reservoir comes from 3 main tributaries, Mill, Marks, and Ochoco creeks, with a total drainage basin of 295 square miles. Eroding streambanks from these streams and their tributaries contribute silt loads to the reservoir during the spring run-off period. As a result, the reservoir is frequently muddy during the spring months. Such turbidity tends to limit production of food organisms for fish. There are virtually no areas of shoreline vegetation such as willows or sedges, which are critical for hiding cover for fish, aquatic insect production, and bank stability. Annual silt load from the tributaries into the reservoir continues to build up shallow flats generally devoid of vegetation or suitable habitat structure.

Water quality conditions were reported to be moderate for fish and aquatic habitat (ODEQ 1988). Water quality parameters of chlorophyll a, phosphorus, alkalinity, and conductivity indicate that Ochoco Reservoir is a eutrophic reservoir and therefore moderately rich in nutrients. However, when zooplankton were sampled in 1987, only 14,800 organisms per cubic meter were found on average throughout the summer, indicating a relatively low level of productivity (Figure 2, page 28). Occasionally, there are large blooms of a blue green algae called *Aphanizomenon* which can cause what appear to be a blue green pollution scum along the shoreline. In some instances where the outbreak of *Aphanizomenon* has been extensive, small numbers of fish die.

Another major habitat limitation for fish production is drawdown of the reservoir for irrigation. The annual drawdown in Ochoco Reservoir exposes shallow areas, and as a result, food production for aquatic life, and prevents shoreline vegetation from becoming established. Shoreline species such as willow and sedge are not able to tolerate prolonged periods of drying out as the reservoir level drops and soil moisture is reduced. Drawdown reduces living space, increases competition for fish living in the reservoir, and may ultimately limit population size.

In normal water years, the reservoir contains on average 12,000 to 14,000 acre feet of water by fall. However, in severe drought years the reservoir has been drawndown to a storage content of less than 5,000 acre feet by fall. Severe drawdown results in direct fish mortality or outmigration to Ochoco Creek below. Several fish salvages have been conducted in the stilling basin below the dam since 1988, when the reservoir has been drawn down to very low levels. During years when salvage occurs, between 5,000 to 26,000 rainbow trout have been recovered. Fishing quality is reduced when this many rainbow trout leave the reservoir during severe drawdown years.

Rainbow trout, particularly 3-4 year old fish, in Ochoco Reservoir can accumulate potentially toxic levels of mercury. Fish collected in 1992, and again in 1994, had accumulated enough mercury in their body tissue to constitute a potential health hazard if eaten in sufficient quantities. The mercury source is probably from inactive mercury mine sites at the headwaters of Canyon Creek; as elevated levels of mercury have been

found in water samples collected from both Canyon and Ochoco creeks. Elevated mercury levels have also been found in the water and sediments of the reservoir.

Access

Shoreline and boat access is fair at Ochoco Reservoir. Public access to the reservoir is primarily via Ochoco State Park on the north shore on Highway 26. A public boat ramp is present at the state park along with overnight camping facilities. The boat ramp quickly becomes unusable for most craft when the reservoir is drawn down for irrigation. Typically, when the reservoir drops down below 15,000 to 20,000 acre feet by mid to late July, the ramp is unusable, except for very small boats. Boating access is essentially eliminated during severe drawdown and angler effort drops dramatically.

A second access point is near the head end of the reservoir on county land between private property lots; it is rarely used except during full pool when walk-in anglers want access to the upper reservoir. A third public walk in access point is at the dam. This access point has become more popular for shoreline anglers during low water episodes. Dam reconstruction by the BOR recently eliminated this access point for vehicles and boat launching. Access is also available at a private resort, the Lakeshore Lodge, on the north shore of the reservoir. Small boats are available for rent and dock facilities are present and usable until mid summer when the reservoir level drops.

All areas of the reservoir are accessible to boats, but there is a 10 mph speed limit in the upper one-third of the reservoir. The east shore of the reservoir is privately owned, as is most of the northern shoreline where access is restricted by houses.

Fish Resources

Ochoco Creek historically supported populations of spring chinook, summer steelhead, inland rainbow (redband) trout, mountain whitefish, suckers, northern squawfish, goldfish, dace, and sculpin. Frey (1942) reported chinook used Ochoco Creek extensively before the reservoir dam was built in 1918-21. Steelhead used the stream for spawning and rearing up into the 1950's (Frey 1942; OSGC 1951; Montgomery 1952). Ochoco Reservoir supported populations of black crappie from 1920-1957, and largemouth bass have been found on occasion up to 1988. Squawfish and goldfish were eliminated by an extensive rotenone treatment project in 1957, and have not been observed since. Ochoco Reservoir currently supports populations of rainbow trout, brown bullhead and bridgelip suckers. Ochoco Creek upstream of the reservoir supports redband trout, bridgelip suckers, sculpins, and dace.

Rainbow Trout

Hatchery rainbow trout grow well in Ochoco Reservoir and have supported the bulk of the angler effort since 1958. Fingerling rainbow trout are stocked in early to mid-May. They normally enter the fishery in mid-summer when they reach 6 to 8 inches. Spring catches usually consist of trout stocked from the previous year and are 10 to 12 inch trout, although 14 to 16 inch trout are observed in the creel and in spring inventory net sets, and fish have been salvaged in the stilling basin up to 5 pounds. Trout stocked in 1995 in the newly filled reservoir showed exceptional growth and grew to 10 to 12 inches by October and were a robust 0.4-0.8 pounds in weight. During severe reservoir drawdown, some hatchery rainbow trout emigrate from the reservoir into the stilling basin below the dam. Many are trapped there, while some fish emigrate into Ochoco Creek over a cement spillway. Rainbow trout also migrate up Ochoco and Mill creeks in the spring. Although these fish may spawn in the creeks, we are not sure how successfully they reproduce.

The majority of the trout harvested in Ochoco Reservoir are from stocked hatchery rainbow trout fingerlings. However, a small number of wild fish are probably caught in the fishery each year. Following a rotenone treatment project in 1988 and following draining of the reservoir in 1994, a few wild redband trout were caught in gillnet sets prior to the spring planting of hatchery rainbow trout, indicating that there is some movement of wild fish to the reservoir.

Warmwater Fish

Brown bullhead are present in the reservoir and support a minor fishery. Despite numerous chemical treatment projects and severe drawdown, they have either been able to survive or have been repeatedly illegally introduced. Brown bullhead grow well in Ochoco Reservoir reaching 14-16 inches and about a pound in weight. However, they are fairly rare. Their low abundance suggests that they have trouble reproducing in the reservoir, and that it will be difficult to support additional angler hours directed at brown bullhead.

Nongame Fish

Bridgelip sucker are abundant in the reservoir. Sampling with experimental gillnets since 1963 indicates that up to 95% of the catches consist of bridgelip suckers. The abundance of nongame fish prompted chemical treatment projects with rotenone in 1949, 1957, 1962, 1968, 1973, and 1988. Rotenone is applied to eradicate “undesirable” species. Rotenone has been applied in Ochoco Reservoir to eradicate undesirable species and attempt to increase the growth rates of rainbow trout. However, within 2 to 3 years following treatment, suckers again comprised 60-80% of the catch in gillnets, indicating that the effects were short lived at best. While the effect of an abundant bridgelip sucker population on trout within the reservoir is not clearly

understood, these fish likely compete with game fish through competition for food and space. When a fish species comprises such a large proportion of the total biomass of an ecosystem, they likely affect other fish present and may be a limiting factor.

Fish Stocking History

The first fish stocked in Ochoco Reservoir appear to have been bass and may have included black crappie. While there are no formal records of warmwater fish being stocked in Ochoco Reservoir, the first district biologist noted that spiny rayed fish were stocked in the reservoir from approximately 1920 to 1950 and included bass. The earliest record of trout stocked in Ochoco Reservoir was 10,000 eastern brook trout in 1932. The first stocking of rainbow trout was in 1946 when approximately 3,800 fish were planted in Ochoco Reservoir. Rainbow trout have been stocked annually since 1950, following the first chemical treatment project of rotenone in 1949. From 1950 to 1980, up to 480,000 trout were released annually in the reservoir, but typically from 100,000 to 200,000 fish were stocked. Juvenile coho were stocked in 1966 but contributed very little to the fishery in subsequent years. Most fish apparently migrated out the outlet in 1966 and 1967.

Rainbow trout release strategies have included variations in time and size of release, and hatchery source. Fish were released at a variety of sizes including fry, fingerling, and catchables, but were primarily fingerling sized fish. Release times were as early as January and as late as November, although most fish were released from March to June. From research conducted at Prineville Reservoir using fin marked rainbow trout, a spring release of large fingerlings appeared to be the most successful strategy, with size at release being the most critical factor.

Since 1980, approximately 100,000 rainbow trout fingerling have been released, although these numbers are adjusted downwards in years with anticipated low water conditions. These fish are released as large fingerling at 35 per pound in mid to late May. In the low water years of 1990 to 1992, the numbers of stocked fish were adjusted downwards to as low as 20,000 fingerlings in anticipation of the extremely low reservoir pool in the fall.

Angling Regulations

Ochoco Reservoir is open to year round angling with any legal gear. The daily limit on rainbow trout is 10 per day, with no more than 5 over 12 inches and 2 over 20 inches. There are no limits on brown bullhead harvest.

Fish Management

An early report by Dick Herrig, the first Ochoco District Biologist, included an historical account of Ochoco Reservoir. There were few records of recreational uses, such as fishing, from 1920-1950. Much of the history was gathered from conversations with old timers, who said that a majority of the fishing was for brown bullhead and crappie. Prior to reconstruction of the dam by the BOR in 1949-50, summer steelhead and mountain whitefish could swim over the spillway and into the reservoir during overflow years, and fishing was very good. Spiny rayed fish were stocked from Sauvie's Island for a number of years and included bass, but the fishery was considered very poor. With the new construction and raising of the dam level by the BOR, no upstream passage for migratory salmonids was provided, and annual hatchery stocking of rainbow trout began.

Black crappie were sporadically present in the reservoir from 1920 to the 1950's and some local anglers fished for them. Herring's report suggests that black crappie abundance was sporadic and as a result they were not very popular. Herrig also suggested that severe fluctuations in the reservoir level appeared to restrict opportunities for warmwater fisheries since the rate of drawdown was often maximum when water temperatures were optimal for spawning, causing spawning nests to dry up and resulting in few juveniles being born. He indicated that warmwater fish populations seemed to be strongly affected by chronic low water conditions, which occurred during drought years and commented that crappie appeared to compete with trout. Net samples in the late 1950's indicated that small crappie were more abundant than trout, but their growth rates were poor. The last crappie seen in the reservoir was in a gillnet sample after the 1957 rotenone treatment project. Largemouth bass were also present in the reservoir during this period. However, they were never very abundant, probably because the severe annual drawdown limited their spawning success.

Once trout were stocked, starting in 1950, public interest and demand for trout fishing increased at Ochoco Reservoir, and more intensive management of the reservoir began. Rotenone treatment projects were often used to treat the reservoir when nongame species became abundant. The reservoir was treated with rotenone in 1949 and again in 1957 for heavy infestations of suckers and squawfish. The 1957 treatment also included 450 miles of mainstem and tributary streams of the 3 major tributaries of Marks, Ochoco, and Mill Creeks. Millions of nongame fish were eliminated including suckers, squawfish, goldfish, and sculpin. Game fish killed included rainbow trout, brown bullhead, and crappie. No squawfish, largescale suckers, or crappie have been reported in the reservoir since the 1957 chemical treatment project.

The reservoir was also treated with rotenone in 1962, 1968, 1973, and 1988. The 1968 treatment project included 45 miles of tributaries, and the 1973 treatment included 50 miles of tributaries. Fish killed in order of abundance from both projects included suckers, dace, rainbow trout, and sculpin. The reservoir was last treated with rotenone in 1988 to reduce bridgelip sucker populations. Large number of bridgelip suckers, brown bullhead, and rainbow trout were killed. The future of chemical

treatment projects at Ochoco Reservoir is questionable given the impacts on native redband trout, and concerns for non target species, including amphibians, reptiles, aquatic insects, and a host of other mammal and bird species that prey on fish. In addition, purchasing and implementing rotenone treatment projects has become very expensive with the high cost of chemicals and labor.

From 1963 to 1980, a series of studies were initiated at several central Oregon reservoirs, including Ochoco Reservoir. These studies were to determine the abundance of game and nongame fish species, catch rate and size of fish harvested, and limnology, including temperature and dissolved oxygen. Rainbow trout fishing has generally been quite good. Catch rates from occasional angler surveys from 1964 to 1980 ranged from 0.37 to 1.09 fish per hour, and averaged 0.60 fish per hour. Percent of rainbow trout harvested over 12 inches in the same time span ranged from 4 to 59% with an average of 31%.

The reservoir is managed for intensive use and basic yield, with the fishery sustained by a hatchery fingerling rainbow trout program. Movement of hatchery fish into Ochoco Creek and its tributaries and into Ochoco Creek below the reservoir may cause hatchery introgression in native redband trout populations. If Ochoco Creek above the reservoir and its tributaries, which are currently managed for wild fish, exhibit a high abundance of hatchery fish, a fin marking program for selective harvest, or termination of the reservoir hatchery trout program may need to be considered. However, numerous irrigation diversions and dams on both Mill and Ochoco creeks may prevent much interchange with the wild redband trout population.

In the past five years, there has been considerable demand by local anglers to stock black crappie in Ochoco Reservoir. At the same time, an equal number of local anglers have expressed concern about how such an introduction would effect the rainbow trout population. The decision to stock black crappie must be made with full public understanding of the issues and potential consequences of such an introduction. A number of preliminary issues have been identified: 1) How will a black crappie introduction effect the rainbow trout fishery?, 2) What is the potential size and abundance of black crappie in Ochoco Reservoir?, 3) What size and abundance of black crappie would satisfy black crappie anglers?, 4) What effects would black crappie have on downstream and upstream fish populations?, 5) What other opportunities are there for rainbow trout fishing and black crappie fishing locally?, and 6) Are black crappie and rainbow trout equally susceptible to accumulation of mercury?

Initial, albeit sketchy, answers to some of these question can be obtained by examining black crappie populations at other reservoirs and historical information from Ochoco Reservoir. As mentioned previously, spawning success at Ochoco Reservoir was inconsistent from 1920-1957, resulting in a fluctuating abundance of catchable size crappie. Growth rates in Ochoco Reservoir did not appear good, with most crappie less than 8 inches in length. Black crappie grow slowly in nearby Prineville Reservoir where they are abundant, and so far only a small portion of the population has exceeded 8 inches. The number exceeding 8 inches is so low that we have not captured any fish

larger than 8 inches in our spring and fall sampling at Prineville Reservoir. Growth rates in Ochoco Reservoir may be similar, or they may be better if the population abundance remains low. However, if growth rates are similar, the black crappie population will probably be dominated by 6-7 inch fish.

Black crappie compete with rainbow trout for zooplankton during the spring and fall. Because Prineville Reservoir has a low abundance of zooplankton, crappie competition for prey items may reduce growth rates of rainbow trout and juvenile bass. Rainbow trout in Phillips Reservoir switch to feeding on insects during the summer (Shrader 1994). If this holds true in Ochoco Reservoir, the reservoir **may** be able to sustain both black crappie and rainbow trout fisheries. Although the black crappie population in Prineville Reservoir is relatively young, we have not been able to detect major changes in rainbow trout growth rates there. Rainbow trout condition factor has also been similar since 1985. However, it needs to be clear that there is a risk that successful establishment of a large population of black crappie has the potential to lead to detrimental changes to the rainbow trout population, including abundance, survival, growth, and size.

The location of other crappie fisheries should also be considered. Black crappie are available at Haystack and Prineville reservoirs, both within a 30 minute drive of the city of Prineville. While Walton Lake provides a put and take catchable rainbow trout fishery, Ochoco Reservoir is the only nearby water body that provides a consistently producing high quality opportunity to catch good sized trout. Haystack and Prineville reservoirs also produce trout, but the presence and abundance of other coldwater, warmwater, and nongame species limits the ability to produce a good quality trout fishery.

Harvestable crappie are typically 3 to 4 years of age, but they may live to 8 or 9 years of age. If black crappie are introduced into Ochoco Reservoir, they may accumulate more mercury in their body tissue than rainbow trout because they may live longer than trout. Consequently, they may pose a greater health hazard to humans and other wildlife.

Because of the uncertainty surrounding an introduction of black crappie, we feel that such a decision should take place only after evaluating the impacts of an introduction. If the management direction for Ochoco Reservoir includes a proposal to stock black crappie, a study should be undertaken to determine what impacts the introduction will have on the reservoir ecology, rainbow trout growth and survival, and angler effort, harvest, and satisfaction. This study should include pre-introduction baseline data and post-introduction data. This information would not only help evaluate the impacts of black crappie on Ochoco Reservoir, but would provide insights to proposed introductions elsewhere in the state. In addition, a introduction proposal would have to be completed. Introduction proposals undergo a thorough review and require approval of the Chief of the Fish Division.

Management Issues and Concerns

1. Ochoco Reservoir is a private impoundment with 100% of the water allocated to irrigation. Annual drawdown reduces food and space for aquatic life and contributes to shoreline erosion.

2. Habitat issues including protection and restoration of habitat, reservoir drawdown and fluctuations, water quality, and passage are encompassed in the habitat section of the basin plan.

3. Riparian vegetation has not become established along the shoreline, probably due to drawdown of the reservoir.

4. Ochoco Reservoir has an unscreened outlet that allows hatchery fish to emigrate into the stilling basin and creek below. When water is shut off following the irrigation season, these fish die unless a salvage is conducted.

5. Native redband trout in the Ochoco Creek watershed above the reservoir may be affected by hatchery trout that may move upstream. Hatchery fish may cause introgression of non-desirable traits that reduce genetic fitness of native stocks or bring diseases into wild fish populations. An unknown number of wild redband trout enter the reservoir from Ochoco Creek and its tributaries above the reservoir, although the number appears to be low.

6. Abundant bridgelip suckers compete with rainbow trout for food and space. Chemical treatment projects to reduce nongame species competition with rainbow trout are becoming increasingly difficult to accomplish given the expense, and impact on non target species. They may not be a management option in the future.

7. Mercury levels appear to be elevated in both sediments and in fish tissue examined and may pose a health threat to anglers who harvest and consume these fish.

8. There has been a recent petition widely circulated in central Oregon to re-stock the reservoir with crappie as an alternative angling opportunity.

9. During drought years and extensive drawdown, the boat ramp becomes unusable and angling effort is substantially reduced.

MANAGEMENT DIRECTION
(hatchery rainbow trout)

POLICIES

Policy 1. Rainbow trout will be managed for hatchery production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).

Policy 2 Warmwater species including brown bullhead will be managed for natural production consistent with the Basic Yield Alternative (ODFW 1987b).

Policy 3. Warmwater fish species will not be stocked in Ochoco Reservoir.

OBJECTIVES

Objective 1. Provide angling opportunities for a consumptive fishery on hatchery rainbow trout .

Assumptions and Rationale

1. These fisheries will be of a general consumptive nature.

2. There are unknown numbers of rainbow trout entering Ochoco Reservoir from Ochoco Creek and Mill Creek and their tributaries, but their numbers appear to be low.

3. Catch rates of 0.4 rainbow trout per hour provide an adequate fishery.

4. Extensive numbers of non-indigenous hatchery rainbow trout stocked in Ochoco Reservoir periodically pass downstream, rear and may reproduce in Ochoco Creek. Hatchery fish may also move upstream, and rear and reproduce in Ochoco and Mill creeks.

Actions

Action 1.1 Annually stock 100,000 hatchery fingerling rainbow at 35 per pound during April-June at full pool. During years of low water hatchery stocking will be adjusted downward to reflect reduced trout habitat.

Action 1.2 Monitor abundance, size, age-class structure and distribution of Ochoco Reservoir rainbow trout by conducting periodic statistical creel surveys and annual inventories using electrofishing or nets.

Action 1.3 Monitor in Ochoco Creek above and below the reservoir the presence and interaction between hatchery and wild inland rainbow trout according to provisions in the Wild Fish Management Policy (ODFW 1990) through sampling trout composition in rearing and spawning areas. Modify numbers, frequency, timing and types of hatchery rainbow trout stocked in Ochoco Reservoir, if necessary, to protect the genetic resources of wild fish.

Action 1.4 Periodically evaluate stocking programs through adjustments in size, number and time at release of hatchery trout in Ochoco Reservoir to meet catch rate and contribution to angler creel guidelines.

Objective 2. Provide angling opportunities for brown bullhead in Ochoco Reservoir where populations currently exist in low abundance.

Assumptions and Rationale

1. Illegally introduced brown bullhead have become established in Ochoco Reservoir.

2. Competitive social interactions between warmwater fish and trout are largely unknown; there is likely some competition for food and space, particularly for juvenile stages, and predation by larger age classes

3. Chemical treatment of the reservoir to remove nongame and warmwater fish species is not likely to be a management option due to expense, lack of success in past efforts, and effects on non-target fish and wildlife species.

Actions

Action 2.1 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Objective 3. Maintain and improve water quality in Ochoco Creek, specifically for elevated levels of mercury.

Assumptions and Rationale

1. Elevated mercury levels have been documented in fish collected in Ochoco Creek and Ochoco Reservoir, likely from inactive mercury (cinnabar) mines located at the headwaters of Canyon Creek.

Actions

Action 3.1 Continue to work with the USFS and ODEQ to identify mercury sources and reduce contamination of Canyon and Ochoco creeks.

Action 3.2 Work with management entities to eliminate mercury discharge into the reservoir.

Action 3.3 Coordinate with state, county and federal land management agencies to improve monitoring and enforcement of water quality standards.

a. Urge ODEQ, EPA, and BOR, and USFS to increase water quality monitoring, especially in important fish production and angling areas.

b. Develop an action plan to address mercury pollution in cooperation with state and federal agencies.

Objective 4. Provide better boat access at Ochoco Reservoir during low water conditions.

Assumptions and Rationale

1. The boat ramp at Ochoco Reservoir State Park is unusable at low water conditions.

2. A former vehicle access site near the dam was recently eliminated by the BOR during dam rehabilitation.

Actions

Action 4.1 Coordinate with BOR, Oregon State Parks and Recreation, and Crook County to extend the boat ramp at Ochoco Reservoir.

Action 4.2 Work with the BOR and OID to restore vehicle access at the dam during low water episodes.

Action 4.3 Explore further opportunities for additional boat ramps and associated parking facilities to better distribute boat angler use.

HAYSTACK RESERVOIR

Overview

Haystack Reservoir is a BOR irrigation regulating reservoir in the lower Crooked River basin (Figure 18). The reservoir was constructed in the mid 1950's and first filled in December, 1957, Its purpose is to temporarily store Deschutes River water for irrigation of NUID agricultural lands in the Madras and Culver areas. It is a component of the BOR's Deschutes Project which includes Wickiup and Crane Prairie Reservoirs. While a small amount of flow comes from Haystack Creek, an intermittent stream, most of the stored water in the reservoir is supplied by a canal and regulates releases from Wickiup Reservoir onto irrigated lands of the NUID. Crops irrigated by Haystack Reservoir water include grass and alfalfa hay, mint, garlic, onions, potatoes, and wheat. The reservoir is not drained seasonally but has daily and weekly water fluctuations in response to irrigation demand.

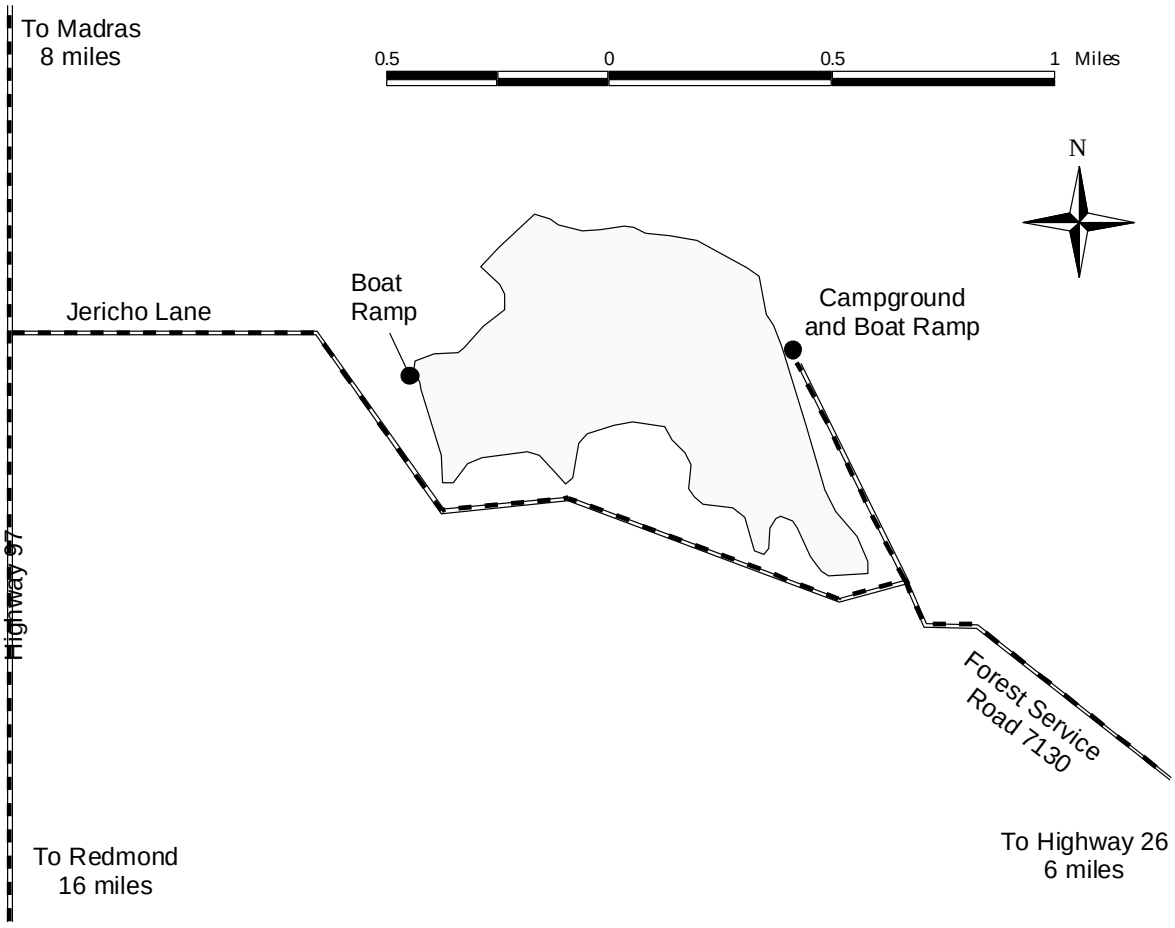

Figure 18. Haystack Reservoir and vicinity.

Since the reservoir is a completely artificial impoundment, no native fish species were in the drainage prior to construction of the reservoir. The reservoir is currently managed for a variety of fish species and has provided popular fisheries for rainbow and brown trout, kokanee, largemouth bass, brown bullhead, bluegill, and black crappie, and is open to year round angling. Smallmouth bass have been occasionally observed in sampling programs or in creel surveys, but none have been observed since 1988. Angler use is moderate. Surveys indicate that fishing is the main boating activity and that use has increased from less than 500 fishing boat days in 1981, to over 1,700 days in 1992 (Oregon State Marine Board 1983, 1986, 1988, and 1993). Although the reservoir's main purpose is for irrigation, the reservoir is also used extensively for boating, water sports and swimming.

Location and Ownership

The reservoir was formed by the construction of Haystack Dam on the ephemeral stream in Haystack Draw, at approximately RM 8. The reservoir is located in Jefferson County, approximately 10 miles south of Madras. Haystack Reservoir lies in the semiarid rangeland of central Oregon on the Crooked River National Grasslands. The reservoir area is characterized by flat plateaus with rolling hills and buttes. Below the dam, irrigated farmlands dominate. Native rangeland vegetation consists of western juniper, sagebrush, rabbitbrush, and bunchgrasses.

The drainage area for the reservoir is Haystack Draw, a tributary of the Deschutes River arm of Lake Billy Chinook. Both the reservoir and its drainage basin are within the boundaries of the Crooked River National Grasslands, administered by the Ochoco National Forest. The reservoir was constructed on lands mostly reclaimed from abandoned homesteads.

Haystack Dam is an earth fill dam with a structural height of 80 feet, a maximum storage capacity of 7,700 acre feet and a minimum capacity of 15 acre feet. The elevation at full pool is 2,848 feet above mean sea level. Maximum surface area of the reservoir at full pool is 235 acres and the minimum at dead storage is approximately 3 acres. At full pool, maximum depth is 75 feet with a mean depth of 25 feet. The length of the reservoir is 1 mile long with a maximum width of 1 mile.

