RECOVERY PLAN

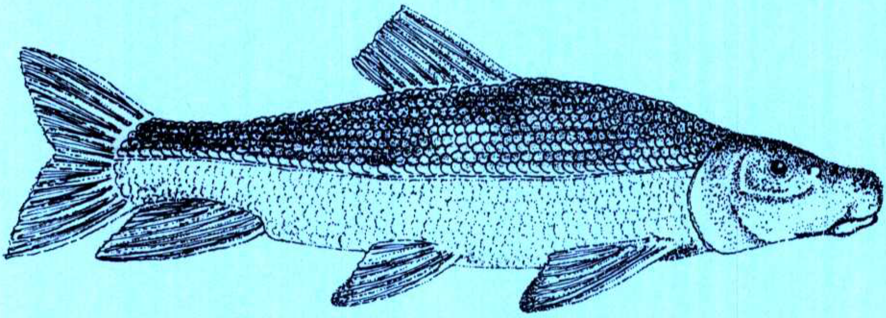
LOST RIVER SUCKER

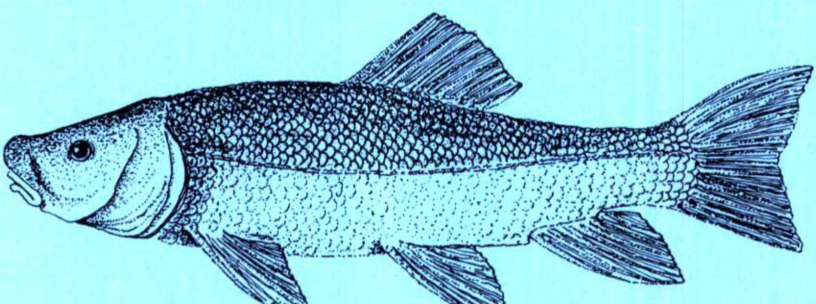
Deltistes luxatus

and

SHORTNOSE SUCKER

Chasmistes brevirostris





U.S. Department of the Interior
Fish and Wildlife Service
Region One, Portland, Oregon
April, 1993

LOST RIVER (*Deltistes luxatus*) AND

SHORTNOSE (*Chasmistes brevirostris*)

SUCKER RECOVERY PLAN

Prepared by

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for

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved ______________________________
Regional Director, U.S. Fish & Wildlife Service

Date: 3/17/93

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EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR LOST RIVER AND SHORTNOSE SUCKERS

Current Status: The declining condition of Klamath Basin sucker species has been recognized since the mid-1960's (Andreasen 1975) but it was not until the mid-1980's that the severity of the situation was realized. Lost River and shortnose suckers were subsequently listed as endangered under the Endangered Species Act in 1988. Both species are endemic to the upper Klamath Basin. Significant losses to the gene pool of the suckers may in fact have already occurred with the disappearance of entire stocks (e.g., Harriman Springs, Barkley Springs, Lower Klamath Lake, and possibly others), and drastic reductions in other populations (Upper Klamath Lake, Tule Lake).

Reasons for Decline and Habitat Requirements: The final rule listing the Lost River and shortnose suckers as endangered species suggested the following reasons for their decline: the damming of rivers, dredging and draining of marshes, water diversions, hybridization, competition and predation by exotic species, insularization of habitat, and water quality problems associated with timber harvest, removal of riparian vegetation, livestock grazing, and agricultural practices (Federal Register 53:27130-27134). A shift toward hypereutrophication in Upper Klamath Lake has been documented (Miller and Tash 1967, Vincent 1968) and is considered by the Service to be a probable cause for the decline of Lost River and shortnose suckers and a major limiting factor in recovery of the species. Tule Lake, lower portions of the Lost River, Lake Ewauna, and the upper Klamath River also have severe water quality problems associated with hypereutrophication. Overharvest and chemical contamination also may have contributed to the decline.

Both species of suckers are lake dwelling but spawn in tributary streams or springs. Reduction and degradation of lake and stream habitats in the upper Klamath Basin has been proposed by the Service as the major factor in the decline of both species.

Recovery Objective: Detailed downlisting or delisting criteria can not be proposed at this time.

Recovery Criteria:

The interim objective is to establish at least one stable refugial population with a minimum of 500 adult fish for each unique stock of both Lost River and shortnose suckers.

Actions Needed:

1. Establish safe refuge populations of both listed suckers within the watershed.

2. Conduct research on sucker populations and habitat needs.

3. Improve Lost River and shortnose sucker habitat conditions through rehabilitating riparian areas and improving land management practices in the watershed, developing and achieving water quality and quantity goals, and improving fish passage, spawning habitat, and other habitat conditions.

Costs: (in $1,000s)

Year	Need 1	Need 2	Need 3	Total
1993	359.0	1111.6	1480.0	2950.6
1994	120.0	775.0	1025.0	1920.0
1995	60.0	530.0	795.0	1385.0
1996	40.0	280.0	335.0	655.0
1997	55.0	210.0	270.0	535.0
1998	0.0	0.0	70.0	70.0
1999	0.0	0.0	180.0	180.0
2000	0.0	0.0	10.0	10.0
2001	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
Total Cost of Recovery	634.0	2906.6	4165.0	7705.6

Date of Recovery: The interim objective of establishing refugia populations for each unique stock should be accomplished by 2012 if research and recovery efforts are coordinated and water quality criteria have been met. A downlisting/delisting target date can not be projected at this time.

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I. INTRODUCTION

A. Brief Overview

The Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) are large, long-lived suckers endemic to the upper Klamath Basin of Oregon and California. Both were originally described by Cope (1879) and both have gone through considerable taxonomic revision. The limited distribution of both sucker species, combined with the level of agricultural development and associated water and land use threats within the drainage, make these fishes susceptible to past and present habitat loss and degradation throughout their distribution. Both Lost River and shortnose suckers were federally listed as endangered species on July 18, 1988 (Federal Register 53:27130-27134). Because the Lost River sucker is the only species in the genus *Deltistes*, this entire genus is endangered as well. The recovery of these fishes and the ecosystem they depend on will require the input and cooperation of numerous Federal, state, county, and city agencies, as well as local organizations and individuals who own or manage basin land and water resources. Many of the tasks in this recovery plan are very similar to actions recommended in the Draft Upper Klamath River Basin Amendment to the Long-Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program, prepared for the Klamath River Basin Fisheries Task Force. Many similar recovery tasks are also in the Klamath Basin Water Users Protective Association's Initial Ecosystem Restoration Plan for the Upper Klamath River Basin (Water Users Plan) and several portions of that plan are incorporated into this recovery plan. Much of the wetland restoration in this recovery plan also is recommended in the North American Waterfowl Management Plan. Implementation of this recovery plan should benefit game fish in the watershed, trout and salmon downstream, amphibians, reptiles, waterfowl, and other wildlife in the basin in addition to the suckers. Most of the sucker populations are within the U.S. Bureau of Reclamation's (Reclamation) Klamath Project area. Pursuant to consultation with Reclamation under section 7 of the Endangered Species Act, the U.S. Fish and Wildlife Service (Service) rendered a biological opinion, dated July 22, 1992, on long-term operations of the Klamath Project, which suggests or requires some of the same actions recommended in this recovery plan. The long-term biological opinion also sets minimum lake levels and other restrictions on Klamath Project operations that are not addressed in this plan. This recovery plan incorporates information from, but does not supersede, the long-term biological opinion.

B. Description

Lost River Sucker Taxonomy

The confusing taxonomic history of the Lost River sucker, as described by Andreasen (1975), began with Cope's description of the species as *Chasmistes luxatus* in 1879 (Cope 1879), based on specimens from Upper Klamath Lake. Eigenmann (1891) then re-classified the species as *Catostomus rex* based on analysis of specimens from Tule Lake and the Lost River. Seale (1896) renamed the sucker into a new monotypic genus (*Deltistes*) after an analysis of gill raker morphology, and used the original species name of *luxatus*. Miller (1959) stated that gill raker characteristics were not always diagnostic for the identification of Lost River suckers, and subsequently placed the sucker back in the genus of *Catostomus*, retaining the species name *luxatus*. Miller and Smith (1967) recognized characteristics of the genus *Deltistes*, described by Seale (1896), in their examination of fossil fishes, and concluded that the one living example of this genus was the Lost River sucker, *Deltistes luxatus*.

Identification

Lost River suckers are one of the largest sucker species and may grow to 1 meter in total length (Moyle 1976). Lost River suckers exhibit some variability in traits commonly used to differentiate fish species. The Lost River sucker is distinguished by its long snout (Cope 1879, Andreasen 1975, Moyle 1976) and a wide median notch in the lower lip that has one or two large papillae between the notch and the edge of the lower lip (Andreasen 1975). Lost River suckers can be distinguished from shortnose and Klamath largescale suckers based on vertebral counts (Markle pers. comm.). Lateral line scale counts differ among specimens, with Gilbert (1897) reporting between 76 and 81, Andreasen (1975) between 79 to 83, Moyle (1976) between 82 to 88, and Buettner and Scoppettone (1991) 82 to 113. Gill raker numbers also vary; 27 to 28 reported by Andreasen (1975) and 24 to 33 by Moyle (1976). The gill raker counts can increase with age (Markle pers. comm.). The gill rakers are short, triangular in shape (Moyle 1976), as well as widely spaced and smooth on the edges (Andreasen 1975). Moyle describes the small hump on the snout of the Lost River sucker as a key characteristic to its identification. Like most suckers, the coloration of the body is dark on the back and sides and fades to white or yellow on the belly (Moyle 1976).

A general description of the morphological characteristics of juvenile Lost River suckers less than 100 millimeters (mm) in standard length (SL) is provided by Bond (1989):

> The lobes of the lower lip are well-separated by a gap and are seldom in contact with each other. A raised

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

Buettner and Scoppettone (1990) provide a descriptive key to the eggs, larvae, and juveniles of Lost River suckers sampled from Upper Klamath Lake.

Shortnose sucker- Taxonomy

The shortnose sucker was described by Cope (1879) from specimens collected in Upper Klamath Lake and given the name *Chasmistes brevirostris*. Cope (1881) then placed the shortnose sucker in a new genus (*Lipomyzon*), based on the characteristics of its pharyngeal teeth. After analyzing more specimens, Cope (1884) decided that pharyngeal teeth characteristics did not warrant a new genus, and changed the genus name back to *Chasmistes*. Fowler (1934), in his review of catostomid fishes, apparently did not realize that Cope had reassigned the shortnose sucker into the genus *Chasmistes*, and published the classification of the shortnose sucker as *Lipomyzon brevirostris*. In 1952, the confusion was ended when the shortnose sucker was classified as *Chasmistes brevirostris* in a personal communication between R.R. Miller and C.E. Bond (see Andreasen 1975). The shortnose sucker has since retained this taxonomic classification (Robbins *et al.* 1991).

Identification

As with the Lost River sucker, the morphological characteristics of the adult shortnose sucker are variable. This variation appears related to the two distinct morphologies of the fish associated with Upper Klamath Lake and the Lost River (Buettner pers. comm., Scoppettone pers. comm.). The reason for the two morphs is not known; enzyme electrophoresis showed that fish from a variety of geographically disparate populations did not appear to be genetically distinct (Moyle and Berg 1991). Additional research is scheduled to investigate genetic differences. The variation could be related to differences in habitat or feeding, or could be ontogenic, with larger adults having morphological characteristics described as shortnose and younger individuals deviating from these characteristics (Markle pers. comm., Moyle pers. comm.).

In general, shortnose suckers are usually less than 50 cm SL and are distinguished by a large head, oblique, terminal mouth, and thin lips that have minute or absent papillae (Moyle 1976). Andreasen (1975) describes the shortnose sucker as having approximately 78 lateral line scales and 40 gill rakers. Moyle (1976) found 73 to 82 lateral line scales and 34 to 49 gill rakers. Shortnose suckers are dark in color on the back and silvery to white on the belly (Moyle 1976). Bond (1989) provides a general morphological key to juvenile shortnose suckers less than 100 mm SL:

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

Buettner and Scoppettone (1990) provide an in depth morphological key to the eggs, larvae, and juveniles of shortnose suckers in Upper Klamath Lake.

C. Historic Distribution and Population Status

Lost River and shortnose suckers are endemic to the upper Klamath Basin of Oregon and California (Map, page 11). Within their range, early records indicate that the Lost River and shortnose suckers were widespread and abundant. Cope (1884) noted that Upper Klamath Lake sustained "a great population of fishes" and was "more prolific in animal life" than any body of water known to him at that time. Gilbert (1898) noted that the Lost River sucker was "the most important food-fish of the Klamath Lake region." At that time, spring sucker runs "in incredible numbers" (Gilbert 1898) were relied upon as a food source by the Klamath and Modoc Indians and were taken by local settlers for both human consumption and livestock feed (Cope 1879, Coots 1965, Howe 1968). Sucker runs were so numerous that a cannery was established on the

Lost River (Howe 1968) and several other commercial operations processed "enormous amounts" of suckers into oil, dried fish, and other products (Andreasen 1975).

The Lost River sucker is native to Upper Klamath Lake (Williams *et al.* 1985), its tributaries, including the Williamson, Sprague, and Wood rivers, Crooked Creek, Seven Mile Creek, Four Mile Creek, Odessa Creek, and Crystal Creek (Stine 1982), the Lost River system, Tule Lake, Lower Klamath Lake, and Sheepy Lake (Moyle 1976). Andreasen (1975) included Clear Lake as the upstream limit of the sucker in the Lost River system.

The documented native distribution of the shortnose sucker is Upper Klamath Lake and its tributaries (Miller and Smith 1981; Williams *et al.* 1985), although Moyle (1976) includes Lake of the Woods, Oregon. Andreasen (1975) referred to the Lake of the Woods suckers as another species, *Chasmistes stomias*. Moyle now agrees with Andreasen and considers the Lake of the Woods population of shortnose suckers to have been another species with an unclear taxonomic status (Moyle pers. comm.). The sucker population or species in this lake was extirpated during "fish control" operations in 1952 (Andreasen 1975). It is likely that shortnose suckers also are native to the Lost River system (Scoppettone pers. comm.) and were documented in the Clear Lake watershed in 1955 (Coots 1965). Williams *et al.* (1985) hypothesized that the fish gained access to the Lost River, and subsequently the other areas, by way of irrigation canals associated with the Bureau of Reclamation's Klamath Project. However, their presence in Clear Lake is evidence that they may be native to the Lost River system. Clear Lake Dam was constructed in 1910 and created an impassible barrier for fish migrating upstream in the Lost River. Construction of the Lost River Diversion Channel that connects the Klamath and Lost River systems did not begin until 1911. The Klamath River and Lost River were connected via a natural slough under high water conditions that may have allowed access under natural conditions prior to construction of irrigation canals.

D. Current Distribution

Lost River suckers

The present distribution of Lost River suckers includes Upper Klamath Lake and its tributaries (Buettner and Scoppettone 1990), Clear Lake Reservoir and its tributaries (Buettner and Scoppettone 1991), Tule Lake and the Lost River up to Anderson-Rose Dam (Scoppettone pers. comm.), and the Klamath River downstream to Copco Reservoir (Beak 1987). A few individual Lost River suckers were observed spawning in the Lost River below the Anderson Rose Dam in 1991, presumably migrating from Tule Lake, where 20 adults and one juvenile were captured in 1992 (Scoppettone pers. comm.). Large suckers that could be Lost River suckers were reported in

Iron Gate Reservoir in 1992 (Maria pers. comm.). In the Upper Klamath Lake watershed, spawning runs are primarily limited to the Sprague and Williamson Rivers. However, larval Lost River suckers were collected in the Wood River and Crooked Creek in 1991 (Markle pers. comm.), which indicates a spawning run still occurs in these streams. Suckers have been reported from Sheepy Lake in 1988 and may represent a resident population but positive species identifications were not made (Johnson pers. comm.).

Shortnose suckers

The present distribution of the shortnose sucker includes Upper Klamath Lake and its tributaries, Klamath River downstream to Iron Gate Reservoir, Clear Lake Reservoir and its tributaries, Gerber Reservoir and its tributaries, the Lost River, and Tule Lake. The Gerber Reservoir population is considered to have been introduced, although the timing of the introduction is not known (Buettner pers. comm.). Shortnose suckers have also been collected in the Upper Klamath River from Link River Dam to Copco Reservoir in recent years (USBR 1992, Maria pers. comm.). A shortnose sucker was collected at the head of Iron Gate Reservoir in 1973 by California Department of Fish and Game biologists. The distribution of shortnose sucker is very similar to that of the Lost River sucker except the shortnose sucker appears to be more widely distributed in the Lost River system.

E. Current Status of Sucker Populations

Upper Klamath Lake

The declining condition of Klamath Basin sucker species has been recognized since the mid-1960's (Andreasen 1975) but it was not until the mid-1980's that the severity of the situation was realized. Surveys in Upper Klamath Lake of sucker spawners in 1984 and 1985 (Bienz and Ziller 1987) produced total population estimates of only 2,650 shortnose in 1984, 8,698 and 6,990 Klamath largescale in 1984 and 1985, respectively, and 23,123 and 11,860 Lost River suckers in 1984 and 1985, respectively. The snag fishery harvest for Upper Klamath Lake spawners declined from approximately 10,000 lake suckers in 1968 (Golden 1969), to only 687 lake suckers in 1985. A fish kill during the summer of 1986 further reduced populations of suckers and apparently eliminated many larger adults (Buettner and Scoppettone 1990). Lost River and shortnose suckers were subsequently listed as endangered under the Endangered Species Act in 1988. Significant losses to the gene pool of the Lost River sucker already may have occurred with the disappearance of entire stocks (e.g. Harriman Springs, Barkley Springs, Lower Klamath Lake, Indian Tom Lake, Lake of the Woods) and drastic reductions in other populations (Upper Klamath Lake, Tule Lake) (Bond pers. comm., Scoppettone pers. comm.).

In Upper Klamath Lake, recruitment of the Lost River and shortnose suckers to adult size classes is poor, and production of the most recent strong year classes in adult populations, probably occurred in 1977 and 1978 (Scoppettone pers. comm.). The presence of younger males (males usually mature before females) of both species in the 1992 spawning run in the Sprague River may indicate that new year classes from the early 1980's will be recruiting in larger numbers over the next few years (Dunsmoor per. comm.). Sexual maturity for Lost River suckers sampled in Upper Klamath Lake occurs between the ages of 6 to 14 years, with most maturing at age 9 (Buettner and Scoppettone 1990). This means that new year classes of Lost River suckers are not present in the spawning populations for about nine years. Shortnose sucker sexual maturity occurs at a slightly younger age (5 to 8 years), which means at least a 5 year wait for evidence of recruitment (Buettner and Scoppettone 1990). A juvenile year class was produced from spawning activity in 1991 and suckers from that year class were still present in significant numbers in the 1992 fall canal salvage (Markle pers. comm.), but because it is not known if most mortalities in any one year class occur in the larval, juvenile, or young adult stages, it is impossible to know if this year class will survive to maturity. Sampling for juveniles in Upper Klamath Lake and canal salvage information indicate that 1992 was probably a poor year for young-of-the-year sucker survival and almost no recruitment from the 1992 year class is expected (Buettner per. comm.).