Irrigation demand drives the operation of the reservoir. In normal water years, the reservoir contains 3,500 to 6,000 acre feet of water throughout the irrigation season. Irrigation water is released from mid-April to mid-October. The water level fluctuates daily and seasonally depending on demand.

Habitat and Habitat Limitations

Prior to inundation, Haystack Draw did not support native fish populations. Haystack Reservoir created a habitat that is fair for both coldwater and warmwater fish species. The inundated lands provided only a moderate base for fish habitat. They were composed of a relatively shallow draw, vegetated with juniper and sagebrush. Currently, the habitat is characterized by a lack or shoreline vegetation, expansive mud flats along much of the southern, western and eastern shorelines, and a rock cliff along much of the northern shoreline.

Riparian zones, with shoreline vegetation of willows and sedges, are limited to the high water line and occur only in a few areas. Most of the shallow water area is located in a large cove in the southeast corner of the reservoir, and a very small cove in the southwest corner. The few willows and macrophytes are found in these 2 coves. Although these zones make up a small proportion of the shoreline, they are a critical resource for increased plant and wildlife diversity. They also provide hiding cover for fish during high water, and bank stability through root systems.

Much of the reservoir bottom consists of mud flats. Low to moderate annual silt loads into the reservoir continue to build up shallow flats generally devoid of vegetation or suitable habitat structure. The lower portion of the reservoir, along the northern shoreline is characterized by a steep rocky cliff area with deep water. This rocky area provides some habitat for fish. The boulder and cobble shoreline along the face of the dam also provides fish habitat, particularly for juvenile warmwater fish. A shallow shoal is located near the inlet and is exposed when water levels are drawndown.

Habitat limitations for fish include turbidity, low to moderate concentrations of nutrients, daily and seasonal water level fluctuations, a lack of structural complexity, and water that is too cold for optimal warmwater fish production, and too warm for optimal trout production. Water temperatures also fluctuate throughout the season as cold Deschutes River water is delivered for irrigation and then warms as it is stored.

Water quality degradation in Haystack Reservoir primarily results from warm summer temperatures, moderate turbidity, and fluctuating water levels. Exposed shorelines and strong winds contribute to water quality problems. Damage to wildlife habitat, vegetation, soils, and area aesthetics has occurred due to off road vehicle activity and dispersed recreation use adjacent to the reservoir. With fragile desert soils and vegetation, the reservoir popularity and topography has led to erosion and vegetative degradation in many places. High winds and wave action, particularly along the mud flats of the southern and eastern shorelines, also contributes to turbidity in the reservoir.

Water quality parameters and nutrient concentrations in the reservoir are fair, and indicate that Haystack Reservoir is eutrophic. Concentrations of major ions, alkalinity, and conductivity are low compared to other central Oregon reservoirs, although phosphorus and chlorophyll are high. When zooplankton were sampled in

1987, approximately 34,800 organisms per cubic meter were found on average throughout the summer, indicating a moderately high level of productivity (Figure 2, page 28).

Occasionally, there are large blooms of a blue green algae called *Aphanizomenon* which can cause what appears to be a blue green pollution scum along the shoreline. This algae also limits light penetration, out competing other phytoplankton species and reducing productivity of zooplankton. *Aphanizomenon* also contains a toxin which is released after it dies and cell walls break down. In some instances where the outbreak of *Aphanizomenon* has been extensive, fish kills have been observed at Haystack Reservoir.

Another major habitat limitation for fish production is daily and seasonal drawdown of the reservoir for irrigation. The annual drawdown at Haystack Reservoir exposes shallow areas, and as a result, reduces food production for aquatic life, and prevents shoreline vegetation from becoming established. Shoreline species such as willow and sedge are not able to tolerate prolonged periods of drying out as the reservoir level drops and soil moisture is reduced. Drawdown also reduces living space, increases competition for fish living in the reservoir, and may contribute to entrainment of fish into the unscreened outlet causing additional mortality.

Daily fluctuations in water content vary with irrigation demand and are controlled by inflow from the Deschutes River and Wickiup Reservoir and outflow to irrigated croplands. These daily fluctuations cause the greatest impact in the spring when warm air temperatures cause high demand for irrigation water and warmwater fish are on their spawning nests. Fluctuating water levels dewater nests causing a delay in, or complete failure of, spawning. In some cases, nests may not be dewatered, but falling water levels cause nest abandonment. Influx of cold water from the canal can lower temperatures and cause a delay or termination of spawning. This cooler water also keeps the summer water temperatures below the optimal range for warmwater fish, limiting their growth rates. However, summer water temperatures can still be excessively high for kokanee, as dead kokanee are sometimes observed in late summer.

The outlet facility is unscreened and likely causes substantial losses of both warmwater and coldwater fish. The outlet works were inspected in the fall of 1993 which required the reservoir be drained to 60 acre feet of water, approximately 1% of its capacity at full pool. This extensive drawdown caused substantial mortality of fish in the reservoir, but mostly because fish were forced through the unscreened outlet. Crayfish and aquatic invertebrate populations were severely impacted as well.

Access

Both shoreline and boat access are good at Haystack Reservoir. Public lands allow access to virtually all of the shoreline although vehicle access is more limited. The USFS operates and maintains 2 boat ramps, one on the east shore at Haystack Reservoir Campground and the second on the west shore at a day use area. The east shore campground and access site is closed to the public during winter and early spring. Both ramps are useable at the typical water levels maintained by the NUID, unless the reservoir is severely drawndown. Developed campsites and a day use area are available at Haystack Reservoir Campground. All areas of the reservoir are accessible to boats.

The entire shoreline is available for bank fishing and is easily accessible via parking and walking from boat ramp areas. In addition, a south shore access provides bank angling access and dispersed primitive camping. Adjacent to the west boat ramp is a second area with dispersed primitive campsites. In 1992, the USFS in cooperation with the BOR, constructed a viewing and fishing platform near the inlet canal, usable by physically challenged anglers.

The reservoir is very popular with wind surfers, jet skiers, and water skiers. This has occasionally caused conflicts with anglers. Restricted speed limit areas now occur near both boat ramps, and include the shallow cove areas in the southeast and southwest portions of the reservoir. The impact of other water sports on fish populations is unknown, but may cause some disturbance to warmwater species during nesting seasons.

Fish Resources

Rainbow Trout

Hatchery rainbow trout are stocked annually into Haystack Reservoir and grow very well. Fish stocked as 3 to 4 inch fingerling normally enter the fishery by mid-summer and are 8 to 10 inches by fall. Fish stocked as 6 to 8 inch catchables in the spring are typically 12 to 14 inches by fall. Fish 13 to 16 inches are common, and fish up to 18 to 19 inches are frequently observed in gillnet and trapnet sets. Mean condition factor of rainbow trout averaged 1.16 from 1989 to 1992 and dropped to 0.89 and 0.92 in 1993 and 1994, respectively. The latter values might have been due to severe drawdown of the reservoir, causing increased competition for food with other species, and decline in availability of food resources. Condition factor of rainbow trout rebounded to 1.12 in 1995.

There is no trout spawning habitat available in Haystack Draw. Fish that exit through the outlet die in the irrigation delivery system. Most fish stocked in the reservoir are caught by anglers, eaten by larger fish or terrestrial predators, die by outmigration through the irrigation system, or succumb to natural mortality in the reservoir.

Rainbow trout production is limited by food availability, seasonal water quality, carryover of trout through the winter, drawdown of the reservoir, intensity of angler use, and competition with brown trout, kokanee, black crappie and nongame fish. Competition for prey items is intensified because the limited littoral zone in the reservoir limits macroinvertebrate and insect population. Prey populations may be further reduced by reservoir drawdown, which would cause both direct mortality to prey populations and reduce their habitat. *Ceratomyxa shasta*, a myxosporan parasite, also occurs in Haystack Reservoir and kills rainbow trout that are not resistant. The Deschutes River stock of rainbow trout, that is resistant to *C*. *shasta*, is stocked at Haystack Reservoir, but infection and mortality can occur if the *C. shasta* spore load (or abundance) is sufficiently high.

Brown Trout

Large brown trout were occasionally observed in gill net catches and in creel surveys since the 1960's. The probably came from Wickiup Reservoir via the NUID canal. More recently, 500-1,000 brown trout have been stocked in the reservoir annually to diversify angling opportunity. Unlike other salmonids not indigenous to the Deschutes River, brown trout are resistant to *C. shasta*. In 1995, brown trout comprised approximately 4% of the spring and fall gillnet catches. At nearby Lake Simtustus , brown trout up to 10 pounds have been observed. Similar or better growth is expected at Haystack Reservoir due to its higher productivity.

As with rainbow trout, there is no spawning habitat available for brown trout at Haystack Reservoir. Recently stocked brown trout may experience competition for zooplankton, aquatic insects, and macroinvertebrates with rainbow trout, black crappie, juvenile largemouth bass, and nongame fish. Competition for these smaller prey items may be intensified because the limited littoral zone in the reservoir limits macroinvertebrate and insect populations. However, once brown trout become mostly piscivorous, largemouth bass and black crappie are probably their biggest competitors. There is probably some spatial segregation between these species due to water temperature, and there are abundant small suckers and other prey fish in the reservoir.

Kokanee

Hatchery kokanee are also stocked in Haystack Reservoir and they are moderately abundant. Some naturally produced and hatchery kokanee come from Wickiup Reservoir via the NUID canal. However, recent improvements to the fish screen at the start of the NUID canal have reduced the number of kokanee entering the canal, and subsequently, Haystack Reservoir.

Kokanee generally exhibit good growth rates in Haystack Reservoir. Three to four inch kokanee stocked in July grow to 7-9 inches by the following spring. A year

later these fish are 13-15 inches, and by fall are 18-19 inches. Because of the good growth rates, they appear to mature a year earlier as 3 year old fish, compared to kokanee in Lake Billy Chinook, which typically mature as smaller 4 year old fish. Kokanee up to 20 inches and two pounds are occasionally caught by anglers in Haystack Reservoir. Like other salmonids, kokanee cannot successfully reproduce in Haystack Reservoir due to the lack of spawning habitat. Large maturing fish are frequently observed in fall net catches.

Kokanee production is limited by food availability, seasonal water quality, carryover of fish through the winter, drawdown of the reservoir, intensity of angler use, and competition with other fish species that prey on zooplankton. Prey populations of zooplankton are further reduced by reservoir drawdowns, which cause direct mortality to prey populations

Largemouth Bass

Largemouth bass were first stocked in 1970, are now reproducing, and are now found throughout the reservoir. While Haystack Reservoir does not provide ideal largemouth bass habitat, they have successfully established and are present in moderately abundant numbers. The coves in the southeastern and southwestern corners with macrophytes, shallow mud flat areas, and the boulder area along the dam are preferred by largemouth bass. An estimate of largemouth bass abundance in 1992 was approximately 580 fish over 8 inches in length, with a density of 2.1 fish per acre (Shrader 1990), which is higher than most other eastern Oregon reservoirs with largemouth bass populations (Figure 19) (Daily 1994).

Sampling conducted in 1984 and 1987 with electroshocking gear indicated that fish ranged in size from 4.6 to 18.2 inches, although most fish were between 6.5 to 8.5 inches in length. More extensive electroshocking from 1990 to 1992 indicated that annual growth was slow and comparable to growth rates at Prineville Reservoir. Five year old bass averaged 10 inches in length, 6 year old bass 11.5 inches in length, and 7 year old fish 13 inches in length. Growth of these fish is likely limited by regular inputs of cold Deschutes River water from the NUID canal.

Bass reproduction is highly variable and appears to depend on reservoir elevation, rate of drawdown, and cool spring time weather fronts. Cold weather, combined with chilling winds, can result in water temperatures that are too cold for good spawning success, or cause bass to abandon their nest. Increased wave action created by strong winds along shallow shoreline areas are also detrimental to bass spawning. Newly born (young of the year) largemouth bass must reach approximately four inches by the end of the summer in order to survive the harsh winter conditions at Haystack Reservoir. Young of the year bass which don't reach this size are subject to heavy mortality during their first winter. Summer conditions in the reservoir vary each year, and the size of young of the year bass varies each fall. Thus, the number of juvenile largemouth bass surviving their first winter also varies. This variation in winter survival

appears to be the major factor determining how many juvenile largemouth bass from a specific years spawning (a cohort) will contribute to the bass fishery in later years. Sometimes entire largemouth bass cohorts are missing from the population. These missing cohorts can cause poor fishing during the time they would have been 12-16 inches in length.

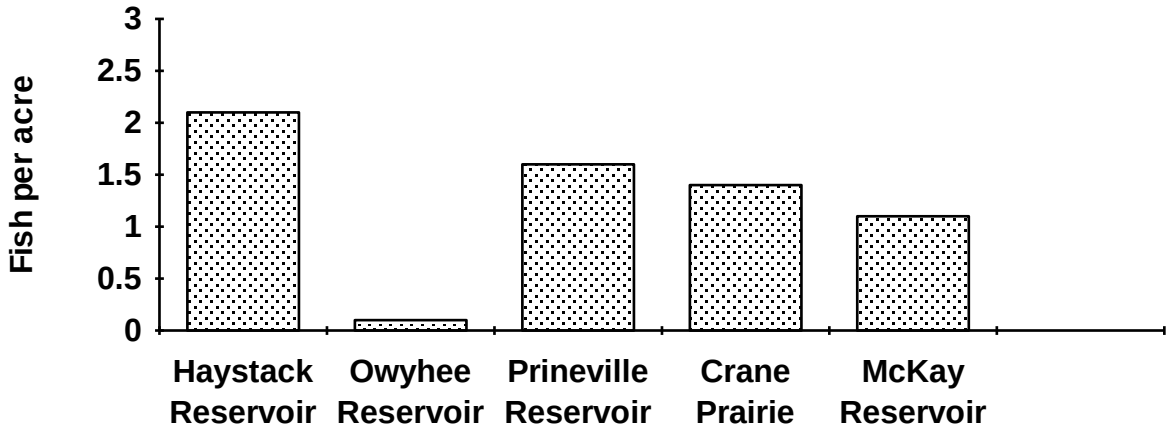

Figure 19. Relative largemouth bass abundance in eastern Oregon reservoirs.

Black Crappie

Black crappie were first stocked in 1970 along with largemouth bass and are now found throughout the reservoir. While Haystack Reservoir does not provide ideal crappie habitat, they have successfully established and are present in moderate numbers. The coves in the southeastern and southwestern corners with macrophytes, shallow mud flat areas, and the boulder area along the dam are preferred by black crappie. Black crappie comprised from 7 to 59% of spring and fall gillnet catches from 1985 to 1991, with an average of 32%. Black crappie comprised from 13 to 91% of trapnet catches for the same years, with an average of 52%. Since the BOR drawdown to inspect the gate in 1993, abundance has dropped considerably, and crappie represented less than 20% of the gillnet catches in 1993, 1994 and 1995.

Sampling conducted in 1984 and 1987 with electroshocking gear indicated that fish ranged in size from 4.9 to 7.6 inches. More extensive electroshocking from 1990 to 1992 indicated that a range of size and age classes were present, with fish ranging from 2 to 11.5 inches. Annual growth appeared to be moderate. Growth of these fish is likely limited by regular inputs of cold Deschutes River water from the NUID canal. Further scale analysis is necessary to fully assess growth.

Similar to largemouth bass, reproduction is highly variable and appears to depend on rate of reservoir fluctuations and drawdown, and cool spring time weather fronts. These variable weather and reservoir conditions result in a wide range of crappie year class strengths. Variable spawning success, and subsequent variations in year class strengths, are reflected in the crappie fishery. Similar to bass, low abundance or the absence of certain size crappie has been observed during sampling efforts.

Bluegill

Bluegill first appeared in Haystack Reservoir gillnet and trapnet catches in the fall of 1986, and were likely illegally introduced. From 1987 to 1991, they were present in low to moderate abundance and ranged from 1 to 9% of gillnet catches and 6 to 50% of the trapnet catches. Only 1 or 2 bluegill have been seen with either sampling method or with electroshocking sampling each year since 1991. A total of 2,100 bluegill were stocked in Haystack Reservoir from 1992 to 1995 from Barnes Butte Lake to restore the population. Bluegill typically provide a better prey species for largemouth bass due to their later spawning date

Brown Bullhead

A population of brown bullhead is present in the reservoir and appears to have a low to moderate abundance. Despite chemical treatment projects in 1962 and 1969, they have been able to survive and become established. Brown bullhead average 12-14 inches long and about a pound, with some up to 18 inches. From 1985 to 1994, brown bullhead comprised from 1 to 56% of the gillnet catches, and 2 to 87% of the trapnet catches, depending on year class strength. Brown bullhead catch abundance was relatively higher in 1985, 1986, 1989, 1990, and 1992.

Length frequency distributions of fish collected from sampling indicate that 2 age classes contribute to the fishery, one at approximately 9 to 12 inches, and a second at 14 to 16 inches. Mean condition factor of brown bullhead ranged from 1.63 to 1.93 from 1990 to 1994, indicating a robust condition for these fish. Compared to other central Oregon water bodies such as Prineville Reservoir, where bullhead are stunted and average 8 to 10 inches, Haystack Reservoir bullheads show very good growth and body weight.

Similar to other warmwater fish species, bullhead experience spawning and recruitment problems due to reservoir fluctuations, water level drawdown, and cool spring weather fronts. This fluctuation in recruitment likely prevents brown bullhead from overpopulating and subsequent stunting.

Nongame Species

The present nongame fish community includes bridgelip and largescale suckers, northern squawfish, chiselmouth and dace. Largescale sucker are by far the most abundant nongame fish species, with bridgelip sucker, a distant second, and squawfish, chiselmouth and dace comprising a very small portion. Tui chub were very abundant in the reservoir until the 1969 rotenone treatment project. Since then, none have been observed in net or electroshock catches, or reported by anglers.

Largescale sucker comprised from 6 to 75% of the gillnet catches from 1986 to 1991. Since 1992, they have comprised from 33 to 57 % of the fish sampled in gillnets, indicating their abundance may be growing. Trapnet catches similarly indicated a growing abundance since 1991. The 1995 trapnet sample captured over 5,400 largescale sucker of which virtually all were 2-4 inches in length indicating a very abundant young of the year age class. Electroshocking in 1991 and 1992 indicated largescale sucker were very abundant for 4 to 5 inch and 9 to 11 inch fish.

Largescale sucker have been observed from 4-20 inches long in net and electroshock catches. Peaks in length frequencies of fish suggest that fish reach the following total lengths at the end of each year of life: age 1, 4-6 inches, age 2, 9-11 inches, age 3 13-16 inches, and age 4, 18-20+ inches. Largescale sucker may play a significant role in management of trout and warmwater fish species in Haystack Reservoir because of competition for food and space resources, and their substantial biomass in the reservoir.

Bridgelip sucker comprise a smaller proportion of the fish community in Haystack Reservoir. From 1986 to 1991, they comprised generally less than 10% of either gillnet or trapnet catches. Since 1992, they have comprised up to 9% of the gillnet and 20% of the trapnet catches, indicating a possible growing abundance.

Threespine stickleback were recently discovered in Haystack Reservoir in the 1995 trapnet sample. They likely emigrated from established populations in the Deschutes River basin and canal system via the NUID canal. While they may be a competitor for aquatic insects and crustaceans, they may also provide forage for trout and bass species.

Fish Stocking History

Annual hatchery stocking of rainbow trout fingerling began in 1958 and ranged from 11,000 to 60,000 annually since then. *Ceratomyxa* and *Aeromonas* were noted as diseases likely affecting stocked rainbow trout in 1969 and *Ceratomyxa* was positively identified in 1973. Rainbow trout stocking was switched to the Deschutes river stock of rainbow trout that is *Ceratomyxa* resistant in 1984. Approximately 5,000 catchable size rainbow trout are stocked annually.

Kokanee were stocked in the reservoir from 1980 to 1985, and have been stocked annually since 1991, although some enter the reservoir from an unscreened outlet at Wickiup Reservoir. Approximately 35,000 fingerling kokanee are stocked annually. A small annual stocking of 500-1,000 catchable brown trout began in 1994. Summer steelhead were stocked once in 1971, and 6 brown trout were stocked in 1984.

Following rotenone treatment in 1969, and due to warm summer water conditions and numerous requests for warmwater species, approximately 500 smallmouth bass were stocked in Haystack Reservoir in 1970, along with largemouth bass and black crappie. Approximately 10,400 largemouth bass fingerling were stocked in 1991 and marked with florescent dye. Approximately 17% of the fish of the appropriate size class examined in September 1992 were from this stocking. An additional 17,000 fingerling largemouth bass were stocked in 1995. Bluegill have also become established in the reservoir and the reservoir was stocked from 1992-95 with 500-800 bluegill each year from Barnes Butte Lake.

Angling Regulations

The reservoir has a 10 fish daily bag limit for trout, with no more than 5 over 12 inches and 2 over 20 inches. The largemouth bass bag limit presently is 5 per day, while there is no bag limit for black crappie, bluegill, or brown bullhead. Haystack Reservoir is open to year-round angling.

Fish Management

Fish management began when the reservoir was filled in December 1957. Early fish management centered around stocking the reservoir with rainbow trout, and infrequent chemical treatment projects to control competing nongame fish species. Chemical treatment projects were conducted in 1962 and 1969 to eliminate tui chub (or roach), which were very abundant and competed with rainbow trout for food and space. Tui chub first appeared in the reservoir in gillnets in the spring of 1960, and by 1962, comprised over 90% of gillnet catches. Tui chub again appeared in net catches in 1963, indicating the 1962 treatment was not completely effective. From 1963 to 1969, tui chub increased from 0.4% of the net catches to over 92% by 1969. Once again, the reservoir was treated with rotenone, but appeared to completely eliminate tui chub this time.

Following stocking of black crappie and largemouth bass, a very popular crappie fishery flourished in the mid to late 1980's due to some very large year classes. Sporadic recruitment has caused extremely variable changes in abundance of bass, bluegill, and crappie. The high quality and enjoyment of these fisheries by the public appears to correspond with abundant populations of warmwater fish, and also declines when populations are less numerous.

In July 1979, Magnacide H, a herbicide used to reduce aquatic macrophytes in irrigation canals, was introduced via the inlet canal. Approximately 10,000 kokanee, and a mixture of rainbow trout, largemouth bass, and suckers were killed.

Angling at Haystack Reservoir is quite variable. Catch rates for rainbow trout ranged from 0.14 to 1.56 fish per hour from 1963 to 1969. Angling for warmwater fish species is also quite variable and success depends on relative abundance of year classes as they are recruited to the fishery.

In recent years, warmwater fish management emphasis has been to inventory the reservoir via electroshocking to determine abundance and distribution. Largemouth bass were released into the reservoir that were marked with fluorescent dye to follow their growth and survival for the first year. Intensive sampling was conducted from 1990 to 1992 to compare standard trend station sampling with habitat stratified sampling. Both methods appeared to provide adequate information. The standard trend transects are less time consuming and easily located on the reservoir. The habitat stratified stations may reduce bias by sampling representative habitats of all types rather than selecting “good” habitat. Largemouth bass, black crappie, bluegill, and brown bullhead were also marked with a fin punch to estimate population sizes. Only a largemouth bass population estimate was made due to the low number of recaptures of the other species.

Another management emphasis in recent years has been to evaluate hatchery stocking programs of coldwater species to evaluate their contribution to fisheries. Fin marked rainbow trout and fingerling kokanee have been stocked and then evaluated in spring and fall net sampling to determine their growth and survival in the reservoir. Almost all kokanee present in the reservoir are now from stocking programs at the reservoir. This is a relatively recent change; previously most kokanee came from the canals.

A cooperative project with the USFS and BOR to enhance access and warmwater fish habitat began in June 1990. Juniper tree bundles were added to the reservoir, primarily in the southeast cove to provide additional habitat complexity and cover for warmwater fish species. Electroshocking in spring of 1991 indicated that both largemouth bass and black crappie were using the tree bundles. Additional activities of this project in 1993 and 1994 have included improving angling access with a platform, and providing additional parking and facility improvements.

Presently, the reservoir is managed for intensive use and basic yield for trout, kokanee, and warmwater fish species. The trout and kokanee fisheries are sustained by legal and fingerling programs, respectively. The warmwater fisheries are primarily sustained by natural production, although some stocking of largemouth bass and bluegill has occurred in recent years.

The ODFW has been seeking a greater diversity of angling opportunities. Haystack Reservoir is an ideal place to try species such as channel catfish or hybrid

bass (a sterile cross between white bass and striped bass) because of its lack of proximity and accessibility to water bodies with wild redband trout populations. In recent years, Prineville area anglers have expressed an interest in a channel catfish opportunity as an alternative to the present warmwater fish species. Channel catfish are a relatively long lived fish with average weights of 2-4 pounds, and occasionally reach 10 pounds or more. Channel catfish may provide an adequate fishery in Haystack Reservoir if anglers are patient. Growth rates will probably be slow because the water temperature is below the optimal for channel catfish. It would probably take 5-10 years for channel catfish to reach 2-4 pounds in Haystack Reservoir. Channel catfish probably would not reproduce in Haystack Reservoir, or their success would be limited like that of brown bullhead. Therefore, channel catfish would have to be stocked on a regular basis to maintain a fishery. Young channel catfish feed primarily on aquatic insects, while older catfish feed on insects, molluscs, crayfish, algae, aquatic plants, and fish (Scott and Crossman 1979). In Haystack Reservoir, channel catfish may feed heavily on the abundant sucker populations.

In reservoirs where they cannot escape, such as Haystack Reservoir, hybrid bass, or “wipers”, may provide an alternative and unique fishery with minimal impacts to indigenous, wild fish. There is a successful hybrid bass fishery in Ana Reservoir, near Lakeview, where wipers reach 16 pounds. Hybrid bass are essentially sterile and would not be able to reproduce in Haystack Reservoir. Hybrid bass are a voracious predator inhabiting pelagic, or open water, portions of lakes and reservoirs. They are generally caught trolling or fishing with live bait. Hybrid bass are also a relatively long lived fish and typically weigh 2-5 pounds, and occasionally reach 10-15 pounds. A proposal to introduce hybrid bass would need to evaluate their potential impact on rainbow trout, kokanee, and black crappie. Most likely, hybrid bass in Haystack Reservoir would consume large numbers of kokanee and possibly rainbow trout. These fisheries may not provide as much angling opportunity as they do now. However, a hybrid bass fishery may provide more angling opportunity and angler satisfaction.

Before introducing channel catfish or hybrid bass, an introduction proposal would have to be completed. Each proposal would go through a thorough review process and needs approval by the Chief of the Fish Division.

Management Issues and Concerns

1. Fluctuating water levels due to irrigation storage and withdrawal affects the spawning and rearing potential for warmwater species. Seasonal drawdown of the reservoir causes increased competition for food and space between game and nongame species. Retention time may also decrease zooplankton production.

2. An unscreened outlet causes an unknown but probably substantial mortality of cold and warmwater fish species.

3. Occasional high summer temperatures, low dissolved oxygen, and algae blooms have caused dieoffs of trout and kokanee.

4. There are occasional conflicts with other recreation users including jet skiers and water skiers.

5. Lack of in lake cover and structure and shoreline vegetation limit production of fish species.

6. Haystack Reservoir is an ideal place to "test" for new species such as channel catfish due to its lack of proximity and accessibility to wild fish populations.

7. Occasionally, poor access to the reservoir during severe drawdown during the boating season eliminates all boating access, and causes poor angler usage.

8. Chronic drawdown of the reservoir to extremely low levels for gate inspections by the BOR will cause loss in production for stocked trout and kokanee, and high loss of naturally sustained warmwater fish populations.

9. Riparian vegetation has not become established along the shoreline in most areas, probably due to erosion caused by wind and boat waves, and by reservoir drawdown. Efforts to establish riparian vegetation will need to be continued.

10. Abundant nongame fish, especially largescale sucker, compete with game fish for food and space, and may prey on juvenile game fish.

MANAGEMENT DIRECTION
(new species)

POLICIES

Policy 1. Rainbow and brown trout and kokanee will be managed for hatchery production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).

Policy 2. Warmwater fish including largemouth bass, bluegill, black crappie, and brown bullhead will be managed for natural production consistent with the Basic Yield Management Alternative (ODFW 1987b).

Policy 3. Examine the feasibility of stocking a warmwater fish species that has the potential to diversify angling opportunities, such as channel catfish or hybrid bass.

OBJECTIVES

Objective 1. Provide diverse angling opportunities for a consumptive fishery on hatchery rainbow and brown trout, and kokanee .