A distinct population of Lost River suckers spawns at Sucker Springs on the shores of Upper Klamath Lake from mid-March through mid-April but may begin as early as the first of February (Andreasen 1975, Buettner and Scoppettone 1990, Klamath Tribe 1991). The Klamath Tribe (1991) states that although a large portion of the spring area was covered by rip rap, a population of Lost River suckers has persisted in spawning there. The railroad was built around 1920, and yet the sucker population has persisted until recruitment failures began about 20-25 years ago. The Klamath Tribe (1993) states, "In over 5 years of tagging fish at Sucker Springs (hundreds), and more than 10 years of tagging fish in the Williamson and Sprague Rivers (thousands), we have yet to recapture any Lost River sucker tagged in the river at Sucker Springs and vice versa". This fact, as well as the temporal differences in spawning is certainly sufficient evidence to conclude that these are distinct stocks (Klamath Tribe 1993). Even if full genetic data sets fail to show genetic differences between two groups of fish with dramatically different life histories, the proper management perspective would be to treat the groups as distinct stocks. The Sucker Springs population appears to be comprised of large, older adults, which suggests a lack of recruitment over the last 20 years (Buettner pers. comm.). Population estimates from 1987 to 1989 range from 817 to 1038 adult fish, with the vast majority of spawners exceeding 650 mm fork length (Klamath Tribe 1993). The Sucker Springs population does not reflect recruitment from the 1977 and 1978 year classes observed in the river spawning populations (Dunsmoor pers. comm., Scoppettone pers. comm.).

Shortnose suckers were first observed spawning at Ouxy Springs in April 1992. Lost River suckers also spawn at Ouxy Springs (Klamath Tribe 1993). A population of Lost River suckers spawned at Barkley Spring until 1960, when access was blocked as a result of the development of Hagelstein Park. Harriman Springs is another historical spawning site that is no longer utilized by suckers but for less obvious reasons. Other springs in Upper Klamath Lake also likely provided spawning habitat for distinct populations of endangered suckers.

Clear Lake

Clear Lake supports a large population of shortnose suckers with consistent recruitment and a diverse age structure (Buettner and Scoppettone 1991). The status of Lost River suckers in Clear Lake is more uncertain because far fewer fish of this species have been collected in the lake and it's tributaries. The population is suspected to be larger than sampling may indicate and the age structure of the fish collected is fairly diverse (Scoppettone pers. comm.). However, recent drought conditions have greatly reduced the habitat available for all fish in the Clear Lake watershed and the long-term effects on the sucker populations is unknown. A larger percentage of the Lost River suckers captured in Clear Lake recently have exhibited signs of stress (Buettner pers. comm.). Populations in small reservoirs above Clear Lake may no longer exist due to total or near desiccation during the summer of 1992. Recruitment from 1991 and 1992 year-classes is unlikely due to drought conditions (Scoppettone per. comm.).

Gerber Reservoir

Little is known about the endangered sucker population inhabiting Gerber Reservoir. In May 1992, over 200 shortnose suckers, but no Lost River suckers, were salvaged from Gerber Reservoir. They ranged in size from 78 to 461 mm fork length (FL). The presence of smaller suckers indicates that the population of shortnose suckers in Gerber reservoir has successfully recruited in recent years (Buettner pers. comm.). Juvenile suckers (less than 100 mm FL) were observed in Barnes Valley Creek in 1992, indicating successful reproduction in the creek in 1991 (Buettner pers. comm.). Gerber reservoir has been drawn down to critically low levels for irrigation releases in the last two years. Gerber reservoir reached a minimum elevation of 4796.37 feet (182 surface acres, 835 acre-feet) in October 1992, which is less than 1% of the reservoirs capacity. The reservoir did maintain a population of suckers but aeration was necessary to improve water quality during the summer of 1992. The shortnose suckers sampled in April, 1992 showed signs of stress such as low body weight, poor gonadal development, and reduced growth rates of juveniles, which were probably related to low reservoir levels (Buettner pers. comm.). A survey conducted during late October and early November of 1992, indicated further degradation in condition factors of the shortnose suckers sampled (Buettner pers. comm.).

Lost River

Koch and Contreras (1973) reported 3 areas from which they captured suckers in their survey of the Lost River, including Harpold Reservoir, the Lost River below River Bridge on the east side of the city of Bonanza, and the Lost River 1 mile downstream from Wilson Dam. At least 3 shortnose suckers have been recorded in Malone Reservoir in earlier surveys and 350 shortnose and 4 Lost River suckers were salvaged from Clear Lake and released into Malone Reservoir during May and June of 1992 (Buettner pers. comm.). Surveys conducted on April 10, 1992 observed approximately 100 shortnose suckers spawning at Big Springs above Harpold Reservoir (Buettner pers. comm.). About 30 days later, several hundred larval suckers were observed in the springs. Thirty-five adult (380 to 490 mm FL) and one juvenile (272 mm FL) shortnose suckers were collected in the Lost River above Harpold Reservoir in 1992. The length-frequency of the suckers sampled does not indicate good recruitment and according to locals, spawning at Big Springs is rare (Buettner pers. comm.). No Lost River suckers were observed in Harpold Reservoir during the 1992 survey.

Tule Lake

Populations of Lost River suckers and shortnose suckers in Tule Lake and Lower Klamath Lake were believed to be extirpated after 1924, when Tule Lake and Lower Klamath Lake were drained for farming (Moyle 1976). However, Lost River and shortnose suckers were observed spawning downstream of Anderson-Rose Dam in May 1991. These fishes may have migrated upstream from Tule Lake, where both species have since been found. In 1992, 18 shortnose and 21 Lost River suckers were captured in Tule Lake. These fish were all tagged and there were no recaptures, which indicates more suckers in the populations but does not allow any estimates of population abundances (Scoppettone pers. comm.). Ongoing research should yield more information on population sizes and composition.

Klamath River Reservoirs

Lost River and shortnose suckers were captured in Copco Reservoir during the 1950's and early 1960's (Coots 1965). By the 1970's very few Lost River suckers were captured and in 1987 Beak

Consultants, Inc. captured only one Lost River sucker. Shortnose suckers are still present as an aged population. All shortnose suckers collected in 1987 were older adults (16-33 years old), indicating that neither successful reproduction nor recruitment from upstream sources has occurred since the early 1970's (Buettner and Scoppettone 1991). Radio-tagged shortnose suckers from Copco Reservoir were followed approximately 2 miles up the Klamath River on apparent spawning migrations and larval suckers were documented migrating back to the reservoir (Beak 1987), but survival to adulthood appears to be limited. Lost River and shortnose suckers have been reported from other reservoirs in the Klamath River system between Upper Klamath Lake and Iron Gate Reservoir but little is known about the suckers in this stretch of river. A shortnose sucker was collected at the head of Iron Gate Reservoir in 1973 by California Department of Fish and Game biologists. Other reports are mostly from observations at fish ladders at J.C. Boyle, Keno and Link River Dams since 1988 (USBR 1992). Several juvenile and adult shortnose and Lost River suckers were captured in J.C. Boyle Reservoir near the Klamath River inflow in August 1988 (Buettner pers. comm.).

F. Life History and Habitat

Lost River and shortnose suckers are large, long-lived and omnivorous suckers that generally spawn in rivers or streams and then return to the lake (Buettner and Scoppettone 1990). However, both species have separate populations that spawn near springs in Upper Klamath Lake (Klamath Tribe 1993).

This is a brief summary of life history information and more detailed information is given in several of the references cited in this recovery plan. Relatively little information is currently available on habitat requirements for all life stages. Most of the available data is indicative of habitat utilization, and not necessarily habitat preference. Little is known about the life history traits of the Lost River and shortnose suckers during the winter months.

AGE AND GROWTH

Lost River suckers

Scoppettone (1988) aged Lost River suckers from Upper Klamath Lake up to 43 years old. Lost River suckers are one of the largest sucker species and may obtain a length of up to 1 meter in total length (Moyle 1976). Sexual maturity for suckers sampled in Upper Klamath Lake occurs between the ages of 6 to 14 years, with most maturing at age 9, with most growth in Upper Klamath Lake occurring mainly during the first 8 to 10 years of life (Buettner and Scoppettone 1990).

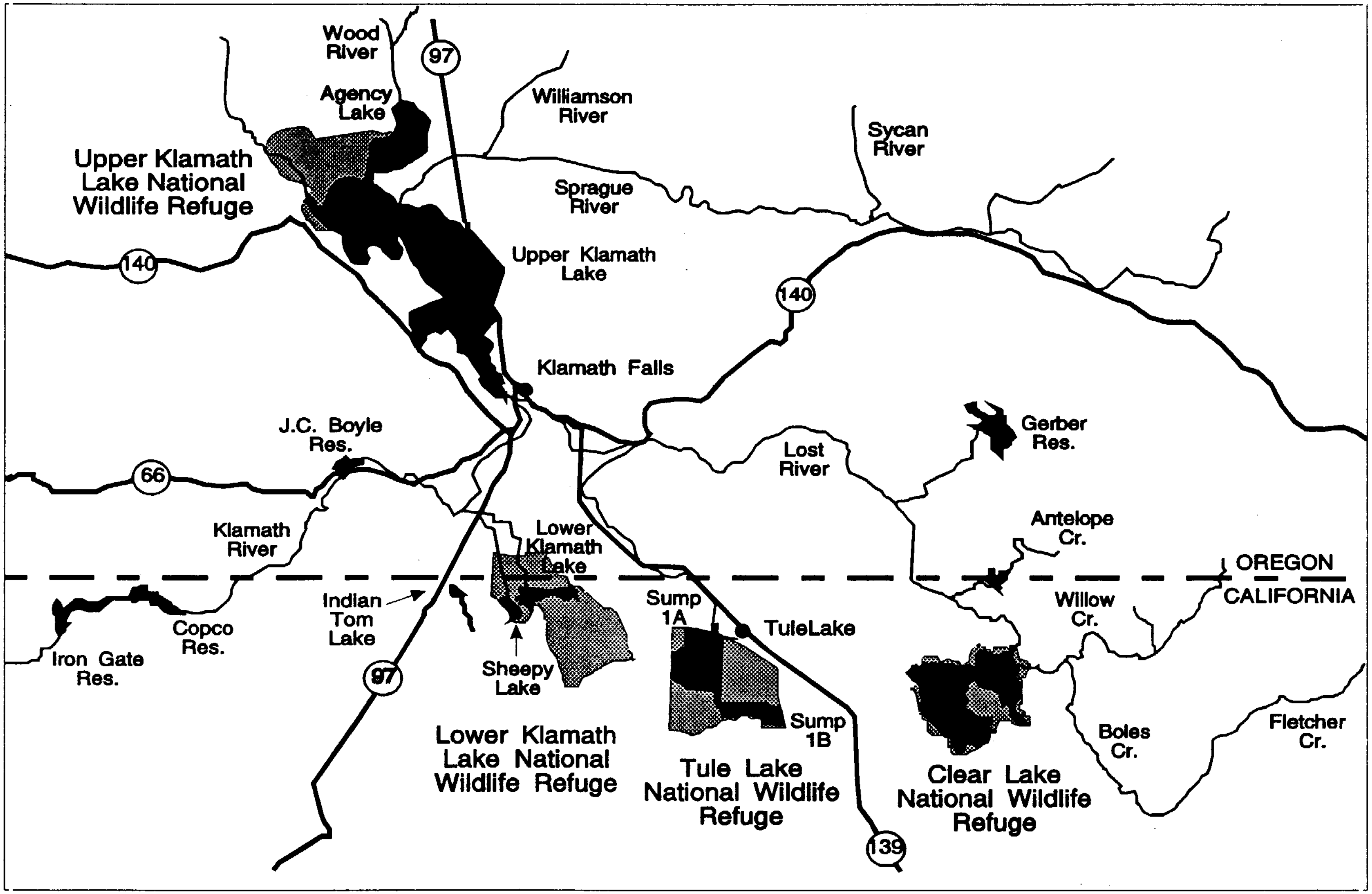

Figure 1. Map of Upper Klamath Basin.

Shortnose suckers

Scoppettone (1988) found shortnose suckers up to 33 years of age from Copco Reservoir. Sexual maturity for shortnose suckers appears to occur between the ages of 5 and 8 with most maturing at the age of 6 or 7 (Buettner and Scoppettone 1990). Buettner and Scoppettone (1990) found that for female shortnose suckers sampled from Upper Klamath Lake, most growth occurred in the first 6 to 8 years of life.

SPAWNING HABITAT

Both species of suckers are lake dwelling but spawn in tributary streams or springs. For stream spawning populations, shortnose and Lost River suckers begin their spawning migration into the Williamson and Sprague Rivers in late March or early April, with spawning activity often continuing well into May (Andreasen 1975, Buettner and Scoppettone 1990). For spawning in the Williamson and Sprague Rivers, water depths ranged from 11 to 70 cm and mean water column velocity ranged from 18 to 125 cm/s for Lost River and shortnose suckers (Buettner and Scoppettone 1990). Water temperatures in the Williamson and Sprague Rivers have ranged from 5.5 to 19° C during the spawning period (Golden 1969, Andreasen 1975, Buettner and Scoppettone 1990). In the Clear Lake watershed, the suckers begin spawning activity in February or early March, depending on peak flow in Willow and Boles Creeks (Scoppettone pers. comm.). Spawning at Sucker Springs can occur from February to mid April in water depths ranging from 18 to 61 cm (Buettner and Scoppettone 1990). Water temperature at the spring is a constant 15° C during the spawning period. Shortnose sucker spawning activity was observed at Ouxy Spring in Upper Klamath Lake on April 30, 1992 (Dunsmoor pers. comm.). Lost River and shortnose suckers spawn near the bottom and when gravel is available, eggs are dispersed within the top several centimeters. When spawning occurs over cobble and armored substrate, eggs fall between crevices or are swept downstream (Buettner and Scoppettone 1990). At Sucker Springs, most spawning occurred over a plot of gravel that was introduced during the 1987 spawning season. Large numbers of Lost River suckers were observed using the gravel area in 1987 and 1988 (Buettner pers. comm.), and some spawning activity was recorded in February of 1992 (Dunsmoor pers. comm). Spawning was rarely observed over the predominant cobble and boulder substrate, suggesting a gravel preference (Buettner and Scoppettone 1990), but more recent observations indicate the preference was more flow related (Klamath Tribe 1993, Scoppettone pers. comm.). More detailed spawning information for both sucker species is provided by Buettner and Scoppettone (1990) and (USBR 1992).

LARVAL AND JUVENILE HABITAT

Larval Lost River and shortnose suckers usually spend relatively little time in tributary streams and migrate back to the lake shortly after swim up. Larval sucker migration from the spawning sites on the Sprague and Williamson Rivers can begin in May or June. Bienz and Ziller (1987) reported that larval sucker emigration surveys were initiated in May of both 1983 and 1984 but no suckers were sampled until mid June of both years. Buettner and Scoppettone (1990) found that in 1987 and 1988 over 90 percent of larval Lost River sucker emigrated back to Upper Klamath Lake between 5 May and 15 June. They found that the majority of larval shortnose sucker emigrated within a six-week period after 1 May in 1978 and after 7 May in 1988. It appears that most larval emigration for both species occurs between the hours of 8:00 P.M. and 07:00 A.M. (Coleman and McGie 1988, Buettner and Scoppettone 1990). During the day, the larvae typically move to shallow shoreline areas in the river (Dunsmoor pers. comm.). Ninety percent of larvae were found in water depths less than 50 cm, were surface oriented and over sand, mud and concrete; they were absent from soft organic mud and silt bottom (Buettner and Scoppettone 1990).

The channelization of the lower Williamson and Wood Rivers may have negatively affected sucker survival by reducing larval rearing and refuge habitat (Dunsmoor, pers. comm.). Higher densities of larval suckers seem to occur in "pockets of open water surrounded by emergent vegetation" (Klamath Tribe 1991). Coleman and McGie (1988) found sucker larvae during the spring of 1987 in slack, near-shore water at depths less than 30 cm and in close proximity to rooted aquatic vegetation. In the lower Williamson River, the substrate consisted primarily of sand and mud. After emigrating from the parental spawning sites in late spring, larval and juvenile Lost River and shortnose suckers inhabited near shore waters, primarily under 50 cm (19.7 inches) in depth, throughout the summer months (Buettner and Scoppettone 1990). Larval and juvenile suckers were found by Buettner and Scoppettone (1990) to occur in greatest frequency at 10 to 60 cm depth. Along the lower margins of the Williamson, Buettner found that 35 percent of the larvae were found at sites with emergent vegetation. Coleman and McGie (1988) reported that larvae were found in close proximity to rooted aquatic vegetation, and that they avoided areas devoid of vegetation. Juvenile suckers were found along gentle slopes and were bottom oriented over sand and mud, both in areas devoid of cover and next to macrophytes (Buettner and Scoppettone 1990). Although dissolved oxygen in Upper Klamath Lake ranged from 1.3 to 20.0 mg/l in sampling during the summer of 1988, juvenile suckers were only found where concentrations were 4.5 to 12.9 mg/l (Buettner and Scoppettone 1990). Few sites with pH values of 9.0 or higher had juvenile suckers (Buettner and Scoppettone 1990). In surveys conducted by

Oregon State University between July 18 and October 17, 1991, juvenile suckers were found distributed in near shore areas throughout the lake in beach seine and cast net surveys during the summer. Trawling collected suckers in more open water habitat in October (Markle 1992). Although importance of vegetative cover is unknown and sampling in these areas is difficult and limited, larval and juvenile suckers are known to use these areas. Studies to determine habitat preference and survival rates for larval and juvenile suckers are being conducted by Reclamation. The Klamath Tribe (1993) provides the following information. There is little question that nursery habitat in the lower river is dramatically altered from its historic condition, and that it presently provides poor quality nursery habitat for larval suckers. In fact, this is one of the main reasons behind the water level recommendations made for nursery habitat in Klamath Tribe (1991). The entire delta was once a marsh dominated by emergent vegetation, through which the river meandered. This was a structure-rich environment, and the scientific literature is replete with examples of the value of diverse structure to early life history stages of fish. Given the strong shoreline orientation displayed by sucker larvae, they undoubtedly used the marsh edges as nursery habitat. Indeed, it appears that marsh edges were virtually ubiquitous in the river delta area. Gently sloping, sandy, unvegetated shorelines are common today along the dikes that line the lake and lower river. This type of habitat was probably non-existent historically, and it is unreasonable to assume that such habitats would provide nursery habitats of the same quality as a marsh edge (Klamath Tribe 1993).

ADULT HABITAT

Adult Lost River and shortnose suckers usually spend relatively little time in tributary streams and migrate back to the lake after spawning. Adult Lost River suckers, radio-tagged in the Williamson River and at Sucker Springs in the spring of 1987, gravitated to the northern end of Upper Klamath Lake during the spring and summer. Presumably, this area preference is water-quality related and close proximity to inflow areas may provide refuge when conditions become stressful. Dissolved oxygen levels were at least 6 mg/l where radio-tagged fish were located (Buettner and Scoppettone 1990). Only areas of the lake near inflows from streams or springs maintain relatively low densities of algae and consistently provide the water quality needed to support the suckers through stressful periods (Kann pers. comm.). Refugial areas of relatively good water quality are important for fish in Upper Klamath Lake during the summer and early fall when dissolved oxygen and pH levels can be stressful or lethal in much of the lake (Coleman *et al.* 1988). Bond *et al.* (1968) reported trout, yellow perch and brown bullheads showed seasonal movements apparently related to heavy algal blooms with attendant fluctuations of dissolved oxygen, pH, and suspended and dissolved materials. These fishes were usually found in the north end of the lake during the summer, or in other areas affected by incoming water. Live-boxed trout failed to survive the combination of high pH, moderate temperature and fluctuating dissolved oxygen at the south end of the Lake (Bond *et al.* 1968). Hazel (1969) notes that the onset of warm water, *Aphanizomenon* blooms, and high pH seemingly brings about a redistribution of fish from the entire lake to the northern portion of the lake only, particularly along the north and west shore marshes. Hazel (1969) concludes by stating "Because game fish are in abundance in vicinity of marshes during the summer when water quality conditions in the lake are marginal, there is a good chance that these marshes are necessary for the continued well-being of these fishes. Lost River and shortnose suckers were captured near Pelican Bay, the Wood River, and the Williamson River during summer months of 1986 when water quality was limiting in most of Upper Klamath Lake (Bienz and Ziller 1987). Golden (1969) reported large runs of suckers in the Sprague River during August of 1966 and 1967, which may have been caused by poor water quality in the lake.