Assumptions and Rationale

1. These fisheries will be of a general consumptive nature.

2. There are unknown numbers of rainbow and brown trout and kokanee entering Haystack Reservoir from the inlet canal from Wickiup Reservoir.

3. Catch rates of 0.4 rainbow and brown trout and kokanee per hour provide an adequate fishery.

Actions

Action 1.1 Annually stock 5,000 hatchery catchable rainbow and 500-1,000 brown trout at 3 per pound during April-June at full pool.

Action 1.2 Annually stock 25,000-30,000 kokanee fingerling at 60 -80 per pound. Larger size fingerlings appear to survive better.

Action 1.3 Continue fin marking program for stocked hatchery fish to evaluate their growth and size and contribution to fisheries.

Action 1.4 Monitor abundance, size, age-class structure and distribution of Haystack Reservoir rainbow and brown trout and kokanee by conducting periodic statistical creel surveys and annual inventories using electrofishing or nets.

Action 1.5 Periodically evaluate stocking programs through adjustments in size, number and time at release of hatchery trout in Haystack Reservoir to meet catch rate and contribution to angler creel guidelines.

Objective 2. Provide angling opportunities for warmwater species including largemouth bass, black crappie, bluegill and brown bullhead in Haystack Reservoir.

Assumptions and Rationale

1. Largemouth bass, black crappie, and brown bullhead are moderately abundant and well distributed throughout the reservoir. Bluegill are present in low abundance.

2. During low water episodes, spawning and rearing habitat for warmwater species is greatly reduced and appears to affect abundance and growth rates. Reservoir fluctuations during spawning periods appears to reduce abundance by reducing egg and juvenile survival of warmwater fish.

3. Competitive social interactions for food and space between coldwater and warmwater fish species likely occurs in a reservoir environment and may limit production of either.

4. Special regulations may be necessary to protect stock fitness, maintain multiple age-classes of largemouth bass and distribute harvest over a larger number of anglers.

5. Warmwater fish would be stocked would occur when there was a loss of more than one year class or where opportunities to enhance fisheries occurred.

Actions

Action 2.1 Monitor population abundance, distribution, age-class structure and size of warmwater fish in Haystack Reservoir through annual electrofishing, net sets, and periodic mark and recapture studies.

Action 2.2 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Action 2.3 Determine the need for additional or modified angling regulations to protect populations of largemouth bass by monitoring their reproduction, harvest and catch rates in Haystack Reservoir.

Action 2.4 Stock warmwater fish as available if more than one year class failed and a species appeared likely to disappear from the reservoir, or to enhance fisheries.

Action 2.5 Investigate options for increasing spawning survival and recruitment such as a pond in a corner of the reservoir that would be managed for stable water levels.

Action 2.6 Investigate possible factors which limit production of warmwater species.

Objective 3. Examine the feasibility of stocking channel catfish or hybrid bass to diversify angling opportunities for warmwater fish not currently available in central Oregon.

Assumptions and Rationale

1. Haystack Reservoir is an "ideal impoundment" to evaluate species introductions due to its lack of proximity and accessibility to wild fish populations.

2. Haystack Reservoir has the potential to grow fish to a very large size. Rainbow trout, kokanee, black crappie and bluegill have shown very good growth rates for a central Oregon reservoir. Nutrient levels indicate the reservoir is moderately productive.

3. While growth would likely be slow for channel catfish or hybrid bass, they have long lives and the potential to grow to large sizes, and provide a trophy fishery. Hybrid bass are sterile and would not reproduce. Either species would need periodic stocking as fish are available, to support a fishery.

4. Competitive social interactions for food and space between channel catfish or hybrid bass and other coldwater and warmwater fish species likely occurs in a reservoir environment and may limit production of either. Hybrid bass are pelagic feeders and may prey on stocked kokanee fingerling.

Actions

Action 3.1 Examine feasibility of introduction of channel catfish or hybrid bass and its potential impact on other coldwater and warmwater fish species. Conduct stocking if it appears feasible.

Action 3.2 Monitor abundance, distribution, and size of channel catfish or hybrid bass in Haystack Reservoir through annual electrofishing and net sets.

Action 3.3 Monitor angling pressure and harvest on channel catfish fish through periodic creel surveys.

Action 3.4 Determine the need for additional or modified angling regulations to develop a trophy fishery for channel catfish bass or hybrid bass.

Objective 4. Provide better boat access at Haystack Reservoir during low water conditions. Facilitate cooperation between angling boaters and other water sports users.

Assumptions and Rationale

1. Boat ramps at Haystack Reservoir are unusable at low water conditions.

2. Current boating speed restrictions reduce water skiing and angling conflicts, and minimize potential high speed boat impacts on fish in littoral habitats.

Actions

Action 4.1 Coordinate with BOR and USFS to extend boat ramps at Haystack Reservoir.

Action 4.2 Maintain boating speed limits in the southeast and southwest coves and near the boat ramps.

LAKE BILLY CHINOOK

Overview

Lake Billy Chinook was created in 1964 by the construction of Round Butte Dam on the Deschutes River, 111 miles upstream from the Columbia River, and approximately 8 miles southwest of Madras in Jefferson County (Figure 20). The dam is part of the Pelton Hydroelectric Project operated by PGE. The FERC operating license for the Pelton Hydroelectric Project requires that Lake Billy Chinook be operated within 1 foot of full pool from June 1 through Labor Day weekend. The reservoir is a locally and regionally popular recreation area. Swimming, boating, angling, and water skiing are the primary recreational activities. Not counting overnight campers, the Cove Palisades State Park had 521,535 visitors in 1987, and 447,924 visitors in 1988. Lake Billy Chinook is also the most popular boating reservoir in Oregon, with over 108,000 boating recreation days expended there in 1993 (Oregon State Marine Board 1993). Over 27,000 angler trips are made on the reservoir annually (Thiesfeld et al. 1995).

Native fish currently present in Lake Billy Chinook and its tributaries include bull trout, rainbow trout, chinook salmon, kokanee, mountain whitefish, largescale sucker, bridgelip sucker, longnose dace, northern squawfish, chiselmouth, shorthead sculpin, torrent sculpin, slimy sculpin, mottled sculpin (Fies and Robart 1988), and crayfish. Introduced species recently captured in Lake Billy Chinook include brown trout, largemouth and smallmouth bass, bluegill, black crappie, and goldfish. Kokanee, smallmouth bass, and bridgelip sucker are probably the most abundant fish species in the reservoir. Only token numbers of bluegill, black crappie, largemouth bass and goldfish exist in the reservoir.

Lake Billy Chinook is currently managed for kokanee, bull trout, smallmouth bass, rainbow trout, and brown trout. No hatchery fish are stocked in the reservoir. However, up to 10,000 fin clipped hatchery (> 6 in.) rainbow trout are released annually in the Crooked River at Opal Springs (RM 6.9), just above Lake Billy Chinook, and 17,500 fin clipped hatchery rainbow were released in the Metolius River below Camp Sherman (RM 39) until 1994. Some of these fish migrate downstream and enter the reservoir fishery. The hatchery program at Opal Springs will be adjusted in the future to reduce the number of, or prevent, hatchery rainbow trout entering Lake Billy Chinook.

Treaty rights grant the CTWS exclusive use for fisheries within the reservation, or the Metolius River Arm in this case. Currently the CTWS allows non-tribal members to fish tribal waters with the purchase of a tribal fishing permit.

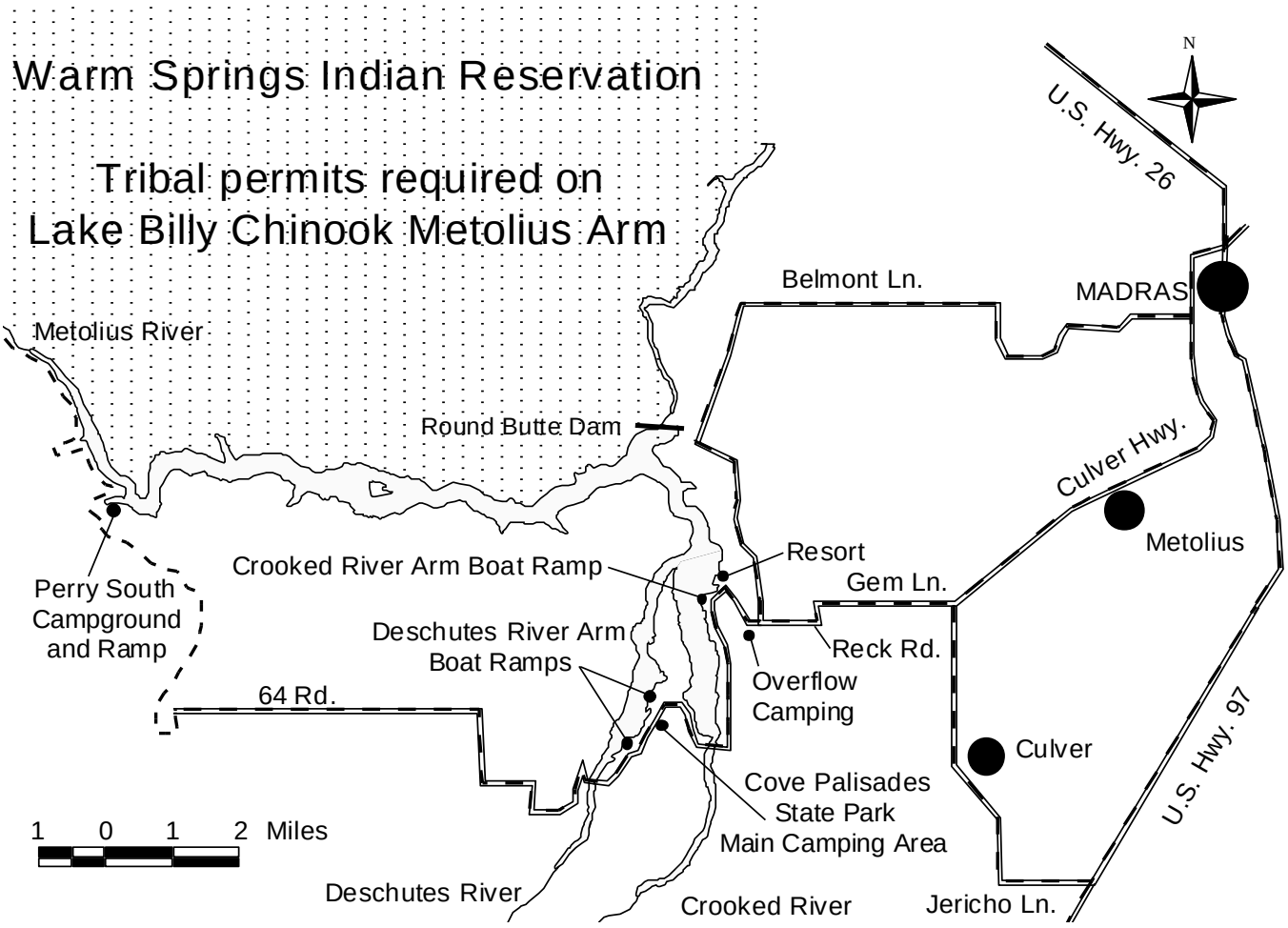

Figure 20. Lake Billy Chinook and vicinity.

Location and Ownership

Lake Billy Chinook lies at the junctions of the Crooked, Deschutes and Metolius rivers. This area is characterized by flat plateaus bisected by deep river canyons. Uplands along the Crooked and Deschutes river arms are dominated by semiarid rangelands, with irrigated farmlands and rural residential development to the east. Native vegetation consists largely of bunch grass, big sagebrush, and juniper. The Metolius River arm extends to the west with juniper, big sage, bunch grass, bitterbrush, and rabbit brush in the lower elevations, yielding to a steeper, mountainous terrain dominated by ponderosa pine, red cedar and mixed conifers at the upper end of the arm.

The reservoir shoreline is owned by a multitude of interests. The entire north shore, down to the middle of the old river channel, from the dam to the mouth of the Metolius River is owned by the CTWS. Large portions of the Crooked and Deschutes

River arms are publicly owned and managed by the USFS and BLM. The State of Oregon owns and operates Cove Palisades State Park, and administers a portion of the federal land surrounding the park. Much of the south side of Metolius River arm up to Fly Creek is privately owned, with the USFS owning most of the remainder.

Round Butte Dam is an earth filled structure with a height of 440 feet, a crest length of 1,380 feet, and a present storage capacity of 535,000 acre feet. The reservoir has a surface area of 4,000 acres and extends 12, 8.5 and 6 miles up the Metolius, Deschutes and Crooked River canyons, respectively. The drainage area for the reservoir is 7,490 square miles and comes from three main tributaries, the Crooked, Metolius, and Deschutes rivers. Lake Billy Chinook has a maximum depth of 415 feet. Much of the shoreline is basalt cliffs and steep talus slopes. Over 60% of the reservoir has a depth greater than 100 feet (Mullarkey 1967) and only 6% of the reservoir is less than 10 feet deep. Elevation at full pool is 1,945 feet above mean sea level, and the maximum surface area is 4,000 acres. Total shoreline of the reservoir is approximately 62 miles. The reservoir usually becomes thermally stratified during May each year, with the thermocline at a depth of 20-25 feet, and becomes homothermal again in late September or early October.

Lake Billy Chinook is generally kept near full pool from Memorial Day through Thanksgiving. Both recreation days and hydroelectric production are maximized when the reservoir is near full pool. From Labor Day through Memorial day, the FERC license allows the reservoir to be drawn down 85 feet during the winter. At times, this drawdown can make boat launching difficult. Portland General Electric Co. prefers to maintain the reservoir as close to full pool as possible. As a result, the reservoir generally is drawn down no more than 10 feet from Thanksgiving to Memorial Day each year. This is the period of highest electricity demand. Hydroelectric production peaks during the morning, with little hydroelectric production or water withdrawal from the reservoir occurring at night. During maximum power generation, 7,000 to 8,000 cfs are typically withdrawn from the reservoir. Water withdrawal occurs from a pen stock opening located at an elevation of 1,780 feet, or 165 feet below the surface at full pool. Because of the large surface area of the reservoir, daily fluctuations in the reservoir level are very minor and usually not detectable.

Habitat and Habitat Limitations

Habitat in Lake Billy Chinook is characterized by steep shoreline topography, a boulder and cobble substrate, and generally good water quality. Most of the shoreline consists of cobble and boulders. A few sandy beaches are present, mostly near developed recreation areas and in secluded coves. Silt and sand are also present in the deltas created by the three main tributary rivers. Due to the steep topography and rocky substrate, very little aquatic vegetation is present in the reservoir. Some woody material has accumulated in the reservoir in recent years. Most of this material is from shoreline alder trees that have fallen into the reservoir.

Very little research has been conducted regarding water quality in recent years. Surface water temperature rarely exceeds 75^{o}F. Normally, a well defined thermocline occurs at 20-25 feet during the summer months. Mullarkey (1967) found that dissolved oxygen in the newly formed reservoir was adequate for salmonids except below the thermocline in the Crooked and Deschutes river arms during the summer of 1964, where dissolved oxygen was 0.0 and 3.0 ppm, respectively. Measurements completed in 1974 showed that dissolved oxygen exceeded 6.0 ppm throughout the lake down to a depth of 100 feet (Herrig 1974). No samples were taken below that point.

Nutrients are the basic element in determining the productivity in a reservoir and ultimately limit fish production. Lake Billy Chinook appears to have adequate phosphorus, but very little nitrogen. Nutrient samples were collected during September of 1973 and May of 1975. Results were averaged for the two sampling periods. Nitrate nitrogen was highest in the Crooked River arm, followed by the Deschutes River arm, with the Metolius River arm having the lowest. Orthophosphate phosphorous was highest in the Crooked River arm followed by the Metolius River arm, with the Deschutes River arm having the lowest. Mean orthophosphate phosphorous for inflow of the three rivers was 0.068 mg/l while nitrate nitrogen was 0.19 mg/l. Surface orthophosphate phosphorous was 0.028 mg/l near the dam while nitrate nitrogen was 0.05 mg/l. At a 35 foot depth, orthophosphate phosphorous was 0.035 mg/l while nitrate nitrogen was 0.09 mg/l.

Zooplankton are the major food source of kokanee and most other juvenile fish. As such, they are another important indicator of the reservoir's potential for fish production. Zooplankton surveys have been conducted in 1974, 1977, and from 1985 to 1988. These surveys indicate that zooplankton densities have remained stable from 1974 to 1988, except for 1986 (Table 11). *Daphnia* and *Bosmina* were the most common zooplankton genera, followed by *Cyclops* and *Diaptomus*. Zooplankton densities were consistently higher in the Metolius River arm and the Crooked River arm than in the Deschutes River arm. *Daphnia* and *Diaptomus* are larger than *Bosmina* and *Cyclops*, and thought to play a more important role as fish prey. Compared to some other central Oregon lakes, the zooplankton densities in Lake Billy Chinook are quite low (Figure 2, page 28). Based on nutrient levels and zooplankton densities, it appears that Lake Billy Chinook is only moderately productive.

The Metolius and Crooked rivers each contribute about twice the volume of water as the Deschutes River (Mullarkey 1967). Because the Metolius River is cooler than the Deschutes and Crooked rivers, the stratification of the water column by temperature is weaker in the Metolius River arm. The Crooked River is generally more turbid than the other two rivers, particularly during late winter and early spring. The Crooked River also has higher alkalinity. Additional studies were initiated in 1994 by PGE and should provide additional insight into the reservoir's limnology, and primary and secondary production levels.

Table 11. Zooplankton species composition and densities (organisms per cubic meter) from 100' vertical tows Lake Billy Chinook.

	Organisms per cubic meter				
Year	*Diaptomus*	*Daphnia*	*Bosmina*	*Cyclops*	Total
1974[1]	2,793	4,118	3,064	916	10,891
1977[2]	5,622	3,595	54	1,139	10,320
1986[3]	3,841	8,756	9,435	3,313	25,344
1987[3]	1,252	2,546	4,159	2,696	10,653
1988[3]	480	2,575	3,642	1,765	8,461

1. Average of samples collected during May through September from all three arms.
2. Average of samples collected on August 12, 1977 from all three arms.
3. Average of samples collected during May through September from the Metolius River and Deschutes River arms.

The steep sides of the reservoir greatly limit the abundance and distribution of littoral fishes such as rainbow trout, brown trout, smallmouth bass, black crappie and bluegill. Because of the limited habitat available for these species, their abundance is much lower than would be found in a shallow reservoir. A lack of shoal areas, juvenile rearing cover, and an adequate supply of forage fish may be limiting factors for smallmouth bass in Lake Billy Chinook.

Access

Bank access to the reservoir is limited due to the steep shoreline topography and tribal ownership. Boat access includes six ramps and two marinas. Boat ramps are located in the Crooked River Arm at the Cove Palisades State Park and at a privately operated marina that is leased from the state park. Two additional state park boat ramps are located in the Deschutes River arm. The only public ramp on the Metolius River arm is at Perry South Campground, while another ramp is available at a private recreation area. This recreation area also includes a houseboat rental operation.

Fish Resources

Kokanee

Kokanee are actually landlocked sockeye salmon. They are distributed throughout Lake Billy Chinook and spawn mostly in the Metolius River and its tributaries. However, kokanee also spawn in the Crooked River upstream to Opal Springs, and in the Deschutes River upstream to Steelhead Falls. Kokanee have been observed in Street Creek during the fall and probably attempt to utilize all other tributary streams for spawning. Regardless of how successful spawning is in these small streams, their contribution to the kokanee population would be extremely minimal.

Kokanee appear to have originated from Suttle Lake or the Metolius Hatchery. By 1968, kokanee made up 67% of the harvest on Lake Billy Chinook, even though kokanee were not stocked in the reservoir until 1970.

Kokanee are probably the most abundant species in the reservoir. Curtain nets have been set annually in the Metolius River arm of Lake Billy Chinook since 1974. The number of kokanee captured each year has varied considerably, but has always been high. Data from creel surveys suggest that the yield of kokanee in Lake Billy Chinook may be among the highest reported (Thiesfeld et al. 1995). The abundance of 2 and 3 year old kokanee certainly exceeds 100,000, as 84,000 were harvested in 1991. The actual number may be closer to 500,000.

Research has not been conducted to determine when juvenile kokanee migrate downstream to Lake Billy Chinook. Kokanee eggs generally hatch in mid-winter. Young kokanee emerge from the gravel in late winter and immediately begin their downstream migration. Therefore, they probably enter Lake Billy Chinook in late winter. Trawl surveys conducted in late March of 1981 and 1982, indicated that at least some age 0 kokanee had already entered the lake. Juvenile kokanee migrations in the reservoir have not been studied. Maturing kokanee congregate in large numbers at the upper end of the Metolius River arm beginning in July. This is believed to be a precursor to their spawning migration up the Metolius River. The spawning migration can begin as early as late-July and continue through October. Most kokanee stage at the mouth and begin their upstream migration during late August and September.

Growth of kokanee in Lake Billy Chinook is quite variable between years. In some years, spawners average 12 inches or more in length, while in other years the average is much less. In 1984, the average size of spawning adults in the Metolius River was only about 9 inches. Length frequency analysis from curtain net sets indicate that kokanee size in the spring varies considerably, and suggest that a strong cohort might limit the growth rates of the next cohort or two. Kokanee collected in the curtain net in 1983 reached 7 inches during April of their second year (age 2+) and 10 inches during their third year (age 3+) (Table 12). This growth rate appears to be typical for Lake Billy Chinook kokanee.

Table 12. Backcalculated fork length (inches) at annulus formation for three year old kokanee (1979 cohort) collected in the Metolius River arm of Lake Billy Chinook, April 1983 (ODFW, unpublished data).

Age		
I	II	III
4.1	6.7	10.1

Based on scale analysis and catches in curtain nets, most kokanee in Lake Billy Chinook begin to mature during their third year of life, which is their fourth summer in

the reservoir. They spawn in the fall when they have just reached age 4, although some may spawn at age 3 or 5. Spawning generally occurs in September, although spawning kokanee have been observed well into October. Heavy concentrations of kokanee have been observed in Jefferson, Candle, Canyon, and Spring Creeks. Most small tributary streams of the Metolius River are used by spawning kokanee. It is unknown if Whitewater River is used for spawning. Surveys for juvenile and adult bull trout upstream of RM 8.0 did not reveal juvenile or adult kokanee (B. Lampman, CTWS, personal communication). As with all Pacific salmon, kokanee die after spawning.

Smallmouth Bass

Smallmouth bass were rare in Lake Billy Chinook until the early 1970's. They were first observed in creel surveys conducted in 1972, and two smallmouth bass were recorded in creel surveys in 1973. Herrig (1973) pointed out that "bass can readily be seen around all the boat docks on the reservoir. Reports have been received of some anglers making good catches of bass at the reservoir, and a fishery for warm-water species may become significant in the near future." Smallmouth bass continued to increase and eventually largemouth bass essentially disappeared from the reservoir. Smallmouth bass are now distributed throughout the reservoir and their abundance is high. Over 3,500 smallmouth bass were estimated harvested in 1990 and 1991. This would be an absolute minimum number of smallmouth bass for the reservoir.

Smallmouth bass in Lake Billy Chinook are generally small and young. Electroshocking surveys were conducted in 1990-1992. None of the scales read in 1990 and 1991 were from fish older than age 4. Smallmouth bass growth rates in Lake Billy Chinook are among the slowest in Oregon, with the exception of Prineville Reservoir (Table 13). Very few smallmouth bass were captured which exceeded 10 inches. Proportional stock density (PSD) measures the percent of fish greater than 7 inches which also exceed a quality size (11 inches). During 1990-93, PSD ranged between 1 and 8, i.e. only 1 to 8 percent of the bass population greater than 7 inches exceeds 11 inches. A good PSD for bass is usually from 40 to 60. Local bass clubs often reduce their minimum size for tournaments on Lake Billy Chinook to 10 inches. Shrader (1992b) examined the relative weight (or plumpness) of smallmouth bass in Lake Billy Chinook. He determined that relative weight was variable among years, but overall, smallmouth bass in Lake Billy Chinook exhibited a better than "average" weight for their length. He suggested that cool water temperatures are limiting the size of smallmouth bass in Lake Billy Chinook.

The mortality rate for smallmouth bass appears to be low. Shrader (1992b) computed total instantaneous mortality rate of 0.37 for the 1986-1988 cohorts. Creel surveys in 1990-1993 suggest that angling mortality on smallmouth bass is low. Minimum annual exploitation rates were calculated at 6.7 percent in 1990 and 4.5 percent in 1991. Most smallmouth bass caught by anglers are voluntarily released, with 73% and 82% of the smallmouth bass released in 1990 and 1991, respectively.

Table 13. Mean backcalculated length at annulus formation for smallmouth bass collected from northwest lakes.

	Mean Backcalculated Length (inches) at Annulus Formation							
	I	II	III	IV	V	VI	VII	VIII
Lake Billy Chinook[1]	3.3	5.4	7.1	8.3	9.8	12.4		
Prineville Reservoir[1]	3.0	4.8	6.5	8.3	8.9			
Oregon[2]	2.9	7.1	10.8	13.0	14.6	15.0	16.4	17.7
Owyhee[3]	4.0	6.9	9.5	11.3	13.4	14.5	15.5	17.6
Lake Sammamish[4]	4.0	7.3	10.2	12.4	14.1	15.1	16.3	
Oxbow Reservoir[5]	3.1	5.8	8.1	9.4	10.6	11.9	12.9	
Hells Canyon[5]	2.9	5.4	7.5	9.0	10.3	11.4	11.3	

1. Unpublished data, Oregon Department of Fish and Wildlife, fork length. 1990-91.
2. Grenfell (1962), mean of 3 Oregon lakes, total length.
3. Rien and Beamsderfer (1991), fork length.
4. Pflug (1981), Lake Sammamish, Washington, total length.
5. Unpublished data, Oregon Department of Fish and Wildlife, total length.

Smallmouth bass in Lake Billy Chinook do not demonstrate long migrations. Over 478 smallmouth bass were tagged with floy anchor tags during electroshocking surveys in 1990 and 1991. Of 35 tagged smallmouth bass recaptured by anglers and electroshocking, only two had migrated from one river arm to another.

The small quantity of littoral habitat is certainly limiting the total biomass of smallmouth bass in Lake Billy Chinook. Shrader (1992b) felt that the reservoir was at its carrying capacity for smallmouth bass. The reason for the small size of these fish is unclear, although he speculated that they may be growing as fast as the water temperature will let them. However, this does not explain why older age class fish are not observed in the harvest or sampling. More research will be necessary to explain the lack of larger smallmouth bass. At this time, the lack of a demonstrated ability to grow larger smallmouth bass severely limits the scope of smallmouth bass management in the reservoir.

Bull Trout

Lake Billy Chinook serves as a rearing area for bull trout that spawn in Metolius River tributaries. They also utilize the Deschutes River from Lake Billy Chinook upstream to Steelhead Falls; and the Crooked River upstream to Opal Springs. Bull trout abundance has increased in recent years. For those tributaries surveyed since 1986, the number of redds counted has generally increased from a low of 27 in 1986 to a high of 330 in 1994, before dropping in 1995 (Figure 21). An adult-per-redd ratio was

calculated for 1990 through 1993. An adult population estimate for the known spawning areas was then calculated by multiplying the number of redds by the adult-per-redd ratio. The estimated population in the known spawning areas increased from 318 in 1990 to 723 in 1994, before dropping to 491 in 1995 (Figure 22). These counts represent only a portion of the spawning that occurs in the system. Additional population estimates were made in 1993 and 1994 based on the number of bull trout tagged at the mouth of the Metolius River versus the number observed in the Jack Creek and Jefferson Creek traps. The mark-recapture population estimates suggest a larger total adult population than calculated using redd counts. We calculated a total spawner population of 818 in 1993 and 1,895 in 1994. Bull trout were also documented spawning in Whitewater River in 1994. The abundance of adult fish in Whitewater River is unknown, but initial research suggests that 20-30% of the population may spawn there (Thiesfeld et al. 1996).