G. Reasons for Decline and Current Threats

The final rule listing the Lost River and shortnose suckers as endangered species cited the following reasons for their decline: the damming of rivers, instream flow diversions, hybridization, competition and predation by exotic species, insularization of habitat, dredging and draining of marshes, and water quality problems associated with timber harvest, removal of riparian vegetation, livestock grazing, and agricultural practices (Federal Register 53:27130-27134). A shift toward hypereutrophication in Upper Klamath Lake has been documented (Miller and Tash 1967, Vincent 1968) and is considered by the Service to be a probable cause for the decline of Lost River and shortnose suckers and a major limiting factor in recovery of the species. Tule Lake, lower portions of the Lost River, Lake Ewauna, and the Klamath River above Keno Dam also have severe water quality problems associated with hypereutrophication. Overharvest and chemical contaminants may also have contributed to the decline. Reduction and degradation of lake and stream habitats in the upper Klamath Basin is considered by the Service as the most important factor in the decline of both species.

Dams

The construction in 1914-1918 of the Sprague River Dam, near Chiloquin, Oregon, may have reduced access to approximately 95% of the potential spawning range of Lost River and shortnose suckers in the Sprague River drainage. Records from the Oregon Department of Fish and Wildlife document the passage of Lost River and shortnose suckers from the mid-1960's to 1986. Since 1981, tribal biologists have found both Lost River and shortnose suckers moving through the ladder, and during the snag fishery the ladder was a favorite snagging area for many tribal members catching Lost River suckers. Limited radio telemetry work further documented use of the ladder by endangered suckers. Radio transmitters were placed on three shortnose suckers and one largescale sucker captured at the Williamson River mouth in October, 1983. All four fish ascended to river mile 6.5 on the Williamson River in January, 1984, and then moved upstream and ascended the ladder at the Chiloquin Dam (Klamath Tribe 1993). In recent years few endangered suckers have been captured in the ladder. Few of either sucker species have been observed passing the fish ladder at Chiloquin Dam (Bienz and Ziller 1987, Buettner and Scoppettone 1990). However, little effort has been expended to monitor fish movement through the ladder, so lack of monitoring may be a reason for the perception that the dam blocks passage of suckers. Potential spawning habitat exists in 50 km of the Sprague River, of which 48 km is upstream from the Chiloquin Dam (Buettner and Scoppettone 1990). However, the habitat upstream of the dam has been severely degraded. Lack of adequate instream flow and virtual removal of the riparian ecosystem along most of the 70+ river miles upstream of the dam have changed this river to a sediment-laden, hypertrophic system (Klamath Tribe 1993). As a result of the low gradient of much of the Sprague River above the dam, fast-water, rocky habitats used for spawning would occur infrequently. In addition, largemouth bass and yellow perch are very abundant, have completely replaced the native species in some reaches above the dam, and may reduce larval survival through predation (Klamath Tribe 1993). The dam may prevent segregation in location and timing of spawning runs of three sucker species. Although the amount of current spawning habitat available may not be limiting the sucker populations, the concentrations of spawning suckers in relatively small areas of suitable habitat may increase the likelihood of hybridization between species (Scoppettone per. comm.). However, since 1990 the Tribe has snorkeled extensively during each spawning season, and have found shortnose and Lost River suckers spawning in more locations in the Sprague River downstream from the dam and at several locations in the Williamson River below the confluence. To say spawning is concentrated completely ignores the ≈6.5 km of Williamson River below the confluence that provides spawning habitat for the suckers (Klamath Tribe 1993). Finally, the dam reduces downstream recruitment of suitable spawning gravel and the effect of the free-fall drop over the dam on 13 mm sucker larva attempting to emigrate to the lake is unknown.

Other diversion dams in many of the spawning streams may restrict access to potential spawning areas or impair downstream migration of adults and larval suckers. The Anderson-Rose Dam on the Lost River may limit spawning access for suckers migrating from Tule Lake (Buettner and Scoppettone 1991). Dams also fragment populations and restrict genetic mixing within populations.

Although spawning habitat has certainly been reduced and degraded, available evidence does not provide strong support for the hypothesis that spawning habitat availability is limiting recruitment. Field work by Oregon State University and results of Bureau of Reclamation canal salvage operations have shown the successful formation of a year class from the 1991 spawn. In 1989, approximately 70 million sucker larvae emigrated downstream past river mile 6 of the Williamson River, and approximately 5 million sucker larvae emigrated into Upper Klamath Lake (Klamath Tribe 1993). Juvenile fish captured in subsequent field work appeared to belong to the 1989 year class (based on length); but accurate aging was not possible because fish were released (Klamath Tribe 1993). While year classes of juveniles have been found in recent years, there is no certainty that sufficient numbers of juveniles were produced to provide adequate recruitment to spawning populations 5 to 9 years later.

Diversions

Diversion of water can reduce flows in streams and lower lake elevations. The EPA Clean Lakes study (Klamath Consulting 1983) states "It became apparent during the course of this project that water level in Upper Klamath Lake was a critical factor in relation to several of the problems". They compared the summer of 1981 (one of "reduced lake surface elevation to minimal levels due to drawdown") to the summer of 1982 (one where lake levels were "near maximum"), and state "although algal mats were still present in the lake in massive amounts [in 1982], they did not become the aesthetic nuisance they did the previous summer [1981] ... and water quality, as measured by several parameters did improve" (e.g. pH, chlorophyll and total phosphorus). Klamath Consulting Service (1982) goes on to state that "the increased level of total phosphorus could be the result of increased sediment resuspension caused by wind action over the shallower water in the lake in 1981". A comparison of July and August values for total phosphorus show that 1981 values averaged 138 ug/L higher than for this same period in 1982 (Klamath Consulting 1983). While other factors can influence these annual differences (e.g. climatic differences), the effect of lake level cannot be ruled out.

Diversions of water out of streams and lakes also can entrain suckers, which can be killed by pumps or trapped in the irrigation canals. Any suckers in the water delivery systems, including canals, drains, fields, headgates, and turnouts potentially could be killed or harmed due to low water quality, chemical vegetation control, entrainment in pumps, increased predation, and desiccation (USFWS 1992). Entrainment of larval suckers has been documented at the A Canal headworks (Markle 1992). In 1991, entrainment estimates peaked twice, once in early June (at 43,887 suckers per day) and once in early July (at 21,773 suckers per day). All but one of the suckers collected during the June peak were identified as Lost River suckers (Markle per. comm.). The suckers collected during the July peak were shortnose and Klamath largescale suckers and preliminary identifications indicate that most of these fish are shortnose suckers (Markle per. comm.). The cumulative estimate for the period between May 13 and July 15 was 759,150 larval suckers entrained. The cumulative estimate was extrapolated from a total catch of 51 larval suckers and 35 of the 51 suckers have been identified as Lost River suckers (Markle 1992). The 3,236 suckers of undetermined species salvaged out of the Project canals in October-December of 1991 provides further evidence of entrainment. Entrainment of suckers also occurs at the PacifiCorp hydroelectric diversion near the Link River Dam. Suckers have been observed in the Eastside Diversion Canal when it was shut down for maintenance (Fortune pers. comm.).

Hybridization and Genetics

A recent analysis of the population genetics of the Lost River sucker and shortnose suckers (Moyle and Berg 1991) suggested that "if populations continue to decline, these species may cross below the minimum viable population threshold and be lost." Low numbers and hybridization could threaten the genetic diversity and purity of the suckers. Intraspecific morphological variation among segregated populations has been thought to be a result of hybridization (e.g., Clear Lake shortnose suckers are morphologically and meristically different from Copco Lake or Upper Klamath Lake shortnose suckers). However, recent preliminary protein electrophoresis research suggests that significant hybridization has not occurred and that the wide range of overlapping morphological characters exhibited by Klamath Basin suckers may reflect differences in phenotypic expression as a response to differing physical environments, or the age of the individual (Moyle and Berg 1991). Two genetic studies have been done to date on Klamath Basin suckers, and while neither has been broad enough in scope to answer all questions, their data did not support the hypothesis that shortnose were introgressed with other sucker species. Moyle and Berg (1991) stated "...we are confident in asserting that the three shortnose sucker populations [Upper Klamath Lake, Copco Reservoir, and Clear Lake] tested in this study are 'pure'". Harris (1991) found no conclusive evidence of hybridization between sucker species, although his analyses were hampered by small sample sizes. More research is being conducted to help resolve hybridization and other genetic questions.

Introduced Fish

Introductions of non-native fishes have contributed to declines in populations of other sucker species in the Colorado River system and could be a factor in the upper Klamath Basin suckers decline. Species such as brown bullhead, fathead minnow, Sacramento perch, yellow perch, pumpkinseed, and green sunfish, bluegill, largemouth bass, and brown trout have become established and abundant in parts of the upper Klamath Basin. Predation or competition with small suckers by fathead minnows, yellow perch, and other introduced species is a possible cause for limited recruitment of suckers in Upper Klamath Lake and Copco Reservoir. However, relatively stable populations of suckers co-exist with abundant non-native species in parts of the Lost River system and native species such as tui chub, blue chub and rainbow trout are also very effective predators and potential competitors. Many of the introduced species have been in the upper Klamath Basin since the 1930's (Fortune pers. comm.) and declining sucker populations were not noticed until the 1960's. Golden (1969) noted a decrease in the number of 'mullet' taken per angler from 1966 to 68. Also, Andreasen (1975) expressed deep concern for the status of these species before exotics like fathead minnows were established in the system. Influences of exotics need to be carefully assessed, but other factors are clearly involved (Klamath Tribe 1993).

Overharvest

A decline in the average size of suckers harvested in the snag fishery from 1966 to 1974 indicates that the fishery may have impacted the population. A fish kill in 1971 also may have contributed to the decline in average size. Exploitation estimates (percent of the population harvested by snagging) in 1984 and 1985 indicated less than a 6 percent angler exploitation rate for Lost River Suckers, which were the most exploited species due to their larger size (Bienz and Ziller 1987).

Chemical Contaminants

Chemical contaminants may have a role in the decline of the suckers. Large amounts of chemicals are applied in the watershed on an annual basis for agricultural uses, control of mosquitoes and other pests, forestry and forest fire control, and other uses. Many of these chemicals are sprayed from airplanes over wide areas and find their way into waterways directly or from surface and sub-surface flow. The reconnaissance investigation of water quality in the Klamath Basin by USGS, et al. in 1991 found that organochlorine pesticides are still detectable in bottom sediments at many locations due to past pesticide applications. Pesticides and other chemicals can have an acute toxicity that causes direct mortality of organisms, which has happened in the Klamath basin on several occasions. Chronic effects of pesticides include reducing the survival of organisms as well as widespread disruption of food chains that can affect aquatic habitats throughout the basin. USGS, et al. in 1991 also observed that there were very low numbers of benthic organisms in many locations, including Tule Lake, and an overall reduction in numbers of aquatic reptiles and amphibians, all of which may be due to the effects of pesticides. Potential for a major catastrophic spill exists with roads and railways crossing and running parallel with waterways in many areas of the upper Klamath Basin.

Habitat Reduction

Over 350,000 acres of natural wetlands probably existed in the Klamath Basin prior to 1900 (Adkins 1970). Since the Klamath Reclamation Project was passed in 1905, well over 100,000 acres of wetlands have been destroyed and reservoirs have inundated some of the former wetlands (USFWS 1989). Additionally, thousands of acres of wet meadows and shallow marsh have been and are continuing to be degraded or lost as a result of ditching, tiling and diking, and intensive livestock grazing (USFWS 1989). Estimates of direct loss range from 75 to 90 percent (USFWS 1989). Approximately 35,000 acres of marshland around Upper Klamath and Agency Lakes have been lost this century. Between 1940 and 1955 approximately 12 miles of wetland shoreline habitat were lost between Modoc Point and the Narrows linking Upper Klamath and Agency Lakes, in addition to more than 3 miles in the lower Williamson River (Klamath Tribe 1993). Since 1955, approximately 3 miles of wetland shoreline habitat was lost on the west side of Agency Lake (Klamath Tribe 1993). Tule Lake was reduced from a historical 96,000 surface acres of open lake and marsh to only 13,000 acres of water available to the suckers. Lower Klamath Lake was eliminated as sucker habitat after 1924 when it was drained for farming (Moyle 1976), with the possible exception of the area referred to as Sheepy Lake. In addition to losses of lake habitats, an unknown number of miles of sucker spawning habitat in streams has been eliminated due to construction of dams with poor or no provisions for fish passage.

Degradation and Water Quality

Upper Klamath Lake was historically eutrophic (highly productive) but has become hypereutrophic (Goldman and Horne 1983). It has been hypothesized that the hypereutrophic condition of the lake is a result of 20th century marsh drainage and agricultural practices within its watershed (Miller and Tash 1967, Vincent 1968). Phinney *et al.* (1959) state that "except for *Microcystis*, the bloom algae (*Aphanizomenon*) do not flourish where humate content is high". They state that the reason for this effect is an inhibition of blue-green algae by the low pH water caused by high concentrations of humates (Phinney *et al.* 1959). They note that this same water can have a stimulatory effect at lower pH's, but that this serves as an explanation for the low productivity of the humic waters at the north end of the lake. Such waters may have been crucial for providing adequate rearing areas for larval and juvenile suckers entering the lake through the tributaries and dispersing out along the shoreline (Klamath Tribe 1993).

The following description of wetlands benefits is extracted from an EPA publication on wetlands (EPA 1988). In their natural condition, wetlands provide many benefits, including water quality improvement, flood protection, shoreline erosion control, natural products for human use, food, habitat and spawning grounds for fish, and opportunities for recreation and aesthetic appreciation. One of the most important values of wetlands is their ability to help maintain and improve the water quality of our nation's rivers, estuaries, and other water bodies. Wetlands do this by removing and retaining nutrients, processing chemical and organic wastes, and reducing sediment from flood waters. Wetlands function like natural tubs, storing either flood waters that overflow riverbanks or surface water that collects in isolated depressions. When wetlands absorb flood waters, they reduce damage downstream. Trees and other wetland vegetation help slow the speed of flood waters. This action, combined with water storage, lowers flood heights and reduces the water's erosive potential. The stored water is then slowly released downstream as the flood peaks recede (EPA 1988). This EPA reference and the following statement, "Wetlands restoration at appropriate locations will likely be a desirable measure toward upper Klamath River Basin ecosystem restoration," are also in the Klamath Basin Water Users Protective Association's Initial Ecosystem Restoration Plan for the Upper Klamath River Basin.

Historical data suggests that man's increasing activity in the basin is causing longer, more intense periods of low water quality (Coleman *et al.* 1988). The hypereutrophic condition of Upper Klamath Lake impacts Tule Lake, lower portions of the Lost River, the Link River, Lake Ewauna, and the Klamath River downstream. Tule Lake is hypereutrophic and water quality is marginal for suckers during the summer months. In June and July of 1992, the pH in most of Tule Lake was frequently above 9.5 (Reclamation unpublished data). Most of the inflow during these months is irrigation return water that has been reused up to 6 times and is of poor quality for fish with high pH and low dissolved oxygen levels (USGS 1991). In 1970, Upper Klamath Lake's algal blooms were noted to be "seriously detrimental to the quality of water in Link and Klamath Rivers" (OSWRB 1971). In 1986, the majority of nutrients (79% of the nitrogen and 68% of the phosphorus) found in the Klamath River at Seiad Valley were determined to come from sources upstream of Iron Gate (CDWR 1986).

Other evidence indicates that while the Upper Klamath Lake has been historically eutrophic, man-caused changes have served to increase the level of nutrient export to the lake over background levels. Miller and Tash (1967) and USACE (1982) reported that, despite accounting for only 12.4% of the inflow, direct agricultural input from pumps and canals accounted for 31% of the phosphorus entering the lake. This figure includes only direct agricultural input, so the overall increase over background (historic) levels is likely substantially higher when considering non-point agricultural sources (Klamath Tribe 1993). This is especially true considering the large scale changes which have occurred throughout the watershed over the past 50 years. Such changes include grazing of more than 100,000 head of cattle upstream from the lake and conversion of riparian corridors and wetlands to cattle pasture and cropping areas (Klamath Tribe 1993). These practices have led to severe degradation of the Sprague and Wood River riparian areas and have therefore greatly increased the nutrient and sediment export potential (Karr and Schlosser 1978; Schlosser and Karr 1981; Lowrance et al. 1984; Peterjohn and Correll 1984; Gregory et al. 1991).

Disturbing marshlands aerates the soil, increases its pH, increases phosphate release from peat, and increases aerobic decomposition of nitrogen. Even in eutrophic systems increased availability of nutrients will cause further changes in productivity and associated water quality parameters; this is what has happened in Upper Klamath Lake (Klamath Tribe 1993). It is important to note that because hypertrophic systems are disturbed and unstable (Barica 1980), they have the potential to deteriorate further.

Upper Klamath Lake nutrient inputs and cycling have been altered, and it has been hypothesized that, as a result, the algal community has shifted to more of a monoculture of the bluegreen algae *Aphanizomenon flos-aquae* which is more efficient than green algae at utilizing low concentrations of carbon dioxide. The massive blooms of algae that occur during the summer and autumn months are known to cause extremely high pH, wide fluctuations of dissolved oxygen and carbon dioxide levels, a green appearance and foul odors as the algae decay, and possibly an algal toxicity problem. When the algae crashes, the pH declines, but dissolved oxygen levels usually fall to very low levels (Kann per. comm.). At least minor fish kills due to water quality problems have occurred in parts of the basin since at least the 1960's. The most recent Upper Klamath Lake fish kill in 1986 is thought to have been caused by water quality problems associated with the algae, such as dissolved oxygen depletion due to high water temperatures, and extensive algal decay. Water quality in Upper