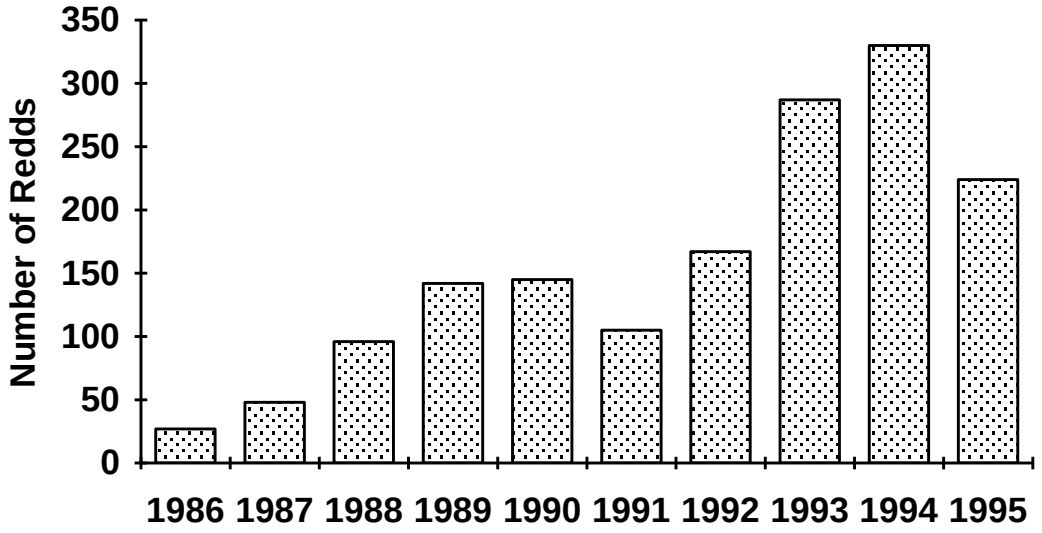

Figure 21. Number of bull trout redds counted in Jack, Canyon, Candle, Roaring, and Jefferson creeks, and the Metolius River.

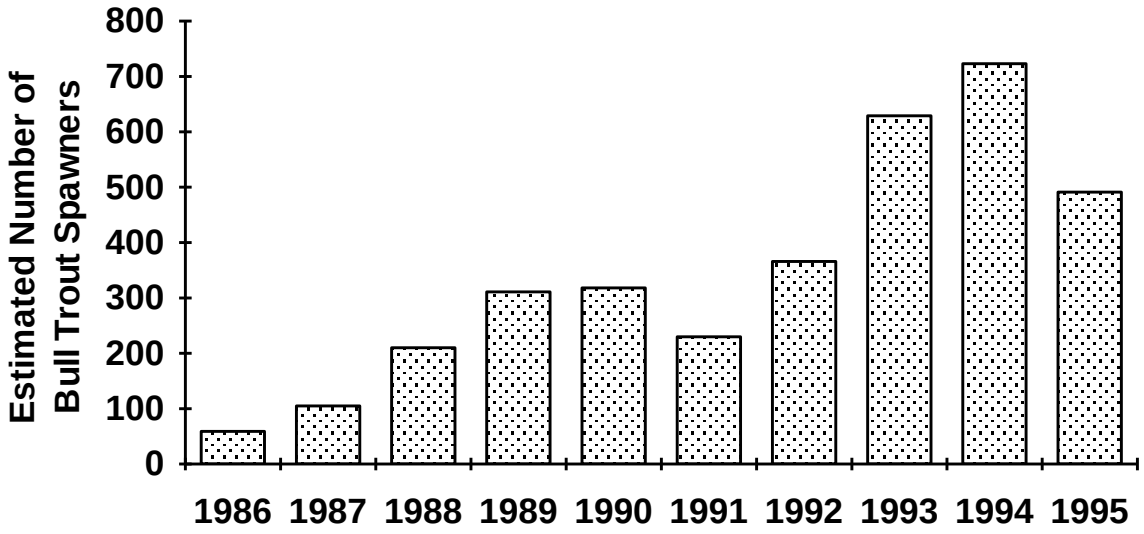

Figure 22. Estimated number of bull trout spawners in Jack, Canyon, Candle, Roaring, and Jefferson creeks, and the Metolius River, calculated by multiplying redd counts by the adult-per-redd-ratio.

The abundance of juvenile bull trout is apparently high and the abundance of subadults appears to be increasing. When compared to other basins with bull trout, the Metolius River tributaries have some of the highest densities documented (Shepard et al. 1984; Goetz 1991). Trap net catches of subadult bull trout at the head of the Metolius River Arm in April and May have generally increased since 1986. Length frequency analysis shows a substantial increase in trap net catches of bull trout larger than 12 inches in 1993. This is likely due to the more restrictive angling regulation in Lake Billy Chinook starting in 1992.

Juvenile bull trout generally rear in their natal spawning stream until age 2, when they migrate downstream to Lake Billy Chinook. Based on growth rates observed during scale analysis, many adfluvial fish enter the reservoir when they are 5-8 inches long. Although the timing of reservoir entry is unclear, it appears that many enter the reservoir in the early spring based upon trap net catches. Recaptures of bull trout tagged at the head of the Metolius River arm indicate that subadults move into all available waters, including the Deschutes and Crooked rivers. For example, at least three tagged bull trout have migrated 12 miles down the Metolius River arm of Lake Billy Chinook, 8 miles up the Deschutes River arm, and at least 3 miles up the Deschutes River to Squaw Creek. Other tagged bull trout have been captured at various locations in the reservoir, and in the lower Crooked River above the reservoir. Sub-adult bull trout remain in the reservoir until mature at age 5, or 18-22 inches. Maturing bull trout migrate up the Metolius River system from April through August. Bull trout spawning in the upper Metolius River tributaries reside in the mainstem until just prior to spawning. They migrate into the spawning tributary, spawn, and return to the mainstem within two

weeks. Peak upstream movement into tributary streams occurs between late August and mid-September. Most spawning activity occurs between mid-August and the end of October, although spawning has been observed as early as mid-July (Ratliff 1992) and as late as mid-October. Bull trout in Whitewater River migrate upstream to near their spawning location quickly, and stay there for almost two months before spawning. After spawning, most bull trout move back down to Lake Billy Chinook within 3 weeks. However, some fish stay in the Metolius River for longer periods.

Bull trout grow rather slowly in the tributary streams, but grow quite rapidly upon reaching Lake Billy Chinook. In April 1987, mean fork lengths for juvenile bull trout for ages 0+, 1+, and 2+ sampled in the Metolius River tributaries were 1.3, 2.8, and 4.2 inches, respectively (Ratliff 1992). Pratt (1991) examined bull trout scales and back calculated growth at annulus formation (Table 14). Spawning adults observed at tributary traps ranged from 9 to 32 inches in length, with most adults between 18 and 26 inches. Recovery of tagged bull trout indicates considerable variation in growth rates, likely dependent upon area of residence and density of available forage species. Growth rates for bull trout recaptured after residing in Lake Billy Chinook is extraordinary. Length increased an average of 6.5 inches per 12 months (Ratliff 1992). Bull trout tagged and recaptured in the Metolius River increased in length an average of 3 inches per 12 months.

Table 14. Backcalculated fork length at annulus formation for bull trout collected in the Metolius River/Lake Billy Chinook system (from Pratt 1991).

Age						
1	II	III	IV	V	VI	VII
54	111	191	299	459	652	820

Based on both scale analysis and upstream trapping of adults, bull trout in the Metolius River/Lake Billy Chinook system generally spawn for the first time at age 5. However, a few fish, which show no lake growth, first spawn at age 4 (Pratt 1991). Most bull trout appear to spawn each year, and spawn in the same stream. A small percentage of bull trout have been observed straying into other streams to spawn.

Rainbow Trout

Rainbow trout in Lake Billy Chinook are probably derived from three separate populations, those belonging to each of the three tributary rivers. Rainbow trout are located throughout the reservoir, 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. Other rainbow trout populations exist upstream of Steelhead Falls and Opal Springs, but these barriers prevent the populations from mixing. Rainbow

trout indigenous to the lower Deschutes River basin are resistant to *C. shasta*. This gives the population a unique genetic makeup.

Only anecdotal information exists regarding the abundance of rainbow trout in Lake Billy Chinook. The population in recent years exceeds the 1,600 fish harvested in 1990 (Thiesfeld et al. 1995). During 1991 and 1992, approximately 800 fish were harvested, although the creel surveys were not exactly comparable with the 1990 data. Nonetheless, these data suggest that the population was somewhat stable during this period. Population estimates for rainbow trout (greater than 6 inches) were made in 1989 to 1991 by snorkeling and raft electrofishing in the Deschutes River from Big Falls to Lake Billy Chinook. The population in this stretch of the river was estimated to be between 1,600 and 1,700 rainbow trout per mile.

Rainbow trout in Lake Billy Chinook have an adfluvial life history. They are born in tributary streams, migrate to the reservoir, and then return to the tributary streams to spawn. Rainbow trout were often captured during electroshocking surveys in the reservoir during May, especially near the mouths of the Crooked and Deschutes rivers. The smallest rainbow trout captured were 3.5 inches, although most of the smaller fish were between 4 and 5 inches. These fish were most likely age 1 trout that migrated downstream during the previous year. The migration patterns of sub-adult rainbow trout are unknown. Age at maturity is speculated to be 3 years old, or approximately 10-12 inches. We have not studied spawning locations and timing for rainbow trout in Lake Billy Chinook. However, we believe that these fish spawn in April, May and June in all three river systems. Spawning may occur over a longer time period due to the spring fed nature of the tributary rivers. Spring fed streams in the Klamath River and Metolius River basins have redband trout that spawn 9 to 1l months of the year (Buchanan et al. 1990; Hemmingsen et al. 1992). Very few rainbow trout captured in the reservoir exceed 10 inches. This suggests that few rainbow trout migrate back to the reservoir after their initial spawning, they die after spawning, or they stop growing after spawning.

Production constraints for rainbow trout include competition, predation, and poor habitat quality. Kokanee, smallmouth bass, suckers, and brown trout all compete with rainbow trout for prey items. The competition for prey items is intensified because the small quantity of shallow shoreline habitat in the reservoir limits macroinvertebrate and insect production. These prey populations may be further reduced by reservoir drawdowns which cause direct mortality and reduce the amount of available habitat. Bull trout, brown trout, smallmouth bass and squawfish probably consume some rainbow trout, but the extent of this predation is unknown.

Brown Trout

Brown trout are common and found throughout Lake Billy Chinook, but they are not abundant. Densities appear to be higher near the mouth of all three river tributaries. It appears there are fewer brown trout than rainbow trout. Otherwise, there is no information to determine whether the population is increasing or decreasing. It is clear

that the population is at least stable and reproducing. Brown trout captured by electroshocking in 1989-1992 were generally 4-13 inches, with an occasional fish 16-24 inches. Brown trout captured in curtain nets set downstream from the mouth of the Metolius River are generally 6-14 inches, with an occasional fish 16-20 inches. Fish measured during creel surveys in 1990-93 showed a similar size distribution.

Brown trout are fall spawners. We assume that brown trout migrate up all three river tributaries to spawn. Concentrations of large brown trout have been observed below Steelhead Falls during the fall and were presumed to be spawners. Unlike other salmonids which are not native to the Deschutes River, brown trout are resistant to *C. shasta*.

Production constraints for brown trout include competition, predation, and poor habitat quality. Kokanee, smallmouth bass, suckers, and rainbow trout all compete with juvenile brown trout for prey items. Once brown trout become mostly piscivorous, smallmouth bass are probably their biggest competitor although there is probably some spatial segregation due to water temperature. Near the mouth of the Metolius River, bull trout probably compete directly with brown trout for food and space. The small quantity of shallow shoreline habitat in the reservoir limits macroinvertebrate and insect production, and probably limits the number of juvenile brown trout in the reservoir. Bull trout, smallmouth bass and squawfish probably consume some brown trout. The extent of this predation is unknown.

Chinook Salmon

A remnant population of spring chinook salmon is believed to exist in Lake Billy Chinook. The population would be extremely depressed. Anglers reported seeing chinook salmon adults in the Deschutes River up to Steelhead Falls during the mid-1980's. They have not been reported there in recent years. Juvenile chinook salmon were captured during seining in the Deschutes River below Steelhead Falls in 1986 (PGE, unpublished data). A few chinook salmon were reported as harvested from the reservoir during creel surveys conducted in 1990-1993. However, these may have been mis-identified by the surveyors. A single 8 inch chinook salmon was captured in trap nets set below the mouth of the Metolius River in 1994. This suggests that the population may still exist.

Other game fish

Mountain whitefish, black crappie and bluegill are rare in the reservoir. Because they do not appear to effect other game fishes, they will not be discussed in detail.

Crayfish

Crayfish are abundant in all three arm of Lake Billy Chinook. They inhabit benthic environments down to 330 feet, but are most abundant between 30 and 80 feet. The population apparently took some time to develop. An estimated 1,700 crayfish were captured in four shoreline gill nets set in July, 1974. In other reservoirs in the Ochoco District, 10-50 crayfish per net would be typical. In 1975, the ODFW discontinued setting shoreline based gill nets because "Extremely large populations [sic] of crayfish make this type of netting impractical because of the large numbers [sic] taken in the nets, and the damage done to all fish taken in the nets" (Herrig 1975). The population was estimated at approximately 12 million crayfish in 1995 (S. Lewis, Master's Candidate, Oregon State University, personal communication). Densities range from approximately 0.2 to 1.1 per square yard and varies by the type of substrate. Data collected in ODFW sampling programs in 1983 and 1988 suggest that the abundance of smaller crayfish (< 3 5/8 inches) has remained fairly stable in recent years, while the abundance of larger crayfish has declined.

Unsorted commercial catches have crayfish from 2-4.5 inches. Most crayfish captured in pots in Lake Billy Chinook are 3.1 to 3.7 inches in length. Mating occurs in the fall and appears to be dependent on the amount of daylight. Females may spawn twice or more during their life. Females extrude 100 to 300 eggs shortly after mating. Eggs are carried through the winter and hatch in April. Young remain with the female for several weeks, molting twice Sexual maturity occurs at 18-30 months and about 2.5 inches. Some crayfish with good growth rates may mate during their first fall. Juveniles favor shallow weedy areas where they can find protection from predators, and large adults favor deeper areas.

Nongame Fish

Bridgelip and largescale suckers are the most abundant of several nongame fish species found in Lake Billy Chinook, and are perhaps the second most abundant fish in the reservoir behind kokanee. Largescale sucker grow to lengths of 20 inches or more in the lake. Bridgelip sucker are considerably smaller, but more numerous than largescale sucker. Both species are widespread throughout the lake. Gillnet inventories conducted from 1964 to 1974 showed that suckers as a group often made up over 70% of the catch. At their present abundance, suckers could be a major limiting factor for rainbow and brown trout due to competition for space and forage in the limited amount of shallow water habitat. Approximately 60% of the suckers captured during electroshocking surveys in 1990 and 1991 were bridgelip sucker, the remainder were

largescale sucker. Gravid female bridgelip sucker have been observed in trap net sets at the head of the Metolius River Arm in late April and early May. Length frequency analysis of electroshocking data collected from Lake Billy Chinook in 1992 suggests that bridgelip sucker reach the following total lengths (inches) at the end of each year of life: age 1, 3.5; age 2, 4.9; age 3, 7.1, age 4, 8.2. Although not as numerous as bridgelip sucker, largescale sucker may play a more important role in trout management because of competition for prey and their greater biomass than bridgelip sucker. Aggregations of spawning female largescale sucker have been observed in the Deschutes River upstream of Lake Billy Chinook during the spring.

Other nongame fish are not as abundant as suckers and do not appear to be major influences on the biology and management of game fishes. In the past, a few tui chub (roach) have appeared in fish samples collected by the ODFW, but only one has been captured in recent years. Apparently they have never been present in the reservoir in significant numbers. While tui chub have caused serious management problems in other lakes in the basin, they appear to play an insignificant role in the ecology of Lake Billy Chinook. Small numbers of dace and sculpins also exist in the lake. Their presence goes almost unnoticed when considered along with the other nongame fish species. Goldfish have also been found in the Crooked River arm. Northern squawfish are present in low numbers in the reservoir. Although quite piscivorous, their low abundance prevents it from being a major influence on other species. Chiselmouth are also present in low numbers.

Fish Stocking History

Upon completion of the reservoir, intensive research was undertaken to develop a recreational fishery in Lake Billy Chinook. Early stocking efforts concentrated on rainbow trout, although numerous other species of fish were also stocked. Rainbow trout fingerlings were stocked annually from 1964 to 1975 by the OSGC. However, it was discovered that the lake had *Ceratomyxa shasta*, a parasitic disease that kills salmonids that are not resistant to it. The development of a rainbow trout fishery was limited by the disease which resulted in high mortalities of stocked rainbow trout.

In 1970-71, the OSGC also released kokanee fingerling into the lake. However, kokanee were well on their way toward establishing a population in the lake. The OSGC also released about 10,000 excess summer steelhead smolts in 1966 and 13,000 Atlantic salmon fingerlings in 1973. While the OSGC was releasing rainbow trout, the OSFC was also releasing coho salmon into the lake. From 1962-64, about 3 million young coho salmon were released to evaluate downstream passage facilities associated with Round Butte and Pelton dams.

In addition to stocking of juvenile fish, returning adult salmon and steelhead were passed over Pelton and Round Butte dams into Lake Billy Chinook. From 1963-1966, approximately 400-600 adult chinook salmon and 250-430 summer steelhead were

passed annually over Round Butte Dam. During 1971, 1972, and 1973 run years, 925, 291 and 50 excess hatchery adult summer were passed, respectively.

Bass, black crappie, and bluegill were never stocked into the reservoir. Largemouth and smallmouth bass have been present in Prineville Reservoir since 1961 and are most likely the source of bass in Lake Billy Chinook. Black crappie and bluegill are present in many private farm ponds in the area and may have been introduced into Lake Billy Chinook from irrigation runoff water.

Angling Regulations

The Crooked River and Deschutes River arms of the reservoir are open to angling year around, whereas the Metolius River Arm is open from March through October. Anglers must have both an Oregon angling license and a CTWS tribal fishing permit to fish in the Metolius River arm. The trout daily limit was five per day until 1992, when it changed to five per day of which only one could be a bull trout. The kokanee daily limit is 25 per day in addition to the standard 5 trout per day limit, while five smallmouth bass can be harvested daily. These fishing regulations have become more restrictive in the last decade in order to protect native trout (Table 15). The Metolius River was closed to the harvest of wild trout in 1983. This regulation appears to be a major reason for the rebound of the bull trout population.

Angling regulations on tributary rivers also help protect trout in Lake Billy Chinook. Special angling regulations were adopted in 1992 for the Deschutes River from North Canal Dam near Bend to Lake Billy Chinook. These regulations allow year-round angling, a bag limit of two trout per day, only one of which may be a bull trout, a six-inch minimum size and only 1 trout over 20 inches. Gear restrictions include angling with barbless artificial flies and lures only. In the Metolius River, all wild trout must be released unharmed.

Table 15. A chronology of protective regulation changes enacted in the Metolius River/Lake Billy Chinook system to prevent overharvest of native trout.

Year	Location	Regulation Change
1980	All Oregon Streams	Trout bag limit reduced from 10/day to 5/day
1983	Metolius River	All wild trout including bull trout must be released unharmed
1988	Lake Billy Chinook	Trout bag limit reduced from 10/day to 5/day
1988	Metolius River tributaries (except Lake Creek)	Closed to angling from August 15 through 3rd Saturday in April
1992	Lake Billy Chinook	Trout bag limit reduced to only one bull trout/day
1994	Metolius River tributaries	All tributaries below Lake Creek closed to angling

The commercial crayfish season is from April through October, with a minimum length of 3 5/8 inches. Commercial anglers must release females with eggs. There are no season or length restrictions for recreational crayfish anglers and the daily limit is 100. The Metolius River arm is closed to the harvest of crayfish except by tribal anglers.

Fish Management

Early fish management in Lake Billy Chinook centered around continuation of anadromous fish runs and attempting to create a rainbow trout fishery. The failure of the downstream migrant facilities, the presence of *C. shasta*, and the cooler water temperature severely limited management options for reservoir fisheries. Since the early 1970's, when the fish communities in the reservoir began to stabilize, management has focused primarily on the developing kokanee and smallmouth bass fisheries.

A fish management plan was completed for Lake Billy Chinook in 1989 and considered a number of management alternatives. For kokanee, the preferred management option was to manage exclusively for wild fish and intensive use. For rainbow and brown trout, the preferred management option was to manage for wild plus hatchery fish and basic yield. For bull trout, the preferred management option was to manage exclusively for wild fish and as a featured species. For smallmouth bass, the preferred management option was to manage exclusively for wild fish and basic yield. For crayfish, the commercial fishery continued to be managed under the then existing statewide and Tribal regulations. Management objectives were: 1) Protect, maintain, and enhance fish habitat in Lake Billy Chinook; 2) Protect, maintain, and enhance angler access; 3) Continue to provide a diversity of angling opportunities on the reservoir; 4) Place added emphasis on protecting, maintaining, and enhancing the bull trout population; 5) Continue monitoring the crayfish population; 6) Implement an educational program to make the public more aware of the fishery resource and issues surrounding them.

In 1992, a petition was filed requesting a determination whether bull trout should be listed as threatened or endangered under the Federal Endangered Species Act. In 1994, the USFWS determined that listing was "warranted but precluded" due to the number of higher priority species needing protection. If bull trout are eventually listed, a recovery plan would need to be written. Management emphasis has shifted in recent years to gather data needed to prepare a bull trout recovery plan and to make a determination whether harvest is adversely impacting the bull trout population. In the interim, ODFW, CTWS, and other interested parties will draft a conservation strategy for bull trout in the Deschutes River basin including Lake Billy Chinook.

Angler Effort and Harvest

Intensive creel surveys were conducted from 1990-1993 to estimate angler hours and harvest (Thiesfeld et al. 1995). Most of the following information comes from those surveys. Most fishing effort during the surveys was expended by boat anglers. Houseboat and bank angler effort (and harvest) accounted for less than 5% of the pressure and were frequently zero. Total boat angler effort during the survey period ranged between 130,000 and 150,000 hours annually. The number of angler trips was fairly constant between 27,000 and 30,000. Effort peaked in July all three years. The greatest angling effort was directed at kokanee (Figure 23). However, both bull trout and smallmouth bass angling were also popular on the reservoir. Bull trout angling effort peaked in March, although many anglers were also fishing for kokanee. Starting in late April, kokanee anglers began to dominate the effort, with smallmouth bass anglers also contributing to the effort.

Over 95,000 hours were spent fishing for kokanee annually. From May through October, over 70% of the fishing effort was directed toward kokanee each year. Peak kokanee effort was generally expended in July and August. Between 60,000 and 85,000 kokanee were harvested annually. Peak kokanee harvest usually occurred in July, although June was the high month in 1992. Very few kokanee were released. We observed that kokanee congregated in large numbers near the mouth of the Metolius River during late summer and many were harvested there. The kokanee catch rate generally peaked in August and September, and was very high during the fall of 1990, and again during the summer of 1991, when it peaked at over 1.5 fish/hour. Kokanee catch rate averaged 0.63 fish per hour for 1990-1992.

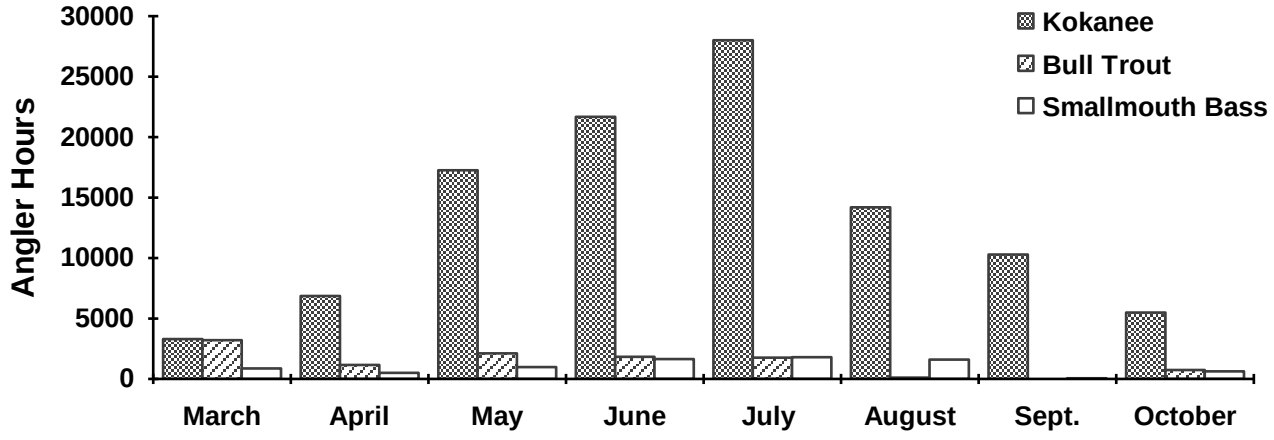

Figure 23. Distribution of estimated angler hours by species for anglers at Lake Billy Chinook in 1991.

The total weight of angler-harvested kokanee was estimated at 11,160 kg in 1990 and 20,956 kg in 1991. Thus the kokanee harvested yield was 6.89 and 12.944 kg/ha, respectively. The 1991 yield was higher than any yield published in the summary by Myers and Rieman (1990) and the 1990 yield exceeded that reported for all but three of the lakes reviewed.

Effort for smallmouth bass was a distant second to kokanee, ranging from 0.7% to 25.4% of the total fishing effort. The highest smallmouth bass fishing effort was measured at 13,761 hours in 1990. Peak catches of smallmouth bass occurred from April through August. Most smallmouth bass caught were released. Smallmouth bass catch rate was erratic throughout the sampling period, but over the course of the survey averaged 0.094 fish/hour for all anglers combined, and 1.42 for anglers targeting smallmouth bass. Most of the smallmouth bass harvest occurred in the Crooked River arm.

Bull trout angling comprised only a small percentage of the total fishing effort in Lake Billy Chinook. The highest bull trout fishing effort occurs in March, and by 1993, most of the March angling effort was directed at bull trout. Effort toward bull trout during March and April increased from 4,376 hours in 1991 to 8,108 hours in 1993. Bull trout harvest increased from approximately 803 fish in 1990 to a minimum of 1,097 fish in 1992. By 1993, over 80% of the bull trout caught were being released by anglers. Bull trout harvest peaked three times during the year. The first peak occurred in March when the Metolius River arm opens for fishing. A second peak usually occurred in June and/or July as fish congregate around the mouth of the Metolius River. Finally, a third peak occurred in August and September when large numbers of mostly smaller bull trout were harvested incidentally by the large number of kokanee anglers fishing in the upper portion of the Metolius River arm.

Rainbow trout and brown trout were also harvested in modest numbers from Lake Billy Chinook. Approximately 800-1,600 rainbow trout and 300-600 brown trout were harvested annually. Rainbow trout harvested from Lake Billy Chinook were from 8 to 10 inches. In 1993, marked hatchery rainbow trout from the stocking program in the Crooked River at Opal Springs comprised 7% of the rainbow trout harvest. Rainbow trout catch rate averaged 0.009 fish per hour over the survey period. Brown trout generally ranged from 10 to 14 inches; however, several fish larger than 16 inches were observed in the harvest. Brown trout catch rate averaged 0.004 fish per hour over the survey period.

Crayfish

Commercial landings at Lake Billy Chinook have dropped considerably in recent years (Table 16), which is believed to be due to the loss of a market. Total landings of crayfish in Oregon have dropped from 357,870 pounds in 1987 to 3,000 pounds in 1993. Harvest has rebounded slightly during the past two years, but still remains relatively low. Commercial regulations are designed to allow female crayfish to spawn

at least once, and to leave smaller crayfish as prey items for fish. The minimum length increased from 3.5 to 3.625 inches in 1988. Examination of length frequency distributions in 1983 and 1988 shows that crayfish larger than 3.625 inches made up a smaller percentage of the population in 1988 than in 1983.

Very little is known about the recreational crayfish fishery in Lake Billy Chinook. The fishery is believed to be very small. During creel surveys conducted in 1990-1993, no anglers identified crayfish as their primary or secondary target species. Very few crayfish pots were observed being fished during the surveys. A study was initiated in 1994 by PGE to evaluate the abundance, life history, movement and harvest of crayfish.

Table 16. Tribal and commercial harvest (Lbs.) of crayfish from the Crooked River, Deschutes River and Metolius River arms of Lake Billy Chinook.

	Tribal Landings (Lbs.)	Commercial Landings (Lbs.)
1981		29,850
1982		81,169
1983		76,580
1984		64,439
1985		49,517
1986		93,264
1987	52,967	154,251
1988[1]	18,242	64,979
1989	21,189	64,821
1990	17,920	47,762
1991	16,908	46,012
1992	18,242	32,795
1993[2]	50	2,828
1994[2]	0	9,746
1995	0	16,666

1. Minimum size increased from 3.5 to 3.625 inches.
2. No market existed for the catch.

Management Issues and Concerns

1. Lake Billy Chinook is a FERC licensed impoundment. Under present license conditions, a winter drawdown of 85 feet is allowed. Extreme drawdown would reduce food and space for littoral aquatic life, and could lead to slumping and soil movement. Boat ramps would also be unusable.