Klamath Lake during these summer and fall months can quickly degrade to pH values in excess of 10.0 and dissolved oxygen concentrations near 0 mg/l (Scoppettone 1986, Bienz and Ziller 1987, Kann pers. comm.). Dissolved oxygen depletion can occur on a regular diel basis through respiration, not only when blooms crash and decomposition occurs and conditions leading to dissolved oxygen depletion are not always localized, but can occur over large areas of the lake (Klamath Tribe 1993). Another point to consider is that too much dissolved oxygen may also be harmful to fish (e.g. Stewart *et al.* 1967), so the frequent occurrence of supersaturated dissolved oxygen conditions from high rates of productivity may be harmful. High ammonia levels are also a problem at times in most of the upper Klamath Basin and the more toxic unionized form is more prevalent at high pH levels (Kann pers. comm., Schwarzbach per. comm.). During the summer and early fall months, pH levels have been above 9.5 in most of Upper Klamath Lake on several occasions in recent years (Kann per. comm.) and in June of 1992, pH levels as high as 10.5 were measured in the water leaving the lake through the A-Canal (Schwarzbach pers. comm.). Falter and Cech (1991) found the maximum pH tolerance (permanent loss of equilibrium) found for juvenile shortnose suckers to be 9.55 and Castleberry and Cech (1990) found the minimum critical dissolved oxygen concentration (permanent loss of equilibrium) to be 0.7 mg/l. Preliminary toxicity research by the Service in 1992, observed mortalities of juvenile Lost River and shortnose suckers beginning at a pH of about 10 during a 96 hour test. The same preliminary research found mortalities in dissolved oxygen tests began at 3 to 4 mg/l, and mortalities began to occur at 0.2 ppm in unionized ammonia nitrogen tests. The Service's tolerance results were from single variable tests that were not repeated and do not necessarily reflect actual tolerances in natural conditions where fish face combinations of stressful conditions, nor do they reflect long-term or sublethal conditions. Tule Lake, lower portions of the Lost River, Lake Ewauna, and the Klamath River above Keno Dam have similar water quality problems. In situ, survival of fathead minnow fry was very low with no more than 2 of 20 surviving during any of 4 separate tests at the same site in the Lost River just above Tule Lake during June of 1992 (Schwarzbach per. comm). Water quality conditions in the upper Klamath River are described as poor, high water temperature, low dissolved oxygen, high turbidity, high pH, and high levels of algae, bacteria, and suspended sediment (ODEQ 1988).

Upper Klamath Lake is now classified as hypertrophic (Goldman and Horne 1983) because of its mono-specific *Aphanizomenon* blooms of long duration and extremely high biomass, and the coincident extreme fluctuations in pH, CO_2, and dissolved oxygen. Given that lakes are not static systems (even under totally natural circumstances) it logically follows that Upper Klamath Lake has undergone trophic changes over the last 100 years. Bond et al.

(1968) states "since 1913 there has been a change in the dominant species of plankton", and goes on to state that this thesis is supportable in that "the concentration of *Aphanizomenon* has increased greatly over the last 50 years, and it is also supported by conversations with older residents who recall conditions in the lake previous to about 1917". Hazel (1969) states that production was historically at a high level, but that "in the past several years complaints about odor, unsightly concentrations of algae, dead fish and birds, unpalatable fish and drinking water, etc., have increased in frequency, especially during the summer". Such changes in phytoplankton diversity and quantity are typical of lakes undergoing a change from eutrophic to hypertrophic conditions (diatom/green algae dominance to mixed blue-green algae assemblages to mono-cultures of blue-green algae [Goldman and Horne 1983; Wetzel 1985]).

Nutrient Loading

Many tributaries to Upper Klamath Lake are known to have serious nonpoint source pollution problems, including high turbidity, low dissolved oxygen, excessive nutrients, pesticides, sediment, and excessive plant growths (ODEQ 1988). Studies by Sanville *et al.* (1974) showed concentrations of nitrogen and phosphorus in the interstitial water of Howard Bay sediment were several times higher than those near Buck Island and the lake outlet. These high concentrations of nitrogen and phosphorus in the interstitial water of Howard Bay was believed to be the result of agricultural drainage from nearby ranches. A sediment core taken near the outlet of the lake indicated an accelerated rate of sedimentation in more recent years, possibly related to changes in the watershed and productivity of the lake (Sanville *et al.* 1974). Miller and Tash (1967) stated "the quantity of nitrogen and phosphorus in only the upper inch of lake sediments is as great as that quantity which would flow into the lake during the next 60 years if the present rate of inflow continues." However, the availability of sediment nutrients is unknown. Wildung and Schmidt (1973) concluded that generally 12 percent of total sediment phosphorus was subject to release, not including interstitial phosphorus.

Available nutrients may not be unlimited in Upper Klamath Lake. Dissolved inorganic nitrogen usually was depleted below the detection level when algal production was high, suggesting that nitrogen could be a limiting nutrient for algal production (USACE 1982). Even though background phosphorus concentrations are relatively high and are likely to support high algal growth, evidence exists to support the fact that phosphorus does become limiting in the system. For example, annual depletions of soluble reactive phosphorus occur during periods of intense algal growth over the growing season, and generally coincide with bloom crashes (Klamath Tribe 1993). Maloney *et al.* (1972) and Miller *et al.* (1974) showed stimulation of algal growth after addition of phosphorus to water from Upper Klamath Lake collected in October and July. The July sample showed stimulation of algal growth with phosphorus addition despite total phosphorus being 330 ug/L, and ortho phosphorus being 50 ug/l (Miller et al. 1974). It is very likely that increased input of nutrients may substantially increase the intensity and duration of algae growth (Klamath Tribe 1993). Water quality data gathered during the summer of 1992 provided potential evidence that reductions in external nutrient loading can alter abundance and composition of the algal community in Upper Klamath Lake. Due to severe drought conditions, Upper Klamath Lake received record low inflows which likely reduced external nutrient loading. An algae bloom of *Aphanizomenon flos-aquae* developed earlier than usual and created water quality problems in May and June, but then crashed and did not re-develop on a lake-wide basis. The algae bloom normally would crash about a month later, then quickly recover and maintain a dense bloom until colder weather in October or November caused a decline (Kann pers. comm.). Other types of algae did increase after the *Aphanizomenon flos-aquae* crash, but did not cause the water quality problems that are normal for Upper Klamath Lake in the late summer and early fall (Kann pers. comm.). If nutrients from sediments were available and unlimited, the *Aphanizomenon flos-aquae* bloom should have recovered. What was limiting the algae is unknown, but it is likely that the availability of essential nutrients was inadequate. If nutrient loading and algal populations can be controlled, water quality should be improved greatly in Upper Klamath Lake and the Klamath River system. Algal blooms are still likely to occur given high background concentrations of nutrients, and a total change in trophic state is unlikely; however, more subtle changes in duration and intensity of blooms, and in such water quality parameters as pH and dissolved oxygen are entirely possible. Data shows that reduced algal biomass decreases the probability of attaining elevated pH in Upper Klamath Lake, even when the reduced biomass still falls within the hypertrophic range (Kann and Smith 1993).

Below Upper Klamath Lake, other sources of nutrients and contaminants contribute to the problem. Another result of consumptive water use in the lower Lost River and upper Klamath River is an increased concentration of salts in surface water (NCRWQCB 1989). During the 1960s, coliform levels were extremely high immediately downstream of Lake Ewauna, which reflected waste discharges from sewage treatment facilities and industries at that time (OSWRB 1971). Sewage effluent from the Klamath Falls area was noted as a water quality problem in the 1960's and early 1970's (Fortune *et al.* 1966, OSWRB 1971). Nutrients and contaminants from an increasing number of housing developments near the Williamson and Sprague Rivers or other areas above Upper Klamath Lake could also be contributing to water quality problems. In the Klamath River at the Highway 97 bridge, coliform counts (bacteria levels indicative of human or animal wastes) were 20 times above acceptable limits for public health and recreational purposes. However, the outflow from Upper Klamath Lake in the Link River about 5.5 miles upstream was well below the standard (OSWRB 1971). Improvements in waste treatment and better regulation of waste discharge as a result of the 1972 Clean Water Act now have reduced coliform levels to acceptable levels. Still, problem levels of pesticides and metals have been detected in the lake (USGS 1991).

Discharges of poor quality water from agricultural operations in the Klamath Project via the Klamath Straits are noted by the Oregon and California state water quality agencies as a problem (NCRWQCB 1989; ODEQ 1988). Dissolved oxygen levels as low as 0.0 mg/l, temperatures up to 31.27 °C, and pH levels as high as 10.08 were measured in the Klamath Straits Drain in 1992 with at least 96 hour periods when the pH did not go below 9.4 (Schwarzbach pers. comm.). Total ammonia levels as high as 0.94 mg/l have been measured in the Klamath Straits Drain and survival of fathead minnow fry was 0/20 in 2 of 4 days of testing at 2 different sites in the drain during June of 1992 (Schwarzbach per. comm.).

Grazing

Overgrazing in the riparian areas of streams, especially in the Sprague River system, has left no stream structure for fish habitat and has exposed the stream to solar radiation (USFS 1989). Grazing practices have led to severe degradation of the riparian areas and have therefore greatly increased the nutrient and sediment export potential (Karr and Schlosser 1978; Schlosser and Karr 1981; Lowrance et al. 1984; Peterjohn and Correll 1984; Gregory *et al*. 1991). On Fishhole Creek, for example, a century of season-long use by cattle has destroyed the stabilizing streambank vegetation, resulting in erosion and lowered water tables (Todd 1989). Similar conditions exist in the Wood River Valley. The resulting conditions have left marginal habitat in the Sprague River for spawning populations of trout and suckers, increased stream temperatures for miles downstream, and contributed sediment and nutrients to the stream system. As a result, the Sprague River was identified by the Oregon Dept. of Environmental Quality as one of the highest priority streams in the state for control of nonpoint source pollution (ODEQ 1989). In addition to the Sprague River system, grazing problems have been noted for the Williamson River, Sevenmile Creek, Spencer Creek and Shovel Creek (ODEQ 1989, USBLM 1990b and 1990c). The Water Users Plan suggests that significant opportunities exist to improve riparian habitat in the Clear Lake/Lost River/Gerber Reservoir drainage, as well as on tributaries of Upper Klamath Lake and Agency Lake. Efforts to improve riparian habitat should also be expanded to watersheds of tributary streams that have been degraded in the Klamath River system below Upper Klamath Lake, such as efforts already initiated on Spencer Creek and Shovel Creek (Maria pers. comm.).