3. Bull trout may be listed as a Threatened species under the Federal Endangered Species Act. A recovery plan would need to be written and the USFWS would

have to approve the plan. Bull trout harvest may or may not be approved by the USFWS.

4. Smallmouth bass exhibit poor growth rates and few fish survive past age five. These factors limit options for management. For example, it is probably not biological feasible to create a featured or trophy fishery for smallmouth bass.

5. The abundance and limiting factors for chinook salmon in the reservoir are poorly understood. Research is needed to examine these issues.

6. Water quality from nonpoint source pollution in the upper watershed is moderately poor due to land and water management practices.

7. Hatchery trout released into the Crooked River at Opal Springs are migrating downstream into Lake Billy Chinook and may spawn with native fish in the Metolius River or Deschutes River (see Lower Crooked River section, page 97). Hatchery fish may cause introgression of non-desirable traits that reduce genetic fitness of native stocks or bring diseases into wild fish populations. This hatchery program may be inconsistent with the Wild Fish Management Policy. Although some of these fish are harvested in Lake Billy Chinook, there is limited access to the river below Opal Springs and the catch rate of these fish may not meet the standard in the Trout Plan (40% catch rate of catchable fish).

9. Abundant nongame fish compete with game fish for food and space, and may prey on juvenile game fish.

10. Riparian vegetation has not become established along the shoreline in most areas, probably due to erosion caused by wind action and boat waves. Efforts to establish riparian vegetation will need to be continued.

11. Very little is known about interspecific relationships, the life history, and the abundance of crayfish in Lake Billy Chinook. A crayfish life history study is currently underway on Lake Billy Chinook. Information gathered will increase our understanding of abundance, distribution, and growth rates of crayfish. Commercial and sport harvest may limit crayfish abundance, and subsequently affect forage abundance for predatory game fish.

MANAGEMENT DIRECTION

POLICIES

Policy 1. **Rainbow trout, brown trout, and mountain whitefish will be managed for natural production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).**

Policy 2. **Kokanee salmon will be managed for natural production consistent with the Intensive Use Management Alternative for trout (ODFW 1987a).**

Policy 3. **Bull trout and chinook salmon will be managed for natural production consistent with the Trophy Fish Management Alternative for trout (ODFW 1987a).**

Policy 4. **Smallmouth and largemouth bass, black crappie and bluegill will be managed for natural production consistent with the Basic Yield Management Alternative for warmwater fish (ODFW 1987b).**

Policy 5. **Crayfish will be managed for natural production and Basic Yield.**

Objective 1. Protect or maintain the genetic diversity, adaptiveness and abundance of wild, indigenous kokanee, chinook salmon, rainbow and bull trout, whitefish, and introduced brown trout in Lake Billy Chinook.

Assumptions and Rationale

1. Lake Billy Chinook supports self-sustaining, healthy populations of indigenous kokanee, bull trout, rainbow trout, whitefish and introduced brown trout.

2. Population levels of kokanee are adequate to support an increased sport fishery.

3. Monitoring abundance, size, age-class structure and distribution of kokanee, rainbow, bull and brown trout, and whitefish will provide an indication of their health and adaptiveness.

4. Bull trout abundance appears to have stabilized in recent years likely as a result of restrictive harvest regulations in the reservoir and Metolius River.

5. A remnant population of chinook salmon exists in the reservoir at a severely depressed level. Their life history is poorly understood due to the

their low abundance. Chinook salmon are rarely caught by anglers in the reservoir.

Actions

Action 1.1 Continue to monitor population abundance, size and age class structure and distribution of chinook and kokanee salmon, rainbow, brown and bull trout and whitefish through annual inventory using electrofishing, nets, spawning ground surveys and periodic statistical creel surveys.

Action 1.2 Conduct life history studies on rainbow, brown and bull trout, chinook salmon, kokanee, and mountain whitefish in Lake Billy Chinook and tributaries to characterize spawning and rearing areas; identify limiting factors.

Action 1.3 Investigate the feasibility of inventorying kokanee and bull trout population abundance and distribution through hydroacoustic techniques.

Action 1.4 Determine the need for additional or modified angling regulations to protect bull trout by monitoring the production, harvest and catch rate of the Lake Billy Chinook/Metolius River population.

Objective 2. Provide angling opportunities for a consumptive fishery on naturally produced kokanee, rainbow trout, and brown trout.

Assumptions and Rationale

1. Lake Billy Chinook supports an abundant and healthy population of naturally producing kokanee well distributed throughout the lake. Kokanee abundance fluctuates, typically characterized by a dominant year class occurring every few years as a result of variability in spawning success in the Metolius River and tributaries. Special regulations have been enacted to utilize the abundant kokanee population.

2. A catch rate of 0.63 kokanee per hour provides an adequate fishery.

3. Rainbow and brown trout distribution is generally limited to the upper reaches of each arm of the reservoir. Factors controlling natural production of rainbow and brown trout are largely unknown, but production may be limited by spawning and rearing habitat associated with the three major tributaries to the reservoir, and the lack of littoral habitat in the reservoir.

4. Catch rates of 0.009 rainbow and 0.004 brown trout per hour provides an adequate fishery.

5. Although no hatchery trout are stocked in Lake Billy Chinook, hatchery rainbow and brown trout are entering the reservoir from stocking programs upstream in the Metolius and Crooked rivers. These programs have been severely reduced or eliminated to decrease the effects of genetic introgression on wild rainbow trout.

6. As part of the Upper Deschutes Basin Plan, it is proposed that hatchery trout will no longer be stocked in the Metolius River after 1995.

Actions

Action 2.1 Monitor abundance, size and age composition of Lake Billy Chinook kokanee, rainbow trout, brown trout and whitefish by conducting periodic statistical creel surveys and through annual net inventories.

Action 2.2 Continue current bonus bag limit on kokanee to utilize abundant year classes.

Action 2.3 Publicize information on distinguishing characteristics of kokanee and additional harvest opportunities.

Action 2.4. Upon approval of the Upper Deschutes Basin Plan, discontinue stocking hatchery trout in the Metolius River after 1995.

Action 2.5. The ODFW will work with the Deschutes Valley Water District to modify the hatchery stocking program to reduce or eliminate hatchery fish from straying into Lake Billy Chinook.

Objective 3. Provide a trophy fishery for naturally produced bull trout.

Assumptions and Rationale

1. Bull trout are a self sustaining wild fish in the Metolius River basin and Lake Billy Chinook. Lake Billy Chinook has historically produced large trophy-size bull trout.

2. There is strong public interest in angling for these large, trophy size bull trout. The ODFW has defined a trophy bull trout as a fish exceeding 24 inches in length. Availability of bull trout larger than 24 inches in Lake Billy Chinook is necessary to meet this objective.

3. Sexual maturity is usually attained at age 5 or 6 years and approximately 20 inches in length.

4. Providing adequate spawning escapement through restrictive angling regulations is more practical than attempting to supplement natural production through hatchery releases.

5. Bull trout have been identified as a state sensitive species and as a federal Category 2 species and they have been proposed for listing as a federal threatened species.

6. Bull trout are vulnerable to overharvest and thus additional harvest regulations may be necessary to achieve this objective and ensure population health and size diversity.

Actions

Action 3.1 Monitor abundance, size, age composition, distribution, angler catch and effort of Lake Billy Chinook bull trout by conducting annual spring trapnet sets, mark and recapture studies, and periodic statistical creel surveys.

Action 3.2 Determine the need for additional or modified angling regulations to protect bull trout by monitoring the production, harvest and catch rate of the Lake Billy Chinook/Metolius population.

Action 3.3 Publicize information on distinguishing characteristics of bull trout and their unique status in the Lake Billy Chinook ecosystem through interpretive displays, feature articles in local news media and brochures.

Objective 4. Provide a trophy fishery for naturally produced chinook salmon.

Assumptions and Rationale

1. A remnant population of landlocked chinook salmon exists in the reservoir as a result of anadromous fish blocked off from access to the ocean by development of the Round Butte-Pelton dam complex.

2. Factors controlling natural production of chinook salmon are largely unknown, but production may be limited by harvest, and lack of suitable spawning and early rearing habitat in the remaining free-flowing reaches of the Metolius River and the Deschutes River below Steelhead Falls.

3. This remnant population may be vulnerable to overharvest and thus additional harvest restrictions may be necessary to ensure population health and size diversity and provide a fishery for trophy-size fish.

4. At present there is a low level of angler awareness of this fishery.

Actions

Action 4.1 Monitor abundance, size, age composition, distribution, angler catch and effort of chinook salmon in Lake Billy Chinook by conducting periodic seining and snorkel surveys, and periodic statistical creel surveys in the reservoir and lower reaches of Metolius River and Deschutes River below Steelhead Falls.

Action 4.2 Determine the need for additional or modified angling regulations to protect chinook salmon by monitoring production, harvest and catch rate of chinook in Lake Billy Chinook, Metolius River and Deschutes River below Steelhead Falls.

Objective 5. Provide angling opportunities for smallmouth and largemouth bass, bluegill, and black crappie in Lake Billy Chinook.

Assumptions and Rationale

1. Smallmouth bass are abundant and well distributed throughout the reservoir. Largemouth bass, bluegill, and black crappie are limited in distribution and abundance.

2. Bass, black crappie and bluegill are associated with shoreline areas and do not appear to compete with kokanee for food and rearing habitat.

3. Competitive social interactions between rainbow, brown and bull trout and warmwater species, are not well studied. However, there is likely some competition for food and mutual predation.

4. Bass and black crappie appear stunted for reasons unknown.

Actions

Action 5.1 Monitor population abundance, distribution, and age and size structure of warmwater fish in Lake Billy Chinook through annual electrofishing and mark and recapture studies.

Action 5.2 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Action 5.3 Investigate possible factors which limit production, survival, and growth rates of warmwater species.

Objective 6. Provide better boat access at Lake Billy Chinook during low water conditions and peak use periods.

Assumptions and Rationale

1. Boat ramps at Cove Palisades State Park, Deschutes Arm and Perry South Campground are unusable at low water conditions, and extremely crowded from Memorial Day through Labor Day.

2. Current boat speed restrictions are in place in the upper portions of all three arms of Lake Billy Chinook. These restrictions reduce user group conflicts and boat wake damage to riparian areas.

Actions

Action 6.1 Coordinate with USFS, PGE, and Oregon State Parks and Recreation to extend boat ramps at Lake Billy Chinook.

Action 6.2 Explore further opportunities for additional boat ramps and associated parking facilities to alleviate crowding during peak use periods.

Action 6.3 Continue to support the current boat speed regulations on the reservoir.

Objective 7. Provide tribal, recreational, and commercial fisheries for crayfish in Lake Billy Chinook.

Assumptions and Rationale

1. Lake Billy Chinook supports a population of several million crayfish; and tribal, commercial and recreational crayfish fisheries.

2. The Metolius River arm is open to tribal crayfish angling only.

3. Tribal and commercial crayfish harvest varies with the market. Tribal and commercial harvest exceeded 400,000 lb. in 1987, but was only 2,800 lb. in 1994. The recreational fishery harvests a minimal quantity of crayfish.

4. Crayfish are an important food source for game fish, especially smallmouth bass.

5. There is a high public interest in maintaining a population level that will support tribal, recreational, and commercial fisheries.

5. A crayfish life history study is currently underway on Lake Billy Chinook. Information gathered will increase our understanding of abundance, distribution, and growth rates of crayfish.

ACTIONS

Action 7.1 Monitor population abundance in Lake Billy Chinook through the commercial fishery catch per unit effort.

Action 7.2 Inventory crayfish populations for sex ratio, size, growth, and condition factor.

Action 7.3 Monitor tribal, commercial, and recreational effort and catch through catch reports and statistical creel surveys.

Action 7.4 Change reporting of commercial crayfish harvest from county to water body.

LAKE SIMTUSTUS

Overview

Lake Simtustus was created by the completion of Pelton Dam in 1958 on the Deschutes River, 103 miles upstream from the Columbia River and approximately 10 miles northwest of Madras in Jefferson County (Figure 24). The dam is part of the Pelton Hydroelectric Project operated by PGE. The reservoir has a surface area of 611 acres and is 7.5 miles long. Water enters the reservoir from three sources: the Round Butte Dam draft tubes, supplying an average flow of approximately 4,200 cfs; and Seekseequa and Willow creeks which normally supply minimal amounts of water (<30 cfs).

Lake Simtustus is an artificial habitat that is currently managed for kokanee, brown trout, rainbow trout, and bull trout Approximately 5,000 fin clipped hatchery rainbow trout (> 6 inches), 20,000 fin clipped hatchery brown trout (> 6 inches), and 37,000 hatchery kokanee fingerlings (2-3 inches) are released annually. Bull trout, kokanee and possibly some nongame fish also pass through the turbines of Round Butte Dam and supplement hatchery stocking programs. A small number of rainbow and brown trout may also pass downstream through Round Butte Dam into Lake Simtustus. Fish management is co-administered by the CTWS.

Location and Ownership

Lake Simtustus lies just downstream of the junctions of the Deschutes and Metolius rivers, and 6 miles upstream of community of Warm Springs. The area is characterized by flat plateaus bisected by deep river canyons. Native vegetation consists largely of juniper, big sage, bunch grass, bitterbrush, and rabbitbrush.

The entire western shoreline (to the old river channel) from Pelton Dam to Round Butte Dam is owned by the CTWS. The eastern shoreline is owned by the USFS, BLM, PGE, with a few isolated parcels of private land in Willow Creek cove.

Pelton Dam is a variable-radius, thin-arch concrete dam with a structural height of 204 feet, a crest length of 965 feet, and a present storage capacity of 37,300 acre feet. Lake Simtustus has a maximum depth of 200 feet. Elevation at full pool is 1,580 feet above mean sea level, and the maximum surface area is 611 acres. Total shoreline of the reservoir is approximately 20 miles. Much of the shoreline is basalt cliffs and steep talus slopes, although a few gently sloping beaches are available. About 12% of Lake Simtustus is less than 10 feet deep. The reservoir usually becomes thermally stratified during May each year, with the thermocline near a depth of 16 feet, and becomes homothermal again in late September or early October.

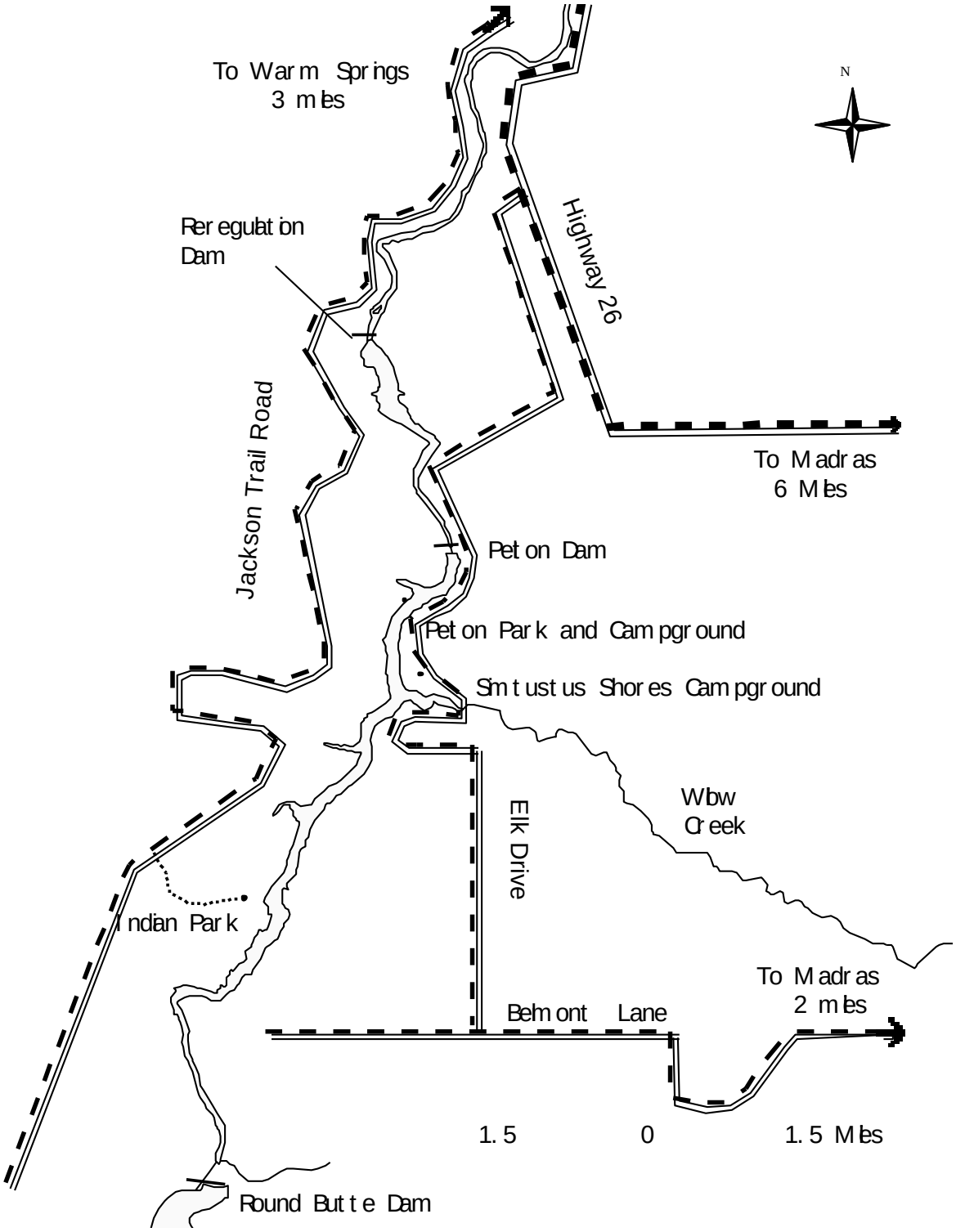

Figure 24. Lake Simtustus and vicinity.

Lake Simtustus is generally kept near 80% capacity year around, with a seven foot drawdown variance. Both recreation days and hydroelectric production are maximized when the reservoir is near full pool. The reservoir is subject to daily fluctuations which generally do not exceed 1 foot. Pelton and Round Butte dams produce electricity in tandem. Thus, the amount of water entering Lake Simtustus is equal to the amount leaving. Hydroelectric production peaks during early morning hours, with little hydroelectric production or withdrawal from the reservoir occurring at night. At peak power generation from Round Butte Dam, a swift current makes fishing difficult at the upper half mile of the reservoir. During maximum power generation, 12,000 cfs are withdrawn from the reservoir, but generally peaks range from 7-8,000 cfs. Water withdrawal occurs from a penstock located at elevation 1,445 feet, or 135 feet below the surface at full pool.

Habitat and Habitat Limitations

Habitat in Lake Simtustus is characterized by the steep shoreline topography, a boulder and cobble substrate, and generally good water quality. As a percentage of the total shoreline, more gently sloping shoreline habitat is available in Lake Simtustus than in Lake Billy Chinook. Only 12% of the reservoir is less than 10 feet deep. The majority of the shoreline consists of cobble and boulders. A few sandy beaches are present, mostly near developed recreation areas and in secluded coves. Silt and sand are also present in the deltas created by Willow and Seekseequa creeks. Small patches of aquatic vegetation are present in the reservoir, mostly associated with the few sandy beaches. Some woody material has accumulated in the reservoir in recent years. Most of this material is from alder and juniper trees which have fallen into the lake.

Lake Simtustus is generally considered to be meso-trophic. Data collected near the dam in September 1973 showed that orthophosphate phosphorous was 0.00, 0.00, and 0.056 mg/l at the surface, 50 feet, and 150 feet, respectively. Nitrate nitrogen was 0.03, 0.03, and 0.10 mg/l at the same locations. Data collected near the dam in May 1975 showed that orthophosphate phosphorous was 0.015, 0.045, and 0.068 mg/l at the surface, 50 feet, and 150 feet, respectively. Nitrate nitrogen was 0.020, 0.045, and 0.165 mg/l at the same locations. These nutrient levels suggest that the reservoir is eutrophic, or productive. Dissolved oxygen profiles collected in 1974 showed that all areas of the lake less than 100 feet deep are well oxygenated. Surface water temperature rarely exceeds 70^{o}F. Normally, a well defined thermocline occurs at 15-25 feet during the summer months.

Zooplankton are the major food source of kokanee and most other juvenile fish. As such, they are an important indicator of the reservoirs total potential for fish production. Zooplankton counts have fluctuated widely during the four years of data collection, giving no indication whether kokanee and rainbow trout forage has increased or decreased (Table 17). *Daphnia* is the most numerous zooplankton, with *Cyclops* a distant second. *Daphnia* and *Diaptomus* are larger than *Bosmina* and *Cyclops* and thought to play a more important role as fish prey. Zooplankton counts in Lake

Simtustus have been higher than in Lake Billy Chinook, but overall they are low (Figure 2, page 28). Therefore, one would conclude that Lake Simtustus is fairly productive during years of high zooplankton density, and fairly unproductive during years of low zooplankton density.

The steep sides of the reservoir greatly limit the abundance and distribution of littoral fishes such as rainbow and brown trout. Because of the limited habitat available for these species, their abundance is much lower than would be found in a reservoir with a shallow gradient shoreline. Largemouth bass were present in the lake historically, but have been extirpated, probably during nongame fish control efforts during the 1970's. Smallmouth bass may be present in the reservoir at a low abundance. There was an unsubstantiated report that a smallmouth bass was caught in the reservoir during 1994.

Table 17. Zooplankton species composition and densities (organisms per cubic meter) from 100' vertical tows in Lake Simtustus.

	Organisms per cubic meter				
Year	*Diaptomus*	*Daphnia*	*Bosmina*	*Cyclops*	Total
1973[1]	998	2,971	1,798	2,264	7,647
1974[2]	1,736	17,265	7,639	9,255	35,895
1987[3]	574	11,978	1,064	4,788	18,404
1988[3]	117	3,495	1,643	1,682	6,937

1. Average of samples collected from March through October.
2. Average of samples collected from April through October.
3. Average of samples collected from May through September .

Access

Bank access to the reservoir is limited due to the steep shoreline topography and tribal ownership. Boat access includes three ramps and two marinas (Figure 24). Camping facilities and boat ramps are located at Pelton Park and Simtustus Shores on the eastern shore, and at Indian Park on the western shoreline. Moorage facilities are available at Pelton Park and Simtustus Shores.

Fish Resources

Native fish currently found in Lake Simtustus include redband trout, kokanee, bull trout, mountain whitefish, northern squawfish, chiselmouth, and largescale and bridgelip suckers. In addition to the native fish species, introduced species that have been recently captured in Lake Simtustus include brown trout and possibly smallmouth bass. Chiselmouth, largescale sucker and squawfish are probably the most abundant fish species in the reservoir. Brown bullhead, largemouth bass and redear sunfish were

captured in Lake Simtustus before completion of Round Butte Dam, but none have been captured in recent years. Apparently they were eradicated by nongame fish control programs in the 1970's.

The only available spawning habitat for salmonids in Lake Simtustus is in Willow and Seekseequa creeks. Rainbow trout and possibly brown trout spawn in Willow Creek. It is unknown if rainbow trout spawning in Willow Creek are contributing to the population in Lake Simtustus. Seekseequa Creek supports a resident population of rainbow trout which may migrate down to the reservoir. All hatchery trout stocked in the reservoir are now fin clipped and the presence of wild fish should be easier to verify in the future.

Rainbow Trout

The rainbow trout population in Lake Simtustus is probably entirely from hatchery fish. It is possible that some reproduction is occurring in Willow and Seekseequa creeks. The last juvenile rainbow trout seen without a fin clip was caught in the curtain net in 1992. Rainbow trout are located throughout the reservoir, but may prefer the lotic environment at the upper end of the reservoir. Abundance of rainbow trout in the reservoir has likely declined since hatchery fingerling releases have been terminated. Total rainbow trout population is probably less than 10,000 fish.

There is some potential that a small portion of the rainbow trout in Lake Simtustus have an adfluvial life history. These fish would be born in tributary streams, migrate to the reservoir, and then return to the tributary streams to spawn. The smallest rainbow trout captured were 3.5 inches, although most of the smaller fish were between 4 and 5 inches. These fish were most likely age 1 trout, but they may have migrated downstream during the previous year. The migration patterns of sub-adult rainbow trout are unknown. Maturing rainbow trout migrate up their respective spawning tributary, probably during March, April, or May. Spawned-out rainbow trout have sometimes been observed dead in the reservoir. Sampling in the reregulating reservoir and catches in the upstream migrant trap directly below the reregulating reservoir have revealed that rainbow trout in Lake Simtustus are able to migrate downstream via the turbines at Pelton Dam.

Most rainbow trout caught by anglers in Lake Simtustus are similar to their size when they were stocked, 8-10 inches. Rainbow trout surviving a year in the reservoir are generally 12-16 inches. Each spring, a few rainbow trout in the 5 to 10 pound range are harvested. The largest known rainbow trout harvested from Lake Simtustus was over 20 pounds.

Production constraints for rainbow trout include competition with other reservoir fishes, predation, poor habitat, and infections from the disease *C. shasta*. Kokanee, suckers, and brown trout all compete with rainbow trout for prey items. The competition for prey items is intensified because the small amount of littoral habitat in the reservoir

limits macroinvertebrate and insect population. These prey populations may be further reduced by reservoir fluctuations, which cause direct mortality to prey populations and reduce their habitat. Bull trout, brown trout and squawfish probably consume some rainbow trout. The extent of this predation is unknown. Very little spawning habitat exists. Perhaps the biggest production constraint is the presence of *C. shasta* and the conflicts that arise from wild fish management in the lower Deschutes River when *C. shasta* resistant rainbow trout are stocked into Lake Simtustus. Rainbow trout stocking has been limited due to concerns about their ability to migrate downstream into the Deschutes River where they would breed with, and compete with, wild rainbow trout.

Brown Trout

Brown trout are common in Lake Simtustus and distributed throughout the reservoir. Brown trout have become abundant in the reservoir since hatchery stocking began in 1986. Before that, they were rarely observed in creel surveys or in net sets. Unlike other salmonids not indigenous to the Deschutes River, brown trout are resistant to *C. shasta*.

Although brown trout are numerous, very few brown trout have been captured in sampling programs in Lake Simtustus. Brown trout occasionally jump into the "jump pool" at Round Butte Hatchery (where they are raised). Brown trout up to 10 pounds have been observed there. Anglers generally catch brown trout immediately after stocking, and they are usually 8-12 inches at that time. Anglers occasionally harvest brown trout from 5 to 10 pounds. However, we have no information regarding the abundance of these larger fish. Growth rates appear to be quite variable in Lake Simtustus. Some brown trout will attain 16-17 inches after a year in the reservoir, while others exhibit very little growth.

We believe that brown trout are not reproducing in the reservoir or its tributaries. Some maturing brown trout migrate up the reservoir and enter the jump pool at the hatchery during September and October, their typical spawning season. There is some potential that a small portion of the brown trout in Lake Simtustus have adapted to an adfluvial life history. These maturing hatchery brown trout would migrate up Willow or Seekseequa creeks to spawn. Willow Creek was examined for spawning brown trout in 1990. Some possible trout redds were located, but no brown trout were captured during electroshocking, while rainbow trout were captured. No juvenile brown trout have been captured during net sampling in the reservoir or captured in Seekseequa Creek. Additionally, brown trout were present in the Deschutes River when Pelton Dam was completed. Up to 285 brown trout were measured in creel surveys conducted before Round Butte Dam was completed, but none were observed within a few years of completion of Round Butte Dam. Apparently brown trout were not able to adapt to an adfluvial life history at that time. Sampling in the reregulating reservoir and catches in the upstream migrant trap directly below the reregulating reservoir have revealed that brown trout in Lake Simtustus are able to migrate downstream via the turbines and fish

ladder at Pelton Dam. Some naturally spawned brown trout from Lake Billy Chinook may survive the turbines of Round Butte Dam and take up residence in the reservoir.

Production constraints for brown trout include competition, predation, and poor habitat. Kokanee, smallmouth bass, suckers, and rainbow trout all compete with juvenile brown trout for prey items. Once brown trout become mostly piscivorous, smallmouth bass are probably their biggest competitor although smallmouth bass are very rare in the reservoir and there is probably some spatial segregation due to water temperature. The competition for prey items is intensified because of the small amount of littoral habitat in the reservoir limits macroinvertebrate and insect population. These prey populations may be further reduced by reservoir drawdowns, which cause direct mortality to prey populations and reduce their habitat. Bull trout, smallmouth bass and squawfish probably consume some brown trout. The extent of this predation is unknown.

Bull Trout

Bull trout are present in the reservoir at a low abundance. They enter the reservoir via the outlet structure and turbines of Round Butte Dam. Bull trout life history is discussed in detail in the Lake Billy Chinook section of this plan. Bull trout in the reservoir cannot successfully reproduce in Willow or Seekseequa creeks because water temperatures are too warm for successful egg hatching. Bull trout have not been captured in Willow Creek. Bull trout grow quite well in Lake Simtustus, attaining weights exceeding 10 pounds. They probably feed predominately on kokanee and may become separated spatially from other forage fish in the littoral zone because of high water temperatures.

Kokanee

Both wild and hatchery kokanee are present in Lake Simtustus. They are generally low in abundance. Like other salmonids, kokanee cannot successfully reproduce in Lake Simtustus. Their life history is discussed in detail in the Lake Billy Chinook section of this plan. Kokanee have not been captured in Willow Creek. Kokanee generally exhibit good growth rates in Lake Simtustus, easily outgrowing those in Lake Billy Chinook. Kokanee up to 20 inches and two pounds are occasionally caught by anglers.

Non-Game Fish

Chiselmouth, northern squawfish and largescale sucker are the most abundant of several nongame fish species found in Lake Simtustus. Chiselmouth are abundant and found throughout the reservoir. Chiselmouth may be an important food source for

brown trout. The generally cool water of Lake Simtustus is probably the limiting factor for chiselmouth.

Squawfish are present at a high abundance and are found throughout the reservoir. Because of its high abundance and its role as a piscivore, the northern squawfish is probably a major influence on game fish populations. Squawfish are a predator on kokanee, brown trout and rainbow trout. Elimination of fingerling rainbow trout stocking has probably greatly reduced squawfish predation on rainbow trout. Squawfish probably have difficulty preying on catchable size rainbow and brown trout. However, juvenile squawfish are probably preyed upon by larger brown trout. Squawfish compete with brown trout for forage fish.

Largescale sucker may play an important role in trout management because of their great biomass and the resulting competition for food. Largescale sucker are abundant and well distributed throughout the reservoir.

Bridgelip sucker and sculpins are also present in the reservoir, but their abundance is much lower than other nongame fish species. As such, they do not appear to influence the biology and management of game fishes.

Fish Stocking History

When Lake Simtustus was created, there were many different and sometimes conflicting objectives for the reservoir. Until 1968, when upstream passage of fish was terminated, the management objective was to continue the native runs of anadromous fish. Juvenile anadromous fish were captured from Lake Billy Chinook, transported to the base of Round Butte Dam, and released into Lake Simtustus. However, there were also attempts to create a fishery in the reservoir. Fingerling and catchable size rainbow trout and kokanee were stocked in the reservoir by the USFWS under the direction of the CTWS. Over half a million rainbow trout were stocked in 1962, but the stocking rate was usually between 50,000 and 100,000 from 1959 to 1974. Kokanee were also stocked by the OSGC (now ODFW) on an occasional basis. Kokanee are now stocked annually. Starting in 1969, studies were initiated to determine the feasibility of rearing chinook salmon in the reservoir and over 150,000 juvenile salmon were released into the reservoir annually until 1978. From 1973 to 1986, excess grade out steelhead from Round Butte hatchery were stocked in the reservoir. Again in 1974, over half a million summer steelhead were stocked in the reservoir. Although these fish were intended to provide a fishery in the lake, some of these fish may have emigrated downstream as smolts and contributed to steelhead runs in the Deschutes River. Rainbow trout stocking by the USFWS was terminated in 1978 after discovery of the disease *C. shasta* in the reservoir. At that time, rainbow trout being stocked in the reservoir were dying because they were not resistant to the disease. These dying fish caused an increase in the virulence of the disease. Fingerling and catchable *C. shasta* resistant rainbow trout were stocked by ODFW from 1985 to 1991. Fingerling rainbow trout stockings were terminated due to concerns about their downstream migration into the Deschutes River,

which is managed exclusively for wild rainbow trout. Approximately 5,000 catchable rainbow trout are still stocked annually in Lake Simtustus. In 1986, an experimental program was initiated to determine if brown trout would be able to utilize the abundant squawfish in the reservoir. Twenty thousand brown trout have been stocked annually since 1987.

In addition to stocking of juvenile fish, returning adult salmon and steelhead were passed over Pelton Dam into Lake Simtustus. From 1963-1966, approximately 400-600 adult chinook salmon and 250-430 summer steelhead were passed annually over Round Butte Dam. During 1971, 1972, and 1973 run years, 925, 291 and 50 excess hatchery adult summer were passed, respectively.

Angling Regulations

A CTWS tribal permit is required to fish Lake Simtustus. Lake Simtustus is open during the general trout season (fourth Saturday in April to October 31). The daily limit is five per day for trout and bass. Only three of the five bass may be over 15 inches in length.

Fish Management

As mentioned in the fish stocking section, initial management efforts were directed primarily at continuing the anadromous runs above the Pelton/Round Butte Project, while at the same time, providing a resident fishery in Lake Simtustus. Eventually it became clear that the anadromous runs were not sustaining themselves because juvenile salmonids could not effectively find the downstream passage facilities in Lake Billy Chinook. In 1968, attempts to continue upstream passage of adult anadromous fish were abandoned. Spring chinook and summer steelhead were allowed to spawn naturally below the project and hatchery strains of spring chinook and summer steelhead were developed. Biologists then tried to raise anadromous fish in Lake Simtustus. From 1969 to 1974, juvenile spring chinook salmon were stocked in Lake Simtustus for the purpose of growing them to smolts. Attempts were also made to raise juvenile salmonids in the reregulating reservoir and in the Pelton Fish Ladder. During this period resident rainbow trout and kokanee were still being stocked into the reservoir to provide a fishery there.

Concern was raised about the number of nongame fish (principally squawfish and suckers) in Lake Simtustus and how that would effect the survival of juvenile salmonids being raised there. In the FERC license for the project, PGE is required to control nongame fish populations in the reservoir. So in 1970, biologists experimented with electroshocking equipment to kill nongame fish in the Willow Creek area, but it was not effective. From 1969-1971, attempts were made to capture nongame fish in the tramway which lifted adult salmonids out of Lake Simtustus and put them into Lake Billy Chinook. Suckers and squawfish were allowed to gather into the tram, lifted out of the

reservoir and disposed. However, the system was difficult to maintain and only a few thousand fish were removed. Most of these fish were probably squawfish and chiselmouth rather than suckers. Eventually, it was determined that this was not a cost efficient way of controlling nongame fish. Starting in 1971, attempts were made to treat the Willow Creek area with fish toxicants, primarily Fintrol. The Willow Creek area was treated three times in 1971, twice in 1972, and four times in 1977. In 1973, a weir was built across Willow Creek near the mouth to prevent nongame fish from entering the stream and was operated until 1978. One half mile of Willow Creek was treated with Fintrol in July of 1973, killing several thousand nongame fish. The weir washed out in the spring of 1979 and was not replaced. The weir was felt to be effective in reducing the number of fish which utilized Willow Creek for spawning; however, the number of game fish attempting to spawn there also appeared to decline. In 1975, nongame fish control efforts with fish toxicants were expanded to Mallard Haven, Dry Hollow Cove, and the shoreline near the boat ramp at Pelton Park. The boat ramp and Dry Hollow Cove were treated again in 1977.

Although hundreds of thousands of nongame fish died in these efforts, they were simply too prolific and spawned in too many other areas in the reservoir. While nongame fish control activities were initiated in 1971, inventory data which could be used to evaluate the effectiveness of control methods was terminated in 1974. No evaluation was ever completed regarding the nongame fish control efforts. The average contribution of nongame fish in gill nets set in Lake Simtustus for the 10-year period 1960-1969 was 83 percent of the catch and 33.2 fish per net. Nongame fish catch per net was actually the highest recorded during 1974, the last year of gill netting, which suggests that control efforts were not effective in reducing the abundance of nongame fish in the reservoir.

By 1978 it became apparent that *C. shasta* was causing great mortality in both chinook salmon and rainbow trout stocked in the reservoir. Both Lake Billy Chinook and Lake Simtustus were abandoned as chinook salmon rearing habitat and stocking of non-resistant rainbow trout stocking was also terminated. Management emphasis shifted at this time from fish rearing and nongame fish control to learning about *C. shasta* and its effects on salmonids in the reservoirs and the Deschutes River below the project. In order to provide a fishery in the reservoir, hundreds of thousands of grade out steelhead from Round Butte Hatchery were stocked in the reservoir. Hatchery fish are often sorted by size, or graded. Grade out fish tend to be the smaller, less desirable fish which will not meet critical smolt size by the designated release time. These fish were from the native Deschutes River steelhead and were resistant to *C. shasta*. Many of the fish stocked were extremely small and probably ended up as squawfish food. However a small sport fishery was maintained. Unfortunately, ODFW did not participate in sampling the reservoir or the fishery at that time. The CTWS collected a small amount of creel survey data, but not enough to evaluate the effectiveness of these stockings.

In 1986, brown trout were introduced into Lake Simtustus as an experiment to see if they would control the numbers of nongame fish and provide a sport fishery. As

with other nongame control efforts, little data is available to evaluate the program. Four gill nets were set in April of 1994 and 40.5 nongame fish per net were captured. This number is higher than the numbers seen from 1963 to 1974, but a twenty year gap in sampling occurred for which we do not know the abundance of nongame fish (Table 18). Currently the reservoir is managed for hatchery rainbow and brown trout, and hatchery and wild kokanee. Only *C. shasta* resistant fish are stocked. Brown trout are the only nongame fish control effort at this time.

Table 18. Catch of nongame fish in experimental gill nets set in Lake Simtustus from 1963-1973, and 1994.

Date	Number of Nets Set	Number of Nongame Fish Captured	Number of Nongame Fish per Net
4-3-63	5	198	39.6
3-4-65	5	46	9.2
3-22-67	5	169	33.8
3-6-68	4	145	36.3
3-11-69	4	109	27.3
3-10-70	5	148	29.6
4-13-71	3	92	30.7
3-4-73	4	123	30.8
3-19-74	4	178	44.5
3-28-75	5	171	34.2
4-19-94	4	162	40.5
4-19-95	4	120	30.0

Angler Effort and Harvest

Occasional creel surveys were conducted from 1958 to 1977 (Table 19). These surveys were usually conducted early in the season when fishing would be better. For example, of the 803 anglers surveyed in 1958, 498 were surveyed on opening day. During early surveys, juvenile summer steelhead comprised up to 22% of the spring catch of game fish. Game fish catch rate varied from 0.28 to 1.03 fish/hour. Creel surveys were conducted monthly in 1988 and the mean catch rate was 0.35 fish/hour. Intensive creel surveys were conducted on Lake Simtustus from 1990-1992. Angler effort decreased throughout the survey period (Table 20). It is not clear why angler effort dropped so substantially when the catch rate (fish/hour) remained similar. Part of the reason may have been due to the decline in the abundance of rainbow trout after fingerling stocking was terminated. Kokanee were the most abundant fish observed caught in 1990 and 1991, while brown trout were in 1992 (Table 21).

Table 19. Measured catch and angler effort on Lake Simtustus,

Year	Anglers	Hours	Total Game Fish	Fish/hour
1958	74	464	249	0.54
1959	803	4,559	4,138	0.91
1960	1,682	9,072	3,455	0.38
1961	963	5,324	3,973	0.75
1962	548	2,597	1,022	0.39
1963	1,468	7,144	3,641	0.51
1964	1,237	5,382	1,505	0.28
1965	1,017	4,187	3,956	0.94
1966	446	1,735	1,389	0.80
1967	9	39	38	0.97
1968	1,322	5,794	5,095	0.88
1969	136	480	152	0.32
1970	241	868	386	0.44
1971	255	268	418	0.63
1972	69	205	208	1.01
1973	154	486	388	0.80
1974	112	395	187	0.47
1975	19	68	70	1.03
1976	26	76	49	0.64
1977	57	182	84	0.46
1978				
1979				
1980				
1981	12	46	10	0.22
1982	168	695	216	0.31
1983	151	654	75	0.11
1984				
1985				
1986				
1987	192	526	201	0.38
1988	177	551	193	0.35
1989	71	203	53	0.26

Table 20. Estimated angler trips and effort on Lake Simtustus, 1990-1992.

Year	Trips	Hours	Total Game Fish	Fish/hour
1990	9,011	31,054	12,313	0.40
1991	5,864	23,358	9,288	0.40
1992	4,361	19,025	5,653	0.30

Table 21. Estimated harvest of game fish from Lake Simtustus, 1990-1992.

Year	Bull Trout	Kokanee	Rainbow Trout	Brown Trout
1990	29	4,405	2,794	3,705
1991	106	3,589	1,181	2,287
1992	24	1,635	790	2,981

Management Issues and Concerns

1. Lake Simtustus is a privately owned impoundment with 100% of the water allocated to hydroelectric production. Daily fluctuations, while generally minor, reduce food and space for aquatic life and contribute to shoreline erosion.

2. Bull trout are a Category I sensitive species and the U.S. Fish and Wildlife Service annually reviews their status to determine if they should be listed as a Threatened species under the Federal Endangered Species Act. A listing may severely limit options for harvesting bull trout in Lake Simtustus.

3. Water quality from nonpoint source pollution in the upper watershed is moderately poor due to land and water management practices.

4. Lake Simtustus has an unscreened outlet that allows an unknown number of fish to emigrate through the turbines into the Pelton Reregulating Reservoir, and then down into the Deschutes River. These fish cannot return to the upper watershed to spawn.

5. Native redband trout in the watershed below the reservoir may be affected by hatchery fish that move downstream. Native redband trout in Willow and Seekseequa creeks may also be affected. Hatchery rainbow trout may cause introgression of non-desirable traits that reduce genetic fitness of native stocks or bring diseases into wild fish populations. Brown trout may compete directly for food or prey upon native fish in the Deschutes River. If the Deschutes River below the reservoir, which is currently managed for wild fish, exhibits a high abundance of hatchery trout from Lake Simtustus, modification of the numbers

or species released, or termination of the hatchery trout programs may be considered.

6. Abundant nongame fish compete with game fish for food and space, and may prey on juvenile game fish.

MANAGEMENT DIRECTION

Policy 1. Kokanee salmon will be managed for natural and hatchery production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).

Policy 2. Rainbow trout and summer steelhead shall be managed for hatchery production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).

Policy 3. Bull trout will be managed for natural production consistent with the Trophy Fish Management Alternative for trout (ODFW 1987a).

OBJECTIVES

Objective 1. Provide angling opportunities for consumptive fisheries on naturally and hatchery produced kokanee, hatchery produced rainbow trout and hatchery produced summer steelhead.

Assumptions and Rationale

1. Lake Simtustus supports a significant but unknown population of wild kokanee which are naturally produced upstream in tributaries to Lake Billy Chinook. These kokanee cannot reproduce in Lake Simtustus or its tributaries. It appears that in years of high abundance of kokanee in Lake Billy Chinook, larger numbers of kokanee drift downstream into Lake Simtustus.

2. A catch rate of 0.15 kokanee per hour does not provide an adequate fishery. Stocking of additional hatchery kokanee will be necessary to generate an adequate fishery.

3. Abundance of naturally produced rainbow trout is unknown, but they are relatively rare. Production may be limited by spawning and rearing habitat in Willow and Seekseequa creeks, the only tributaries to lake Simtustus.

4. A catch rate of 0.073 rainbow trout per hour does not provide an adequate fishery. Stocking of additional hatchery rainbow trout or summer steelhead will be necessary to generate an adequate fishery.

5. Predation by abundant squawfish resident in the reservoir may limit survival of natural and hatchery produced fingerling kokanee and rainbow trout.

6. The myxospore *Ceratomyxa shasta* is indigenous to Lake Simtustus. As a result, only stocks of kokanee, summer steelhead, and rainbow trout resistant to this fish pathogen will be stocked in the reservoir.

7. Twenty thousand summer steelhead stocked in the reservoir at 2-3/lb. may generate an adequate fishery.

Actions

Action 1.1 Annually stock 75,000 hatchery fingerling kokanee at 50-80 per pound during July.

Action 1.2 Annually stock 5,000 hatchery legal-size rainbow trout at 3 per lb. during April-May.

Action 1.3 Annually stock 20,000 hatchery legal-size steelhead at 2-3 per lb. during May.

Action 1.4 Monitor abundance, size, age-class structure and distribution of Lake Simtustus kokanee, rainbow trout and steelhead by conducting periodic statistical creel surveys, electrofishing and through annual inventories using nets.

Action 1.5 Periodically evaluate stocking programs through adjustments in size, number and time at release of hatchery trout in Lake Simtustus to meet catch rate and contribution to angler creel guidelines.

Objective 2. Provide angling opportunities for a trophy fishery on naturally produced bull trout with a low catch rate (fish per hour).

Assumptions and Rationale

1. Predation by abundant squawfish resident in the reservoir may limit survival of bull trout.

2. A small population of bull trout are present in Lake Simtustus. These bull trout often exceed five pounds in weight. They are not able to reproduce because there is not suitable spawning habitat within the system.

3. Catch rates of bull trout are 0.004 fish per hour and may not provide an adequate opportunity to catch a trophy fish.

Actions

Action 2.1 Monitor abundance, size, age-class structure and distribution of Lake Simtustus bull trout by conducting periodic statistical creel surveys, electrofishing and through annual inventories using nets.

Objective 3. Prevent the movement of non-indigenous trout or of trout that pose a genetic risk to Deschutes River rainbow trout downstream from Lake Simtustus into the lower Deschutes River.

Assumptions and Rationale

1. The movement of hatchery trout into the Deschutes River below Pelton Reregulating dam would result in competition with indigenous species.

2. The movement of *C. shasta* resistant rainbow trout into the lower Deschutes River that are not genetically similar to the indigenous rainbow trout of the lower Deschutes River could pose a genetic risk to the indigenous population.

3. The movement of hatchery trout from upstream of the Reregulating Dam can be reduced through physical changes in the dams or changes in the number, size, and timing of hatchery trout released upstream.

4. Monitoring the distribution and abundance of hatchery trout in the Deschutes River immediately below the Reregulating Dam is limited by water conditions, the presence of adult salmon and steelhead, and the timing of spawning of salmon, steelhead and trout in the study reach. July appears to be the month most suitable for sampling.

5. The Deschutes River is currently stocked with 160,000 Deschutes strain summer steelhead, which do not pose a genetic risk to wild summer steelhead.

6. Summer steelhead stocked in the reservoir may emigrate downstream into the Deschutes River. These fish would likely emigrate; however, the low number of fish returning to spawn in the river should not affect whether steelhead are in compliance with the Wild Fish Management Policy.

These fish should not pose a genetic risk to the indigenous steelhead population.

Actions

Action 3.1 Monitor the distribution and abundance of hatchery trout moving out of upstream impoundments and into the lower Deschutes River.

Action 3.2 Develop criteria to identify unacceptable levels of competition and genetic risk of hatchery trout from Lake Simtustus on Lower Deschutes rainbow trout.

Action 3.3 Cooperate with Mid-Columbia Fish District and CTWS to evaluate the impacts of hatchery fish in Lake Simtustus on downstream trout resources and develop management strategies for Lake Simtustus which minimize competitive and genetic risk to Lower Deschutes rainbow trout.

Objective 4. Maintain and/or improve boat access at Lake Simtustus.

Assumptions and Rationale

1. Boat ramps at Pelton and Indian parks are unusable at low water conditions.

2. Boat speed regulations facilitate angling opportunities, reduce conflicts with other users, and minimize boat wake impacts to riparian and littoral zones.

Actions

Action 4.1 Coordinate with PGE and CTWS to improve and extend boat ramps at Pelton and Indian parks, or insure that water levels remain within elevations that boat ramps are useable.

Action 4.2 Explore further opportunities for additional boat ramps and associated parking facilities.

Action 4.3 Support planning actions which maintain the current boat speed regulations.

CROOKED RIVER BASIN SMALL IMPOUNDMENTS
WALTON LAKE, ALLEN CREEK RESERVOIR,
ANTELOPE FLAT RESERVOIR, AND REYNOLDS POND

Overview

Small impoundments in the Crooked River basin include Walton Lake, Allen Creek Reservoir, Antelope Flat Reservoir, and Reynolds Pond. All are artificial impoundments that were constructed for irrigation or to enhance angling opportunities for the public. All impoundments have been stocked with hatchery fish except for Allen Creek Reservoir, which is entirely dependent on wild trout production from tributary streams for recreational fisheries (Table 22). All have outlets that connect with other water bodies with native redband trout bearing streams with the exception of Reynolds Pond.

Table 22. Fish management of Crooked River basin small impoundments. Fingerlings are fish 2-4 inches long, catchable fish are 6-10 inches long.

Water Body	Species	Production	Stocking
Walton	Rainbow Trout	hatchery	15,000 catchables
Allen Creek Reservoir	Redband Trout	wild	none
Antelope Flat Reservoir	Rainbow Trout	hatchery	10,000 fingerlings
Reynolds Pond	Largemouth Bass, Redear Sunfish	natural	none

WALTON LAKE

Location and Ownership

Walton Lake is a small 25 acre public reservoir in the Ochoco Mountains of central Oregon, approximately 35 miles east of Prineville (Figure 25). It was formed in the 1940's as a contribution to the people of Oregon from the Isaac Walton League of Prineville. The lake provides a quality public recreational experience and attracts anglers in a part of the state where few natural lakes exist. The fishery is maintained entirely by frequent stockings of catchable size hatchery rainbow trout.

Walton Lake is located on the Big Summit Ranger District, administered by the USFS. Although the lake's main purpose is for fishing, swimming and camping are also popular.

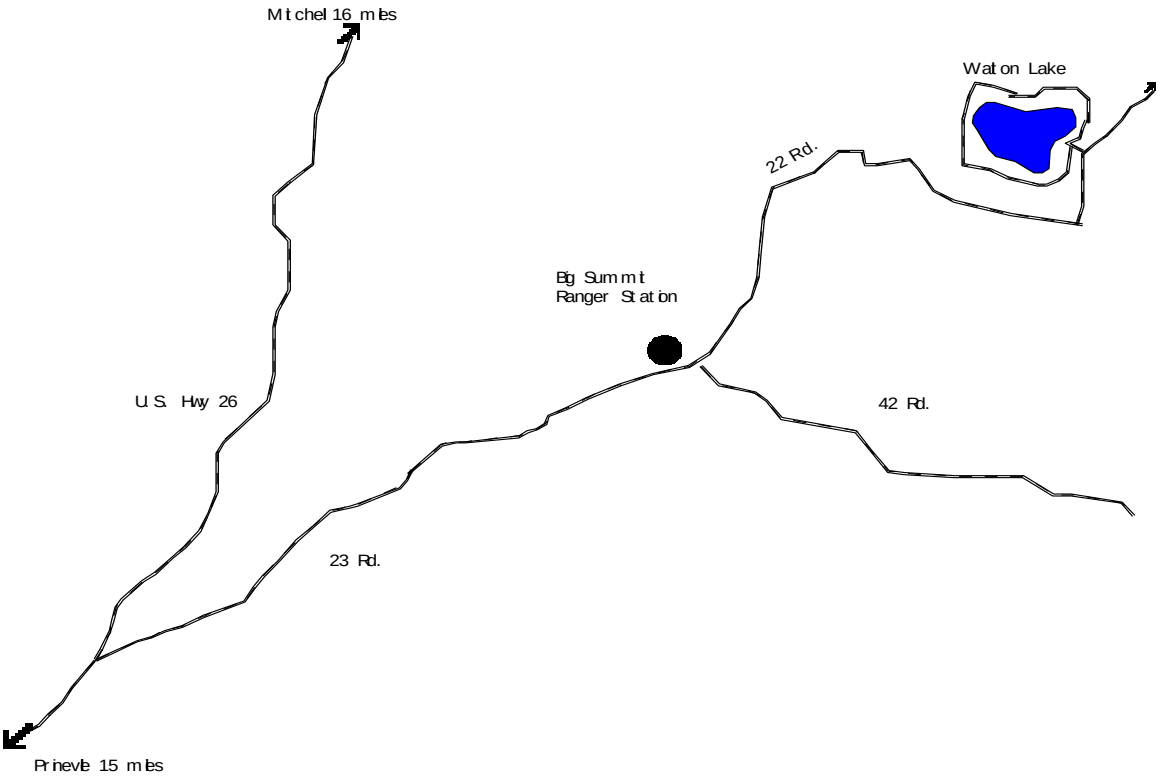

Figure 25. Walton Lake and vicinity

Habitat and Habitat Limitations

Walton Lake was formed by the construction of a 28 foot dam in a marsh at the headwaters of Cady Creek, a tributary of Ochoco Creek. Walton Lake is a relatively high elevation lake at 5,200 feet, and is surrounded by a scenic pine and fir forest. The lake level is stable unlike many nearby central Oregon irrigation impoundments. The water supply comes from snowmelt and a small spring that drains lands north of the reservoir. The lake is relatively shallow with a maximum depth of 21 feet and an average depth of 12 feet.

The reservoir shoreline and bottom consists of mud, cobble, and gravel. Some woody material has accumulated in the lake. Approximately 35% of the reservoir surface area is less than 10 feet deep. Water quality is moderate with above average concentrations of calcium and magnesium ions, indicating mesotrohpic conditions. Macrophytes develop in shallow littoral areas. Summer algae blooms of *Gloeotrichia*, a blue-green algae are frequent, along with other phytoplankton species, and *Cyclops*, *Diamptomus*, *Polyartha*, and *Kertella* zooplankton species have been reported. Phytoplankton blooms are occasionally very abundant and appear to cause a decline in angler success.

Summer water temperatures occasionally exceed 70^{o}F and when combined with low dissolved oxygen, cause occasional dieoffs of rainbow trout. A fish dieoff was reported in July, 1974, but no causative agent was observed. Low dissolved oxygen levels have been reported in the late fall and winter and have been recorded as low as 0.4 ppm. Winter kills of rainbow trout were observed in 1962 and 1964 (OSGC 1963, 1965).

Access

Walton Lake is easily accessible via USFS Road 22 and is approximately 7 miles east of the Ochoco Ranger Station. The USFS maintains a boat ramp on the southwest shore. Two campgrounds are maintained for visitors at Walton Lake. Only electric boat motors are permitted, and angling from canoes and float tubes is popular. The entire shoreline is available for bank fishing and is easily accessible via a trail that encircles the lake. A wheelchair access platform with a paved path is also available for fishing near the boat ramp.

In years with high snow pack, the lake is often inaccessible to vehicles until mid- to late May. ODFW fish liberation trucks are occasionally unable to reach the lake to release fish prior to opening day due to snow and ice conditions on the road.

Fish Resources

Hatchery rainbow trout are the predominate fish in Walton Lake. Until 1995, crayfish were the only other species observed in gill net catches and angling surveys. Most rainbow trout stocked in the reservoir are likely caught by anglers, eaten by larger fish or terrestrial predators, or die of natural mortality. Trout production is limited by food availability, seasonal water quality, winter dieoff, and intensity of angler use.

In 1995, brook trout and brown bullhead were discovered in Walton Lake at the headwaters of Ochoco Creek. For a majority of the year, there is little to no flow escaping the lake. However, the lake outlet is unscreened , and during runoff, non-native fish have the potential to escape to Cady and Ochoco creeks. Once in the Ochoco Creek system, brook and hatchery rainbow trout have the potential to become established and compete with native redband trout for food resources and habitat. Walton Lake needs to be treated with rotenone to eliminate these new species, or a screen should be installed at the outlet to eliminate escape to Ochoco Creek.

Fish Stocking History

Annual hatchery stocking of rainbow trout began in 1954 and included both fingerling and catchable sized fish. Up to 15,000 fingerling and 13,000 catchable trout have been planted annually, but has typically been between 5,000 and 10,000 catchable rainbow trout. Fingerling rainbow trout did not grow or survive well in the reservoir, and now only catchable size trout are stocked. One stocking of approximately 200 catchable cutthroat trout were planted in the lake in 1974.

In the past decade, 10,000 catchable rainbow trout have been stocked annually. Surplus fish from other rainbow trout programs have occasionally been stocked in Walton Lake, most frequently in September and October and have provided popular fall fisheries, during big game hunting seasons when hunters and their families are camped at Walton Lake. Rainbow trout salvaged from Ochoco Dam spillway were also stocked in Walton Lake in the fall of 1988, 1990, and 1991. In 1993, the Marks Creek catchable trout allocation of 2,000 fish was shifted to Walton Lake, bringing the total stocking program at Walton Lake up to 12,000 catchable size rainbow trout. In 1994, a portion of the Ochoco Creek catchable trout allocation was shifted to Walton Lake due to the Safety of Dams work at Ochoco Dam and the low flows in Ochoco Creek providing limited habitat for hatchery releases. Due to the excellent utilization of these fish in Walton Lake, the 1995 catchable program will included 3,000 fish formerly allocated to Ochoco Creek. This will bring the 1995 rainbow trout program at Walton Lake up to 15,000 catchables. In 1994 and 1995, these fish were stocked monthly throughout the fishing season to better distribute angler success.

The “put and take” catchable program has provided a very popular fishery for anglers over the years. While fingerling sized trout have provided an adequate fishery, the catchable program has been more successful due to the high intensity of use and occasional winter kills.

Angling Regulations

Angling is open at Walton Lake during the general trout season from late April to the end of October, similar to nearby streams. The bag limit is 5 trout per day, 6 inch minimum, with no more than 5 over 12 inches and 2 over 20 inches. There are no special tackle restrictions. The Oregon State Marine Board prohibits the use of gasoline powered motors at Walton Lake.

Fish Management

Walton Lake is managed for Basic Yield, with the fishery sustained by a catchable rainbow trout hatchery program. No hatchery fish have been observed in Ochoco Creek; however, an unscreened outlet may allow escape of hatchery rainbow and brook trout during high water episodes. Annual fish inventories have not been

conducted at this lake since 1970. Due to the recent discovery of brook trout and brown bullhead in Walton Lake, two gillnets were set in August 1995 to determine relative abundance of these two species. Of 29 fish captured, 7 (24%) were brook trout, one fish (3%) was a brown bullhead, and the remainder were hatchery rainbow trout. Analysis of scales indicated that these brook trout were age 1, age 2 and age 3 fish, all of hatchery origin.

Rainbow trout captured in gillnets in Walton Lake, from 1963 to 1970, were from 6 to 16 inches with most fish between 8 and 10 inches in length. Size of fish appeared to vary between years, indicating that stocking level likely affects growth of fish, through competition for food resources.

There are no current estimates of total angler use or catch, but annual observations and recent opening day creel checks indicate the lake is very popular and produces good catch rates of rainbow trout. The USFS estimated Walton Lake received 12,000 to 18,000 days of visitor use for angling in the late 1960's. With increasing popularity, this lake likely receives substantially more use now.

Management Issues and Concerns

1. Moderate productivity, short growing season, occasional winter and summer kills, and intensity of harvest requires stocking of catchable trout.

2. There is little woody material in the lake. Additional woody material would add to shoreline and littoral productivity and provide cover and habitat for aquatic insects and trout.

3. The outlet at Walton Lake is unscreened and may cause mortality as fish may emigrate into Ochoco Creek. If fish successfully emigrate, hatchery rainbow trout may cause introgression of non-desirable traits that reduce genetic fitness of native stocks. Hatchery rainbow and brook trout may also compete for food and space, or bring diseases into wild fish populations.

ALLEN CREEK RESERVOIR

Location and Ownership

Allen Creek Reservoir is a 79 acre impoundment in the northeast corner of Big Summit Prairie, in the Ochoco Mountains, approximately 45 miles east of Prineville (Figure 26). It was constructed as a private irrigation impoundment but has public access because a small portion of the reservoir inundated public BLM lands. Drainage area for the reservoir comes from 3 main tributaries, Allen, Beetle, and Yellowjacket

creeks. Water from Allen Creek Reservoir flows through an outlet into a maze of irrigation canals and eventually reaches the North Fork Crooked River.

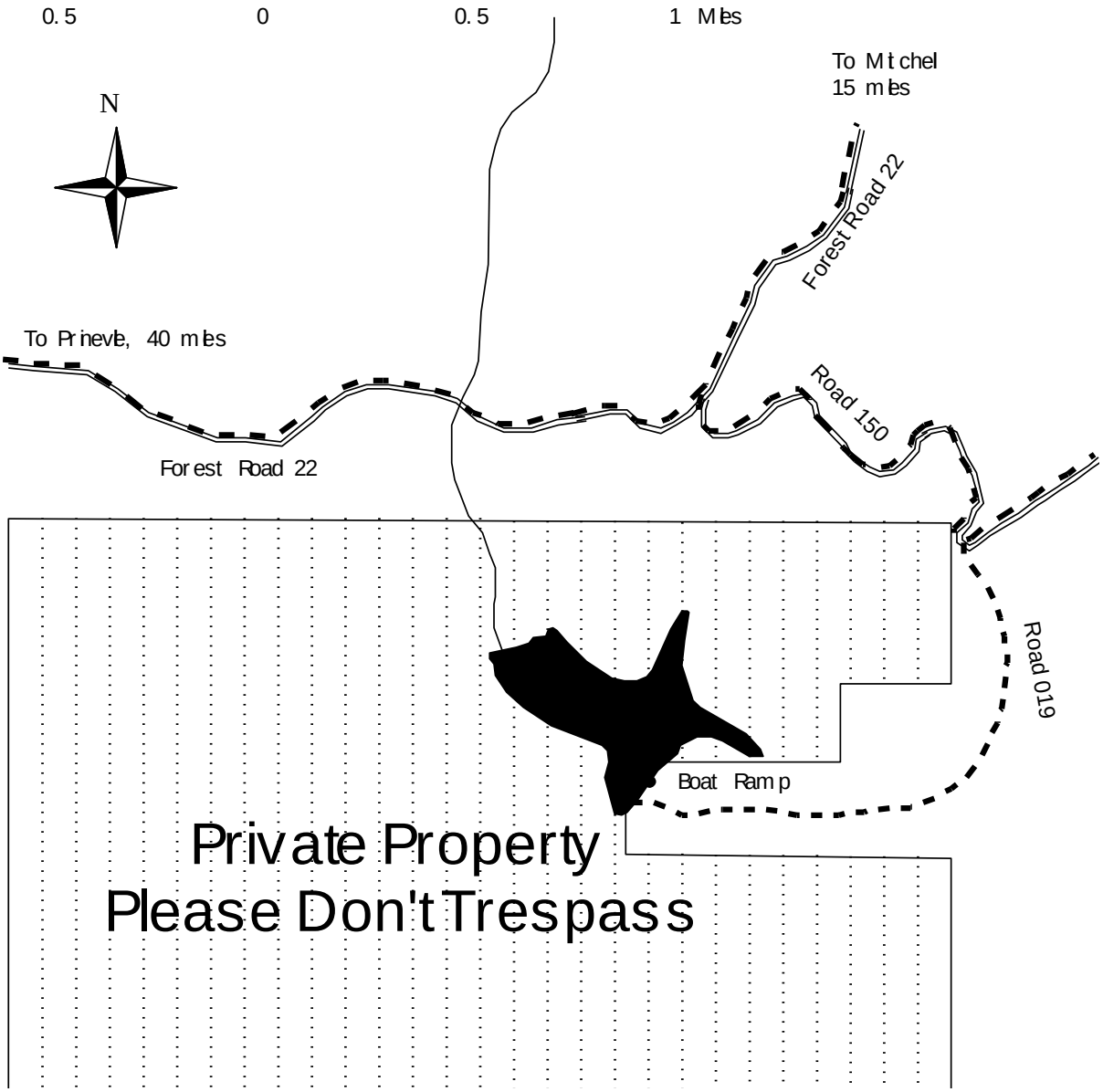

Figure 26. Allen Creek Reservoir and vicinity.

The dam forming Allen Creek Reservoir was constructed on private land, downstream of the junctions of Allen, Beetle, and Yellowjacket creeks, sometime in the 1940's or 1950's. The dam and approximately 90% of the shoreline is currently owned by the Les Schwab Company. A small portion of the southwest shoreline is located on BLM lands, administered by the Prineville District. Although the reservoir's main

purpose is for irrigation, the reservoir has also been popular among a small group of anglers for boating, swimming and camping.

Habitat and Habitat Limitations

Allen Creek Reservoir is a relatively high elevation impoundment at 4,700 feet and is surrounded by a scenic pine forest intermingled with sagebrush and bunchgrass. Most of the reservoir shoreline and bottom consists of mud, cobble, and gravel. A small amount of woody material has accumulated in the lake. Most of the standing trees that would have been inundated were cut prior to filling the reservoir. The lake appears to be moderately productive, as evidenced by good trout growth, although no limnological data has been collected. Macrophytes grow in shallow littoral areas, particularly along the northern shoreline and near the inlet of Allen Creek in the northeast portion of the reservoir.

The reservoir's water supply comes from 3 tributary streams and snowmelt that drains from the north and east sides of the prairie. The lake is over 100 feet deep at its maximum depth near the dam. The reservoir is seasonally drawdown for irrigation of private lands on Big Summit Prairie.

Summer surface water temperatures may exceed 70^{o}F, similar to nearby Walton Lake. However, due to the deeper nature of Allen Creek Reservoir, dissolved oxygen appears to remain high, as fish kills have not been observed. The main tributary, Allen Creek, supports moderately abundant populations of native redband trout and the progeny of hatchery brook trout planted in the late 1920's and early 1930's. Allen Creek probably supports the majority of the spawning habitat. The other two tributaries, Beetle and Yellowjacket creeks, have intermittent flows and limited spawning habitat.

The outlet facility at Allen Creek Reservoir is unscreened and fish may emigrate from the reservoir into irrigation canals. The canal exiting Allen Creek Reservoir transports water across the northern portion of Big Summit Prairie, discharging water into secondary ditches for irrigation, and picking up water from tributary streams of the North Fork Crooked River, including Elliot, Stump, Crosswhite, and Fox creeks. Water from Allen Creek Reservoir ditch eventually discharges all water onto irrigated fields on the prairie. It is uncertain if any fish that emigrate from the canal ever reach the North Fork Crooked River, due to the extensive network of irrigation ditches on the prairie.

Fish production in the reservoir is influenced by the amount of snowpack, the subsequent flow for spawning and rearing adfluvial fish in Allen Creek, and amount of water stored throughout the season in Allen Creek Reservoir. As water is released from the reservoir for irrigation, rearing space, cover, and aquatic food production are reduced. Competition for prey food species is intensified as the reservoir is drawn down, and macroinvertebrate production declines as the littoral zone decreases.

Access

Access to Allen Creek Reservoir is via USFS Roads 22 or 42, and 30. The last 1.3 miles is a primitive dirt road that has not been maintained for a number of years. The gate has been locked at the junction of USFS and BLM lands for the past 2.5 years to prevent vehicle access, although foot traffic is allowed. The BLM recently completed an Environmental Assessment, which will allow public vehicle access from May 15 to September 15, once improvements have been completed for the boundary fence.

Much of the historical recreational use since construction of the reservoir has been via small boats, canoes, and rafts due to the limited publicly owned shoreline available. The recent vehicle closure has eliminated up to 90% of the historical use. Once vehicle access is restored, a public boat launch should be constructed to disperse recreation, improve boating and angling opportunities, extend boating access as water levels are drawn down by irrigation, and protect shoreline resources from damage by off road vehicle activity.

Allen Creek Reservoir is a relatively remote spot with no facilities although camping is available at nearby Allen Creek and Scott campgrounds. It provides a quality angling experience in a relatively remote and scenic setting.

Fish Resources

Wild redband trout are the only known fish species that have been observed in recent years in Allen Creek Reservoir. Naturally produced brook trout are known to occur in Allen Creek and may migrate to the reservoir and rear as adfluvial fish. No other game species of fish have been reported in recent years from gillnet and angling surveys other than crayfish. Brown trout were recorded in the mid 1970's in a fish salvage, but have not been observed since then. Two dace were also captured during the electroshocking surveys in Allen Creek, indicating that they may occur in the reservoir as well.

The wild redband trout population in Allen Creek Reservoir and its 3 tributary streams have been separated from other redband trout populations in the North Fork Crooked River. This isolation could lead to genetic drift and a distinctly different gene pool in the Allen Creek Reservoir population. Redband trout in Allen Creek Reservoir have an adfluvial life history. They are born in Allen Creek or possibly in Beetle or Yellowjacket creeks, migrate to the reservoir, and then return to tributary streams to spawn.

Redband trout captured in gillnets in Allen Creek Reservoir in the fall of 1992 and the spring of 1993 were from 7 to 17 inches with most fish between 9 and 10 inches in length. Electroshocking surveys were conducted in June 1987 in Allen Creek in the campground immediately above the reservoir. Redband trout averaged 2.7 inches at age 1+, 5.0 inches at age 2+, and 6.2 inches at 3+ in length. One fish was 11 inches in

length and appeared to be 6 years old. This data suggests that fish in the reservoir may be age 3+ fish or older. However, growth may be much greater for fish rearing in the reservoir than in the creek, as is often observed in other water bodies with both fluvial and adfluvial life histories.

Fish Stocking History

There are no known stocking records of hatchery fish in Allen Creek Reservoir. However, monthly reports in the fall of 1976 indicated that the owner of the dam at that time, planned to drain the reservoir for dam repairs and sought help from the ODFW for a fish salvage. The ODFW declined under the assumption that hatchery fish were in the reservoir. BLM assisted with the fish salvage and over 1,200 rainbow trout and 10 brown trout were captured. The rainbow trout were transported to Reynolds Pond and the brown trout were destroyed.

Angling Regulations

Angling is open during the general trout season from late April to the end of October with a catch limit of 10 trout per day, 6 inch minimum, with no more than 5 over 12 inches and 2 over 20 inches. There are no special tackle restrictions.

Fish Management

The reservoir is managed for Basic Yield, with the fishery sustained by wild redband trout production primarily from Allen Creek.

Very little management work has been conducted at Allen Creek Reservoir. The lake was inventoried in the fall of 1992 and spring of 1993 with gillnets to assess fish species present and trout growth and abundance. Only 11 trout were captured in the fall of 1992 during an extreme drawdown of the reservoir. They showed a relatively poor condition factor of 0.98. Early in the following spring, after a good snowpack and the reservoir was filled to capacity, gillnets captured 38 redband trout with a condition factor of 0.96. The condition of these fish was probably on the lean side due to the extreme drawdown of the reservoir, reduced food abundance and increased competition for food and space.

There are no estimates of total angler use or catch rates, but sporadic creel checks conducted in the spring have showed anglers with good catches of redband trout. Trout up to 17 inches in length have been harvested, but most trout landed are between 8 and 12 inches in length. These surveys were conducted when vehicle access was permitted and a majority of the angling was via trolling. Bank angling is less successful due to the limited area of public access.

Management Issues and Concerns

1. A small amount of publicly owned shoreline limits public access to the reservoir. The recent temporary road closure further reduces public use of this reservoir. Public vehicle access has been recently resolved by an Environmental Analysis and Decision Memo, and will be allowed from May 15 to September 15 once certain improvements have been completed.

2. Annual drawdown of the reservoir for irrigation limits trout production, through increased competition for food and space.

3. The fishery is entirely dependent on production by wild trout. If angler pressure increases, bag limits may need to be reduced.

4. The outlet at Allen Creek Reservoir is unscreened and may cause fish mortality as fish may emigrate from the reservoir into the canals.

5. Once vehicle access is restored, a gravel ramp should be constructed to facilitate boat access to the reservoir. A public boat launch will disperse recreation, improve boating and angling opportunity, extend boating access as water levels are drawn down by irrigation, and protect shoreline resources from damage by off road vehicle activity.

ANTELOPE FLAT RESERVOIR

Location and Ownership

Antelope Flat Reservoir is an 170 acre irrigation reservoir on the south side of the Maury Mountain in central Oregon, approximately 30 miles southeast of Prineville (Figure 27). It is situated at the headwaters of Bear Creek at the west end of Antelope Flat. Water from Antelope Flat Reservoir flows into Bear Creek, and eventually flows into Prineville Reservoir.

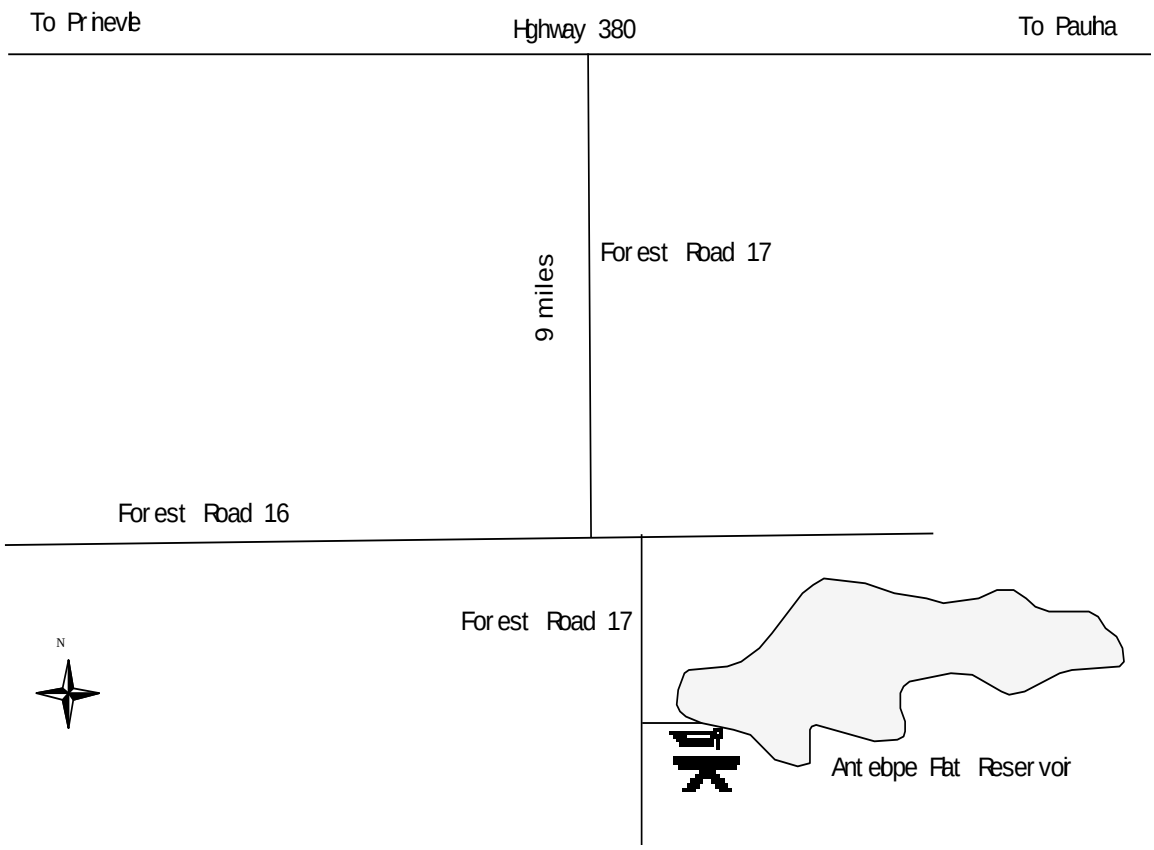

Figure 27. Antelope Flat Reservoir and vicinity.

The Antelope Flat Reservoir dam was constructed in the early 1950's as a private irrigation impoundment but has public access due to its adjacency to USFS lands. The original minimum pool of the reservoir was 100 acre feet. The ODFW obtained a perpetual minimum pool of 250 acre feet in 1974 for fisheries, public angling and recreation by an agreement between the state and the private landowner. The state provided financial assistance to the landowner to renovate the dam and construct a water diversion from Faught Creek to augment water storage in Antelope Flat Reservoir.

Antelope Flat Reservoir is located on Prineville Ranger District, administered by the Ochoco National Forest. Approximately 50% of the shoreline at the head of the reservoir is privately owned. Although the reservoir's main purpose is for irrigation, the reservoir has also been popular for boating, fishing and nearby camping.

Habitat and Habitat Limitations

Antelope Flat Reservoir was formed by the construction of a 33 foot earthen fill dam below the confluence of Antelope and Bear creeks. Antelope Flat Reservoir is a moderately high elevation reservoir at 5,200 feet and is surrounded by a scenic ponderosa pine, juniper, sagebrush, and bunchgrass community. The reservoir's water supply comes from snowmelt, Antelope and Bear creeks, and a spring that drains the northern and eastern sides of the reservoir. The lake is relatively shallow with a maximum depth of 28 feet and an average depth of 11 feet at full pool. The reservoir has a storage capacity of nearly 2,000 acre feet at full pool and a minimum pool of 250 acre feet.

Most of the reservoir shoreline and bottom consists of mud. Approximately 41% of the reservoir surface area is less than 10 feet deep. The reservoir is eutrophic with average to high concentrations of ions including calcium and magnesium, and high alkalinity and conductivity. Concentrations of phosphorus and chlorophyll are relatively high. Macrophytes develop in shallow littoral areas, particularly at the head end of the reservoir. The water is usually turbid due to sediments from runoff and bank erosion from shoreline wave action. Blooms of plankton are common in summer, particularly the blue green algae, *Aphanizomenon*, often adding to turbidity.

Summer time water temperatures occasionally exceed 70^{O}F, and when combined with low oxygen levels cause occasional dieoffs of rainbow trout. Prior to 1974, when the minimum pool was increased, both summer and winter kills of rainbow trout frequently occurred due to low dissolved oxygen levels. In recent years, a complete winter kill occurred in the winter of 1993 with extremely low water conditions and an extremely harsh winter. A partial kill occurred in the summer of 1994 with dissolved oxygen levels recorded at 0 parts per million (ppm) below 3 meters in depth.

Fish production in the reservoir is influenced by amount of snowpack and water stored throughout the season. The reservoir is seasonally drawn down for irrigation. As water is released from the reservoir for irrigation, rearing space, cover, and aquatic food production are reduced.

Access

Access to Antelope Flat Reservoir is via USFS Road 17, approximately 8 miles east of the town of Post. The USFS maintains a boat ramp on the southwest shore. Antelope Flat Campground is a large campground maintained for visitors adjacent to the reservoir, with other campsites available nearby at Wiley Flat, Elkhorn, and Double Cabin campgrounds. Angling is popular from a variety of craft including power boats, canoes and float tubes. The entire shoreline is available for bank fishing. The ramp is wheelchair accessible at higher water conditions. In low water conditions, the ramp is unavailable except for small boats. Extension of the boat ramp has been proposed by the USFS and the ODFW.

In 1993, the reservoir was opened to year round angling. In low snowpack years, the reservoir is accessible to vehicles. The road is not plowed in the winter and therefore access is limited to snowmobiles and skiers in normal to high snowpack years.

Fish Resources

Antelope Flat Reservoir supports hatchery rainbow trout and crayfish. We believe that Antelope and Bear creeks above the reservoir do not support wild redband trout populations, although these fish were endemic to the Bear Creek system prior to construction of the reservoir. There is very limited spawning habitat in Bear Creek above the reservoir to support a wild trout population.

Hatchery rainbow trout have been the primary species observed in the reservoir since its construction. Gillnets have been set in the reservoir periodically in the spring and fall since 1965. Size, growth and condition of fish have varied dramatically over the years indicating a response to fish stocking level, water level conditions, competition with nongame species, and annual productivity of the reservoir. Rainbow trout fingerlings average 3 to 4 inches in length when stocked in May. Trout captured in gillnets from spring and fall sets have ranged in size from 4 to 18 inches, although most fish are typically 8 to 14 inches in length. Fish stocked as fingerlings in the spring typically reach 8 to 11 inches by late summer and 12 to 15 inches the following summer. Catchable size rainbow trout stocked in the reservoir in May following the 1993 winter kill showed dramatic growth and reached 18 inches by fall.

The only nongame species observed in Antelope Flat Reservoir was bridgelip sucker. While this species is common in cold, small swift streams, it has also been found to be abundant in warmer streams and lakes throughout the Crooked River basin. It probably competes with rainbow trout for food by consuming invertebrates while feeding on benthic algae. Bridgelip sucker were recorded in annual gillnet sets in the reservoir from 1977 to 1988 until chemical treatment in the fall of 1988. Since chemical treatment of the reservoir in the fall of 1988, no suckers have been observed in spring and fall net sets, indicating a complete eradication of this species.

Fish Stocking History

Catchable and fingerling sized rainbow trout were stocked sporadically in Antelope Flat Reservoir from 1954 to 1963. An annual hatchery rainbow trout stocking program began in 1964. Up to 24,000 fingerling were stocked, although typically 5,000 to 10,000 fish are stocked. Catchables were stocked in the reservoir in 1969, 1971, and 1993 following winter kills, and in 1989 following chemical treatment, to generate an immediate fishery. No trout were stocked in 1968 and 1976 due to low water conditions and high abundance of rainbow trout observed in gillnet sets. The ODFW currently releases up to 10,000 fingerling sized rainbow trout annually at approximately 35 per

pound, usually in mid-May, depending on snowpack and water conditions. Numbers of fish stocked are adjusted depending on reservoir pool conditions and projected water level conditions by the end of the season.

Angling Regulations

Antelope Flat Reservoir was open during the general trout season from late April to the end of October up until 1992. The reservoir was opened to year round angling beginning in 1993 to encourage more harvest of hatchery stocked rainbow trout. The current bag limit is 10 trout per day, 6 inch minimum, with no more than 5 over 12 inches and 2 over 20 inches. There are no special tackle restrictions.

Fish Management

Antelope Flat Reservoir is managed for Basic Yield, with the fishery sustained by a fingerling rainbow trout hatchery program. Management of the reservoir has been to encourage the utilization of hatchery rainbow trout and provide a consumptive lake fishery in the Ochoco National Forest, where such fishing opportunities are rare. The fishery is very popular locally and provides excellent angling in the fall. There are no current estimates of total angler use or catch, but annual observations and opening day creel checks indicate the lake is very popular and produces good catch rates of rainbow trout.

Antelope Flat Reservoir has the potential to grow large trout due to the eutrophic nature of the reservoir. Catchable sized rainbow trout stocked in the spring of 1993 showed excellent growth reaching lengths of up to 18 inches by the following fall. However, overstocking and low water conditions have also resulted in high densities of rainbow trout with poor growth and condition. Spring condition factor of rainbow trout has ranged from 0.74 in 1991 to 1.33 in 1995.

It is unknown if there are conflicts with wild redband trout populations since there may be native fish both upstream and downstream of the reservoir. Hatchery fish likely escape to Bear Creek below through an unscreened outlet and may cause competition for food and space. Bear Creek, therefore, may not be in compliance with the Wild Fish Management Policy (ODFW 1990) due to hatchery stocking of rainbow trout in Antelope Flat Reservoir.

The only nongame species observed in the reservoir, bridgelip suckers, were first recorded in gillnet surveys in 1977. Abundant bridgelip suckers likely contributed to a decline in trout production through the 1980's. From 1981 to 1988, suckers comprised from 43% to 91% of the fish observed in gillnets sets. Since chemical treatment of the reservoir, rainbow trout have been the only fish species observed in the reservoir and in angling surveys.

Management Issues and Concerns

1. An unscreened outlet at Antelope Flat Reservoir likely allows hatchery fish to escape to Bear Creek and these fish may interbreed with wild redband trout. Hatchery fish may cause introgression of non-desirable traits that reduce genetic fitness of native stocks or bring diseases into wild fish populations.

2. Annual drawdown of the reservoir for irrigation limits trout production. Annual stocking of hatchery fish needs to be adjusted depending on carryover storage and anticipated refill and drawdown of the reservoir. Occasional winter kills require the stocking of catchable hatchery trout to generate a spring fishery.

3. Water quality and turbidity are likely limiting fish production and partial summer kills have been reported due to low dissolved oxygen levels.

4. Extreme drawdown of the reservoir makes the boat ramp inaccessible. The ramp needs to be lengthened to provide continued access throughout the irrigation season.

REYNOLDS POND

Location and Ownership

Reynolds Pond is a small 12 acre impoundment located in Deschutes County 1.25 miles southeast of the town of Alfalfa, and 15 miles east of Bend (Figure 28). The pond is an emergency release and wastewater pond for an irrigation ditch of the Central Oregon Irrigation District. Water from this pond does not empty into a fish bearing stream.

Reynolds Pond is located on BLM lands, administered by the Prineville District. The pond is located just inside a Wilderness Study Area. While the BLM has recommended that it be excluded from the Wilderness Study Area, it will be managed as such until a final determination is made by Congress. Although the pond's main purpose is for irrigation, the reservoir also has been popular for fishing, swimming, picnicking, hiking, dog training, model airplane clubs, wildlife observation, waterfowl hunting and nearby camping.

Prior to 1982, it was a small irrigation wastewater impoundment that held water intermittently. Numerous lava outcroppings in and around the pond caused leakage and an inadequate control gate at the canal prohibited a steady flow of water into the pond. In 1982, a consortium of public agencies and volunteers, including the Deschutes County Recreation Committee, BLM, ODFW, and Central Oregon Flyfishers, proposed the site be developed into a permanent pond for public recreation. Local businesses

and volunteers were solicited to provide equipment and manpower to improve the pond. The pond was deepened, dikes were constructed around suspected leakage sites, several islands were constructed for waterfowl nesting, an adequate water control structure was built at the canal headgate, bentonite clay placed on the pond bottom to seal leaks, and shrubs planted on the dikes and around the periphery of the pond.

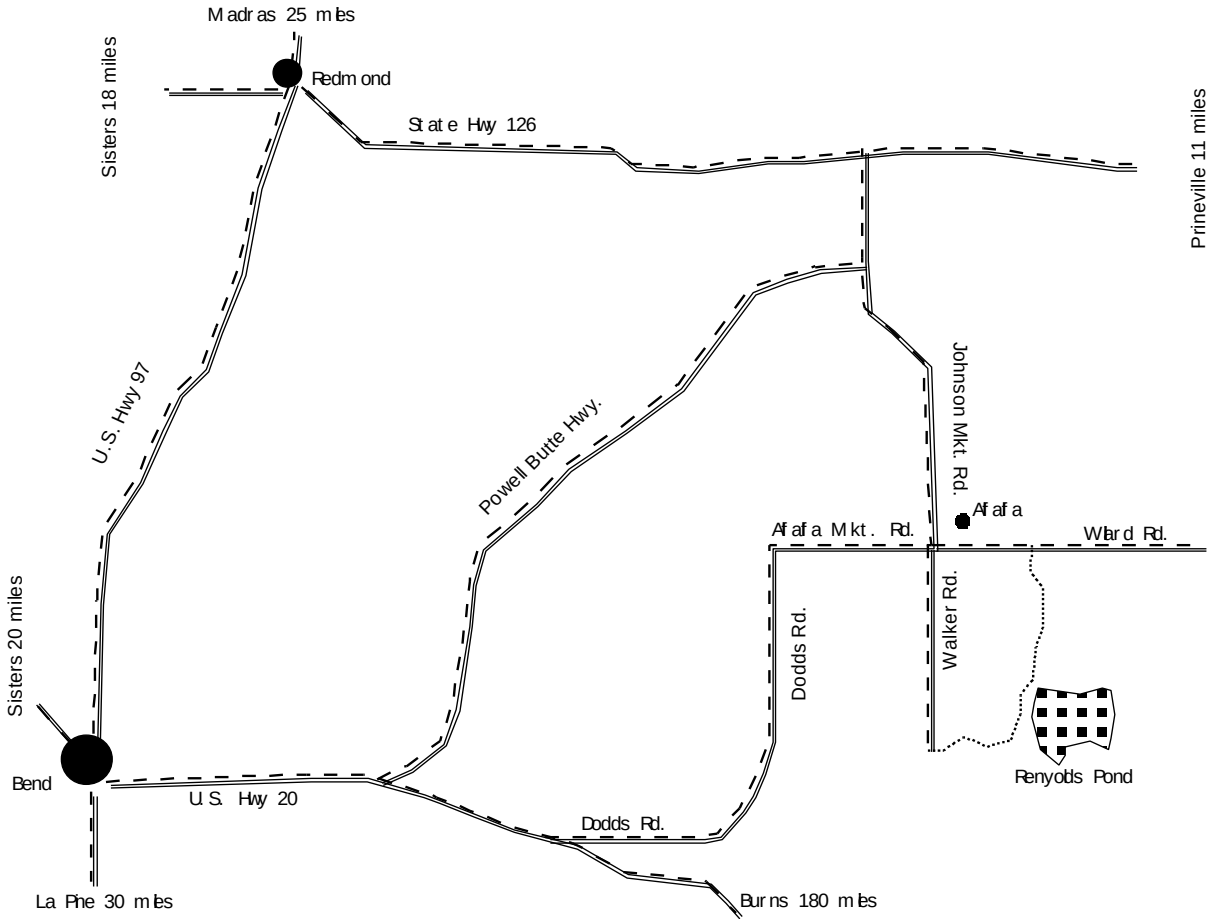

Figure 28. Reynolds Pond and vicinity.

In 1976, the BLM purchased 4 acres of water rights to guarantee a continual supply of water for the pond rather than relying on sporadic dumping of excess irrigation water. The BLM transferred a water right to the pond to insure adequate water from the canal. The rehabilitation work in combination with the BLM water rights has helped to maintain the water level in the pond throughout the irrigation season.

Habitat and Habitat Limitations

Reynolds Pond is a low elevation reservoir at 3,400 feet and is surrounded by a semi-arid sparse vegetative community of juniper, sagebrush, rabbitbrush, and bunchgrass. The area is relatively flat and is characterized by collapsed lava tubes, and small lava domes and outcroppings.

Reynolds Pond varies in size from approximately 8 to 12 surface acres depending on the water level. The pond is relatively shallow with a maximum depth of 12 feet. Approximately 2/3 of the area of the pond is not well utilized by fish species due to shallow depths of less than 3 feet, particularly along the northern shoreline. The pond has very gradual slopes on all sides except the earthen dam along the south shore. Drawdown for irrigation intensifies competition for food and space.

Much of the reservoir substrate consists of mud and gravel. Although there is very little water quality data, the reservoir is likely oligotrophic to mesotrophic. The reservoir's water supply comes from irrigation wastewater. For a majority of the season, 35 gpm of cold Deschutes River water is fed into the pond. It has low concentrations of nitrogen and phosphorus, at 0.02 and 0.08 mg/l, respectively. Macrophytes develop in shallow littoral areas, particularly along the north shore of the pond. Blooms of plankton are sporadic and not as abundant as most central Oregon waters.

A grab sample of water quality data collected in early June 1991 indicated a headgate water temperature of 64^{o}F and pH of 7.5; and a mid pond temperature and pH of 68 ^{o}F and 9.5, respectively. This sample showed a moderate increase in temperature and a substantial increase in alkalinity as water was held in the pond. A secchi disk indicated a clarity of 8.5 feet, suggesting that while turbidity was low, plankton production was also low. Most areas of the pond probably warm to 70 ^{o}F during summer because of its low elevation and shallow depth.

Fish production in the reservoir is influenced by amount of inflow from the irrigation canal, water level of the pond, and amount of water released for irrigation. Plankton production, and spawning and rearing of fish are influenced by the continual cooling by input of cold irrigation water. Cold water inputs could disrupt or delay algae and zooplankton production and delay warmwater fish spawning or cause complete failures.

Access

Reynolds Pond is easily accessible from Bend by traveling 14 miles east to Alfalfa, to the Johnson Market Road, and heading south to the landfill. The pond is about 0.5 miles past the landfill on an unimproved sand road with rock outcroppings that can make it difficult for passenger cars with low clearance. A foot bridge provides public access to the pond over a ditch which separates the parking area from the pond. The

entire shoreline is available for bank fishing. A trail approximately 0.75 miles in length circles the pond inside a livestock exclosure fence. Non-motorized boat use is permitted. Canoes and float tubes are preferred since all craft have to be carried from the parking lot to the pond.

There are no facilities provided at the site and no significant improvements have been made in the past 10 years. However, the BLM is in the process of developing an urban fisheries plan which proposes facility expansions at Reynolds Pond which may include a campground.

Fish Resources

Reynolds Pond has been stocked with rainbow trout, largemouth bass, bluegill, and redear sunfish. Brown bullhead were either illegally introduced or entered the pond via another source from the canal and have been observed during inventory in seine nets or have been caught by anglers. No other fish species have been reported. There is no spawning habitat available for rainbow trout and no escape through the outlet facility. Most fish stocked in the reservoir are likely caught by anglers, eaten by larger fish or terrestrial predators, or die of natural mortality. Since improvement of the pond in 1982, only largemouth bass, redear sunfish, and brown bullhead have been found in the pond. Fish production is limited by food availability, irrigation inputs and outputs, water quality, carryover of fish through the winter, and intensity of angler use.

Warmwater species were stocked in the expectation that they would provide fisheries that would reproduce naturally, have excellent growth, and provide a popular bass and panfishing opportunity in a small pond setting that has not been generally available in central Oregon. Analysis of inventory data collected to date, however, suggests that spawning and recruitment of warmwater species has been sporadic and growth has been very slow.

Largemouth bass were captured in trapnets or seine nets in Reynolds Pond in September and October 1983, and June 1984. Largemouth bass were from 3.5 to 5 inches in length, and moderately abundant. Largemouth bass abundance has decreased since then based on surveys in June 1987, November and December 1990, and June 1993. Largemouth bass captured in trapnet and electroshocking surveys in Reynolds Pond during the late fall of 1990 were from 2 to 10 inches in length. There were 2 size classes of fish, with one averaging approximately 6 inches and the second approximately 9.5 inches. Scale analysis of these 2 groups indicated that they were composed of 2 to 3 year old fish, and 5 to 9 year old fish, respectively. Both relative weight analysis and assessment of condition factor indicated that bass growth was poor for the smaller size class and very poor for the larger size class. Shrader (1991) felt that continual cooling of the pond by cold irrigation water stunted bass growth and did not allow successful utilization of redear sunfish as a prey species. Electroshocking surveys in June 1993 further verified low abundance and poor growth of largemouth bass.

In their native habitat, redear sunfish are found in large warm rivers, bayous, and lakes, occasionally in brackish water, and appear to tolerate fairly high salinity (Carlander 1973). In introduced areas, they appear to require relatively clear water and some vegetation. In northern climates, redear sunfish spawn in their second year, usually in late spring or early summer when water temperatures reach 70^{o}F. Nests are typically in 2 to 4 inches of water, and can be as deep as 8 inches, usually in submerged vegetation. Eggs hatch in 6-10 days and fry remain in the nest about a week. Redear sunfish spawning failure has been noted where largemouth bass spawning was successful, and during sudden cold spells. Research suggests that redear sunfish alone may not provide an adequate forage bass for largemouth bass.

Redear sunfish are found only in 2 small water bodies in eastern Oregon, Reynolds Pond and Taylor Lake, near The Dalles. Forty adult and 1,000 young of the year fish were first stocked in Reynolds Pond in 1983 in the expectation they would provide a forage base and improved growth for largemouth bass, and a diverse and unusual panfish angling opportunity. A trapnet set in 1987 indicated redear sunfish had successfully reproduced and fish were between 5.8 and 9.5 inches in length. Fish captured in 1990 from trapnet and electrofishing surveys indicated a moderately abundant population with fish from 0.5 to 10 inches in length, and a complete range of year classes. Scale analysis and relative weight indicated a very slow growth rate and poor condition of the fish. An electroshocking survey in June 1993 indicated similar abundance and size classes.

Brown bullhead were first observed in 1987 during sampling surveys for largemouth bass and redear sunfish. Since then, they have been caught occasionally by anglers and caught in a seine net survey in 1994.

Fish Stocking History

The earliest record of fish stocked in Reynolds Pond was in 1958, when it was stocked with bass and bluegill (OSGC 1958). Two years later, it was noted that angler use of Reynolds Pond had exceeded all expectations (OSGC 1960). In 1976, 1,200 rainbow trout that were salvaged from Allen Creek Reservoir were stocked in Reynolds Pond. Approximately 500 catchable sized rainbow trout were stocked again in 1978. Occasional drying of the pond caused extensive fish mortality, leading to the pond improvement in 1982. Following the pond reconstruction, largemouth bass were stocked in 1982 and redear sunfish in 1983.

Angling Regulations

Reynolds Pond is open to angling year round, with a largemouth bass bag limit of 5 per day, with no more than 3 over 15 inches. There is no catch limit on redear sunfish. There are no special tackle restrictions.

Fish Management

The present day fishery of largemouth bass and redear sunfish is providing a popular, but relatively unproductive angling opportunity (Shrader 1991). The slow growth, small size, and sporadic recruitment observed in largemouth bass and slow growth of redear sunfish, suggest a relatively low harvest of fish. Cold water inputs likely delay or cause failure of centrarchid spawning, delay zooplankton production, and decrease the activity of bass for long enough periods that they apparently are not able to adequately prey upon young of the year redear sunfish . Monitoring rate of water loss, temperature, and productivity will determine whether efforts at enhancement are feasible. Preliminary results from a fertilization of the reservoir in 1992 suggested that phytoplankton production may be increased but may not translate to increased fish production. Because largemouth bass grow slowly and do not get very large, most of the redear sunfish are probably too big for bass to eat.

There appear to be two major problems with Reynolds Pond for fish production: 1) low fertility of the pond due to the input of cold Deschutes River water, and 2) the very shallow nature of a majority of the pond. One option to increase production includes deepening or enlarging the pond. A major risk includes potential puncturing of the pond bottom and finding a lava tube, ultimately causing the pond to drain. Other options are to fix the leaking dike and apply for more water rights for a larger pond. A third option is to increase utilization of the existing pond area by putting more structure in shallow areas along the northern shoreline.

The BLM is considering expanding Reynolds Pond as an urban fisheries by further developing the site, including a campground. Increased development will likely increase angling pressure on warmwater fish populations and potentially seriously deplete these populations, particularly largemouth bass.

Several habitat improvement projects were conducted to enhance fish production and angling success. Over 500 bare root trees were planted around the perimeter of the reservoir to provide wildlife cover and provide future large woody debris. Junipers were added for large woody debris in the deepest part of the pond along the south shore to provide fish cover for spawning and rearing and increase the nutrient and substrate base for aquatic insect production.

The pond was fertilized in July 1992 to determine if added nutrients would increase productivity. Observations following fertilization indicated that some increase in phytoplankton production did occur. Secchi disk clarity improved slightly from 8.5 to 6 feet. However, sampling efforts in June 1993 have not been compared with previous sampling results to determine if there has been an increase in fish production, particularly for largemouth bass.

Management Issues and Concerns

1. A large area of the reservoir is shallow and provides very limited habitat for fish. Seasonal drawdown of the reservoir for irrigation further limits fish production.

2. Brown bullhead compete for food and space with other more desired game species.

3. Regular inputs of clear cold water from the Deschutes River limits warmwater fish production and disrupts algae and zooplankton growth, and delays or disrupts warmwater fish spawning.

4. Further development of Reynolds Pond as an urban fisheries program may increase angler effort and harvest on existing fisheries. The fishery is entirely dependent on natural production and low productivity indicates the fishery may not be able to tolerate high harvest rates.

MANAGEMENT DIRECTION

POLICIES

Policy 1. Walton Lake and Antelope Flat Reservoir will be stocked with hatchery rainbow trout and managed for hatchery production consistent with the Basic Yield Management Alternative for trout (ODFW 1987a).

Policy 2. Wild redband and introduced brook trout in Allen Creek Reservoir will be managed for natural production consistent with the Wild Fish Management Alternative (ODFW 1987a). No hatchery trout will be stocked in Allen Creek Reservoir.

Policy 3. Largemouth bass, redear sunfish, and brown bullhead in Reynolds Pond will be managed for natural production consistent with the Basic Yield Alternative for warmwater fish (ODFW 1987b).

Objectives

Objective 1. Protect and maintain the genetic diversity, adaptiveness and abundance of wild redband trout and introduced brook trout in Allen Creek Reservoir.

Assumptions and Rationale

1. Allen Creek Reservoir supports a self sustaining population of wild redband trout and likely supports introduced brook trout that have naturally reproduced in Allen Creek. Redband trout populations have been identified on the Department's provisional list of wild fish populations, and are the highest priority species for management.

2. Allen Creek redband trout have been identified as inland rainbow trout and are classified as a sensitive species under the state sensitive species act, and as a Category 2 candidate species under the Federal Endangered Species Act. Population levels of wild redband trout in Allen Creek Reservoir and its tributaries are unknown but likely at depressed levels.

3. Monitoring the distribution and abundance of populations of wild redband and introduced brook trout in both Allen Creek Reservoir and its tributaries will provide an indication of their health and adaptiveness.

4. Catchable or fingerling non-native hatchery rainbow trout and brown trout were stocked in Allen Creek Reservoir in the past but are not stocked there now. Releases of hatchery trout near areas where wild trout spawning occurs will decrease the genetic fitness of wild trout populations if these fish interact or interbreed.

6. Special regulations may be necessary in the future for Allen Creek Reservoir and its tributaries to protect stock fitness and life history characteristics and to maintain healthy wild redband and brook trout populations with multiple age classes.

7. The Allen Creek Reservoir redband trout population has been truncated from the North Fork Crooked River populations by the dam at Allen Creek Reservoir and a maze of irrigation ditches that distribute water over Big Summit Prairie.

Actions

Action 1.1 Establish redband trout distribution, abundance, and trends in Allen Creek Reservoir and in index reaches of Allen, Beetle, and Yellowjacket creeks.

Action 1.2 Verify and document distribution and upper limits of redband and brook trout in Allen, Beetle, and Yellowjacket creeks.

Action 1.3. Assess the status of sensitive rainbow trout in Allen Creek Reservoir.

Action 1.4 Establish baseline data sets on the genetic characteristics of rainbow with the use of biochemical (electrophoresis), DNA and phenotypic parameters.

Objective 2. Provide angling opportunities for wild redband and introduced brook trout in Allen Creek Reservoir.

Assumptions and Rationale

1. Allen Creek Reservoir provides an unusual opportunity to fish for native redband trout in a flat water and relatively undisturbed setting in the Ochoco Mountains.

2. Lack of suitable trout habitat as a result of poor land and water use practices limits the ability of Allen Creek Reservoir to maintain a fishery.

Actions

Action 2.1 Evaluate angling pressure and harvest rates of wild trout on Allen Creek Reservoir and its tributaries through creel surveys to determine consumptive use and impacts on wild populations.

Action 2.2 Determine the need for additional or modified angling regulations to protect populations of wild trout by monitoring the production, harvest, and catch rate of wild trout.

Action 2.3 Develop an information and education program to enhance angler awareness of the sensitive status and life history requirements of wild redband trout.

Action 2.4 Develop an information brochures of Allen Creek Reservoir to highlight diverse angling and recreation opportunities.

Objective 3. Provide angling opportunities for consumptive fisheries on hatchery rainbow trout in Walton Lake and Antelope Flat Reservoir.

Assumptions and Rationale

1. These fisheries are of a general consumptive nature.

2. Lack of suitable trout spawning habitat limits the ability of Walton Lake and Antelope Flat Reservoir to maintain a fishery without stocking of hatchery fish.

3. There is a strong public interest for consumptive fisheries on hatchery trout in these water bodies.

3. A catch rate of 0.4 rainbow trout per hour in Walton Lake provides an adequate fishery.

4. Extensive numbers of non-indigenous hatchery rainbow trout are stocked in Walton Lake and Antelope Flat and may pass downstream, rear and reproduce.

Actions

Action 3.1 Continue to release up to 15,000 catchable hatchery rainbow trout in Walton Lake. Continue to release up to 10,000 fingerling hatchery rainbow trout in Antelope Flat Reservoir.

Action 3.2 Monitor angling pressure and harvest of trout through periodic creel surveys to determine consumptive use. Monitor abundance, size, age-class structure and distribution of Walton Lake and Antelope Flat Reservoir rainbow trout by conducting periodic inventories using electrofishing or nets.

Action 3.3 Periodically evaluate stocking programs through adjustments in size, number and time at release of hatchery trout to meet catch rate and contribution to angler creel guidelines. Adjust stocking levels to maintain a minimum return to the angler of at least 40% from catchable hatchery trout released into Walton Lake.

Action 3.4 Monitor in Ochoco Creek below Walton Lake and in Bear Creek below Antelope Flat Reservoir the presence and interaction between hatchery rainbow and brook trout, and wild redband trout, according to provisions in the Wild Fish Management Policy (ODFW 1990) through sampling trout composition in rearing and spawning areas. Modify the numbers, locations, frequency, timing and types of hatchery rainbow trout stocked, if necessary, to protect the genetic resources of wild fish. Construct screens where feasible to prevent egress of hatchery trout into streams with wild redband trout.

Action 3.5 Develop information brochures of Walton Lake and Antelope Flat Reservoir to highlight diverse angling and recreation opportunities.

Objective 4. Provide angling opportunities for largemouth bass, redear sunfish, and brown bullhead in Reynolds Pond where populations of these fish currently exist.

Assumptions and Rationale

1. Largemouth bass were stocked in Reynolds Pond in 1982.

2. Redear sunfish were stocked in Reynolds Pond in 1983.

3. Brown bullhead were either illegally introduced or entered Reynolds Pond via the canal system from another impoundment in 1987.

4. There is strong public interest for consumptive fisheries on warmwater fish in Reynolds Pond.

Actions

Action 4.1 Monitor angling pressure and harvest on warmwater fish through periodic creel surveys.

Action 4.2 Monitor natural production, growth, abundance and mortality of largemouth bass, redear sunfish, and brown bullhead.

Action 4.3 Continue to use angling regulations to regulate angler harvest of warmwater fish species.

Action 4.4 Develop an information brochure of Reynolds Pond to highlight diverse angling and recreation opportunities.

Objective 5. Improve vehicle access at Allen Creek Reservoir and improve boat access at Allen Creek and Antelope Flat reservoirs during low water conditions.

Assumptions and Rationale

1. Allen Creek boat access has been eliminated temporarily by a road closure 1.3 miles from the reservoir. Only foot access is available.

2. When vehicle access is restored, the boat ramp at Allen Creek Reservoir is unusable at low water conditions. Once vehicle access is restored, a public boat launch should be constructed to disperse recreation, improve boating and angling opportunity, extend boating access as water levels are drawn down by irrigation, and protect shoreline resources from damage by off road vehicle activity.

3. Boat access at Antelope Flat Reservoir is unusable at low water conditions.

Actions

Action 5.1 Work with the private landowner and the BLM to restore and maintain vehicle access at Allen Creek Reservoir. Explore further opportunities with conservation organizations to assist with site improvement and maintenance.

Action 5.2 Once vehicle access is restored at Allen Creek Reservoir, coordinate with BLM to improve and extend the boat ramps.

Action 5.3 Explore opportunities to extend the boat ramp at Antelope Flat Reservoir.

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GLOSSARY

Adfluvial - A fish life history where juveniles are born in streams, move to lakes to rear, and then migrate back up to streams to spawn. Migrating between lakes and streams.

Ammocoetes - The larval form of lampreys.

Amphipods - An order of fresh water and marine malacostracans, having a laterally compressed body, elongated abdomen, and no carapace. An important fish food often referred to as scuds.

Anadromous - A fish life history where juveniles are born in streams, move to the ocean to rear, and then migrate back up to streams to spawn. Moving from the sea to fresh water for reproduction.

Benthic - Relating to, or occurring at the bottom of a body of water. The substrate of a water body (freshwater, estuarine, or marine).

Calcic - Made up of, having, derived from, or relating to calcium or lime.

Chironomid(ae) A diverse and ecologically important family of aquatic insects. An important food item for fish commonly known as midges.

Cladocerans - An order of Branchiopoda including the water fleas. Daphnia, an important fish food in lakes, are a member of this order.

Condition Factor - A measure of how fat a fish is based on the ratio between the length and weight of a given species of fish. The higher the condition factor, the fatter the fish.

Cretaceous - Having the characteristics of or abounding in chalk. Relating to, or being the last period of the Mesozoic era (approx. 63,000,000 to 135, 000,000 years ago) or the corresponding system of rocks.

Degradation - Erosional removal of materials from one place to another. Degradation lowers the elevation of the streambed and floodplain.

Demersal - Living on or near the bottom of a lake or sea.

Detritus - Undissolved organic or inorganic matter resulting from the decomposition of parent material

Dewater - Lowering of the water table in a stream caused by a channel shift or flow reduction.

Diatoms - A class of minute planktonic unicellular or colonial algae with silicified skeletons.

Ephemeral - Streams that flow briefly and in direct response to local precipitation, and whose channel is always above the water table.

Extirpated - Removed from or no longer existing in a particular area.

Fluvial - Pertaining to streams or rivers, or produced by stream actions. Also, a fish life history where juveniles are born in streams, move to a main river to rear, and then migrate back up streams to spawn.

Hydrological net - Referring to the connectedness between streams and ground water within a watershed.

Impoundment - Any structure that impedes the flow of a stream or river, usually used to indicate a reservoir.

Indigenous - Belonging to the locality; not imported; native.

Limnology - The study of ponds, lakes, and reservoirs.

Littoral zone - The shallow water area along the shore of ponds, lakes, or reservoirs.

Lotic - Of or in running water such as a river or stream.

Macroinvertebrate - Aquatic insects large enough to be seen with the naked eye.

Mg/l Milligrams per liter. Equivalent to parts per million (PPM)

Montmorillinite- A type of clay soil prevalent throughout the upper Crooked River basin.

Morphology - The science of form and structure.

Omnivorous - Eating both plants and animals.

Orthophosphate - A form of phosphorous easily used by aquatic plants and phytoplankton.

Ostracods - A subclass of small crustaceans having a bivalve carapace enclosing head and body, and reduced trunk and abdominal limbs. Sometimes used by fish as food.

Paleozoic - Of, relating to, or being an era of geological history which extends from the beginning of the Cambrian to the close of the Permian (approx. 230,000,000 to 600,000,000 years ago).

Pelagic - The deeper water, offshore areas of ponds, lakes or reservoirs.

Phenotypic - Characters arising from reactions to environmental stimulus.

Picivorous - Eating fish.

Proportional stock density (PSD) An index used to determine what proportion of a fish population exceeds a particular size. Often used to describe warmwater fish populations. Proportional stock density is equal to the number of fish greater than stock size divided by the number of fish greater than quality size, multiplied by 100. For largemouth bass, stock size equals 8 inches and quality size equals 12 inches. For smallmouth bass, stock size equals 7 inches and quality size equals 11 inches.

Relative stock density 15 (RSD15) - An index used to determine what proportion of a fish population exceeds 15 inches. Often used to describe warmwater fish populations. Relative stock density 15 is equal to the number of fish greater than stock size divided by the number of fish greater than 15 inches, multiplied by 100.

Relative weight - A measure of how fat a fish is compared to all other fish in North America. A fish having a relative weight of 100 is average, a relative weight less than 100 indicates a skinny fish, while a relative weight greater than 100 indicates a fatter than average fish.

Riffle - Shallow section of stream or river with rapid current and a surface broken by gravel, rubble or boulders.

Riparian - Area with distinctive soils and vegetation between a stream and the adjacent upland.

Rotenone - Commonly used fish toxicant which is derived from the derris root.

Seining - A form of live netting fish by encircling the quarry.

Tertiary - Of third rank, importance or value. Of relating to, or being the first period of the Cenozoic era (approx. 500,000 - 2,000,000 to 63,000,000 years ago).

Thermocline - The region in a thermally stratified body of water, as a lake, in which the temperature decrease with depth is greater than that of the water above and below it. The epiliminon is below and the hypoliminon is above.

Tributary - A stream flowing into a lake or larger stream.

Tricoptera - Referring to the family of aquatic insects commonly known as caddisflies. An important fish food in both lakes and streams.

Tuffaceous - A rock made up of compacted volcanic ash varying in size from fine sand to coarse gravel.

Turbidity - Clouded with stirred up sediment; a darkening or clouding up of what should be clear.

Ultraoligotrophic - Referring to the trophic status of a lake defined by the nutrient concentrations. Ultraoligotrophic lakes are nutrient poor and fish production is generally low.

Weir - A notch or depression in a dam or other water barrier though which the flow of water is measured or regulated. Also a barrier constructed across a stream to divert fish into a trap or to raise the water level or divert water flow.

Zooplankton - Small (often microscopic) animals suspended or weakly swimming in water. Zooplankton feed on phytoplankton and are a critical food item for small fish In lakes and reservoirs.

ACRONYMS

AMP - Allotment management plan

BLM - United States Department of Interior, Bureau of Land Management

BOR - United States Department of Interior, Bureau of Reclamation

CCSD - Crook County School District

CE - Categorical Exclusion

CFS cubic feet per second

CREEC Crooked River Ecosystem Education Council

CTWS Confederated Tribes of the Warms Springs

DSL - State of Oregon Division of State Lands

EA - Environmental Assessment

EIS - Environmental Impact Statement

EPA Environmental Protection Agency

FERC - Federal Energy Regulatory Commission

FL - Fork length

IFIM Instream Flow Incremental Methodology

NUID - North Unit Irrigation District

OID - Ochoco Irrigation District

ODEQ - State of Oregon Department of Environmental Quality

ODFW - State of Oregon Department of Fish and Wildlife

ODOT - State of Oregon Department of Transportation

OSFC State of Oregon Fish Commission

OSGC State of Oregon Game Commission

OSP - Oregon State Police

OWRD State of Oregon Water Resources Department

PGE - Portland General Electric Company

PSD - Proportional Stock Density

RM River Mile

RSD15 - Relative Stock Density 15

STEP Salmon Trout Enhancement Program

TL - Total length

USDA - United States Department of Agriculture

USDI - United States Department of the Interior

USFS - United States Department of Agricultural, Forest Service

USFWS - United States Fish and Wildlife Service