Forestry

Forestry practices also contributed to water quality problems in the basin. In 1970, the Oregon State Water Resources Board noted that "serious erosion and sedimentation problems have been caused by logging and road building practices that have not provided for soil stabilization" in the upper Klamath Basin. By eliminating vegetative cover from much of the volcanic ash and pumice type soils, these sites became highly susceptible to erosion. The soils carry salts and nutrients, especially phosphorous, to surface waters, where they dissolve and "accelerate the eutrophication process in streams and lakes." Sedimentation of fish habitat also was noted as an impact (OSWRB 1971). Log storage on the Klamath River below Klamath Falls was greatly reduced after fish kills in the late 1960s, but sections of the river above US 97 are still used for log storage today.
In the late 1980s, many changes began to occur in forest practices on both private and public land in Oregon. The 1987 amendment to the Oregon Forest Practices Act led to an apparent improvement over the previous practices, especially regarding riparian protection.

Water Quality Summary

The overall picture appears to be one of an unbalanced ecosystem which has become dominated by an algal monoculture only within the past 75 years. In 1913, the Upper Klamath Lake was found to be eutrophic but was characterized by mixed blue-green and diatom communities (Kemmerer *et al.* 1923). By the 1930's, *A. flos-aquae* was present and abundant but not yet dominant (Phinney *et al.* 1959). Since at least the 1950's, however, this one species has dominated the massive algal blooms. Bond *et al.* (1968) reported mean *A. flos-aquae* counts from Phinney and Peak (1961) to be nearly 10,000 times those of the maximum count reported by Bonnell and Mote (1942). Its die-offs and high production are the cause of the drastic fluctuations in dissolved oxygen and pH observed throughout the lake (Kann 1989; Coleman *et al.* 1988) and similar problems exist downstream. The water quality problems have limited the availability and quality of habitat for suckers and other fish and caused major fish kills in the basin. It is the Service's opinion that water quality must be improved to provide stable habitat for the recovery of the suckers and other fish and wildlife in the upper Klamath Basin.

Other Factors

Additionally, a multi-year drought throughout the basin has reduced the quantity and quality of sucker habitats, although in most cases water diversions have contributed to this reduction. For example, Clear Lake was recently described as supporting the largest and healthiest population of shortnose suckers. In 1992, only the western lobe of the lake held water and spawning runs were not observed in 1991 or 1992 (Scoppettone pers. comm.). Suckers in Gerber Reservoir were also in a greatly reduced body of water in 1991 and 1992 and were exhibiting signs of stress (Buettner pers. comm.).

H. Conservation Efforts

Recovery Efforts to Improve Habitat and Water Quality

Potential eutrophication control measures have been investigated using numerous lake restoration or management techniques (USACE 1982). Short term or smaller scale techniques, such as chemical treatment of algae, would not be effective or economical for the upper Klamath Basin. Improvements in land management, including changes in agricultural practices, riparian and wetland restoration, improved forestry practices, range management, and erosion control are all proven methods of improving water quality in a watershed. However, the principal debate focuses on whether the lake's quality can be improved in any cost-effective way from the current hypereutrophic condition to a condition where the duration and intensity of the underlying *Aphanizomenon* blooms can be reduced (Kann 1989; Bortleson and Fretwell 1990). The lake may still be hypereutrophic but decreased duration and intensity of blooms will have beneficial effects for water quality and fish species.

Independent actions, such as fencing and planting vegetation along portions of tributary streams like the Wood and Sprague Rivers, already have been initiated by local landowners and private organizations. Wetlands are being restored on private lands in the basin through the Service's Partners for Wildlife program. These lands are primarily managed as duck clubs and provide a source of income for owners and managers. Other sources of funding also are available for restoring wetlands and new sources should be investigated. The term "wetlands" includes seasonal wetlands, like wet meadows, as well as marshes. Improving watershed conditions and reducing nutrient loading by changing land management to wet meadows for hay production, or improving grazing practices to restore riparian areas and range conditions, are examples of recovery actions that would be relatively inexpensive to implement and provide a beneficial use for landowners. Efforts like this should be encouraged with assistance in planning and funding to make them economically feasible.

Many of the tasks for water quality improvements in this recovery plan are very similar to actions recommended in the Draft Upper Klamath River Basin Amendment to the Long-Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program, prepared for the Klamath River Basin Fisheries Task Force for restoration of salmonids. Much of the wetland restoration in this recovery plan is recommended in the North American Waterfowl Plan. Many similar recovery tasks also are recommended in the Klamath Basin Water Users Protective Association's Initial Ecosystem Restoration Plan for the Upper Klamath River Basin (Water Users Plan).

Agency Actions

Current conservation efforts for the Klamath suckers have focused on the need to re-establish a more naturally functioning Klamath ecosystem. Among the research efforts are projects designed and coordinated through a series of research coordination meetings, where researchers from all involved agencies present results and research plans to allow for coordination and to prevent duplication of effort. This will provide data to help quantify many of the complex interactions in the Klamath ecosystem. Specific projects include: Wetland Nutrient Processing studies (Reclamation, Denver Office), Hydrology of Shallow Groundwater for the Upper Klamath/Agency Lake Basin (USGS Portland, Tribe), External Nutrient Inflows to Upper Klamath lake (USGS Portland), Assessing Contaminant Load in Irrigation Drainwater (USGS, Reclamation, USFWS, Sacramento Field Office), Genetic Surveys of Sucker Populations (CDFG), and Modeling Nutrient Flux and Water Quality and Their Effects on Sucker Habitat (Tribe). All federal agency actions and other projects involving federal funding, require compliance with the National Environmental Policy Act and other appropriate legislation before implementation.

Oregon has a Statewide Water Quality Management Plan, as required by section 208 of the Federal Clean Water Act. A Memorandum of Understanding (MOU) between the Oregon Dept. of Environmental Quality (ODEQ) and the U.S. Forest Service includes recommended water quality protection by the Pacific Northwest Region, as identified in "General Water Quality Best Management Practices" (USFS 1988). For private lands, DEQ and the U.S. Environmental Protection Agency (EPA) annually certified the Oregon Forest Practices Act as Best Management Practices (BMPs) between 1978 and 1985. However, no significant water quality data is available to assess the effectiveness of the practices. The DEQ concluded that Forest Service practices meet or exceed State forest practice requirements (R. Wood, ODEQ, pers. comm.).

The Forest Service recently has conducted fish surveys on some of the potential sucker spawning tributaries on Forest Service lands and hired fisheries biologists in the Modoc, Fremont, and Winema National Forests. The Forest Service also is helping to fund sucker research efforts. The Fremont and Winema National Forests adopted their Land and Resource Management Plans, which address riparian protection and restoration, watershed management, and erosion prevention and control. The Modoc National Forest has a similar management plan. For example, the Winema National Forest has specific standards relating to prevention of temperature increases in Class I and II streams, limiting the increase in stream turbidities, and contribution of Class III and IV streams to downstream water quality. In addition, the timing of road building and timber harvest shall be scheduled to minimize long-term detrimental changes in watershed conditions as a principle means to avoid unacceptable cumulative impacts.

The Clear Lake watershed occurs primarily within the boundaries of the Fremont and Modoc National Forests. The Gerber Reservoir watershed is located primarily on lands administered by the U.S. Bureau of Land Management (BLM) and the Fremont National Forest. The Forest Service and BLM have initiated fencing projects on some Gerber Reservoir tributaries to restore the riparian areas. The Modoc National Forest has initiated fencing projects on some tributaries in these watersheds to restore riparian habitat.

BLM is in the process of developing its Resource Management Plan but is already acknowledging habitat protection for the upper Klamath River canyon. Current BLM management direction to mitigate timber harvesting impacts on water quality include: no or restricted timber harvest within the riparian zone of streams (restrictions vary with stream class); special logging practices, where appropriate; and road construction to state-of-the-art standards. In addition, BLM has closed and rehabilitated unsurfaced roads and seeded, mulched, and fertilized road cutbanks, fill slopes, and landings (USBLM 1990b). For the Klamath River Canyon area, BLM's current management direction is to allow no new roads and to perform minimal forest management activities, with recreational, scenic, and wildlife values to be emphasized. (Pacific Power and Light's management of its forestland in the canyon is reportedly similar)(USBLM 1990a). BLM has designated the Gerber watershed as a state Riparian Demonstration Area and has implemented multiple use management strategies to restore, maintain, and improve riparian areas. BLM is also pursuing acquisition of the 3,000 acre Wood River Ranch with the objective of restoring marsh habitat on the property.

The Oregon Department of Fish and Wildlife (ODFW) closed the snag fishery in 1987. Section 6 funds provided under the Endangered Species Act to ODFW have funded research projects into the biology of the suckers since 1987. Research since 1991 has been conducted by Dr. Douglas Markle of Oregon State University, Corvallis. This research has focused on understanding important features of the juvenile ecology of the suckers, including estimating year class strength of juvenile suckers (Markle 1992). Markle's research also seeks to improve identification of species in their larval and juvenile life stages. Reclamation also began contracting Dr. Markle's group from OSU in 1990. The first project sought to quantify sucker entrainment into the "A" Canal of the Klamath Project.

The CDFG has funded several stream restoration projects on Shovel Creek. Banks were stabilized with riprap and planted with willows, and check dams were constructed. Riparian areas were fenced on Klamath National Forest lands and the lower mile of Shovel Creek, owned by PacifiCorp. The resident trout population in Shovel Creek has increased as much as ten fold in some reaches, however this increase may not be representative of the creek's entire population trend. The population is expected to increase dramatically in the upper Shovel Creek meadow area because of stream enhancement efforts (Maria pers. comm.).

The Service's, National Fisheries Research, Seattle Research Station, Reno Office (NFRSR) has conducted research on suckers in the upper Klamath Basin since 1986. At first in Upper Klamath Lake with funding from the Tribe and the ODFW, and more recently in the California portion of the basin with funding from the California Department of Fish and Game (Buettner pers. comm.). These projects have focused on the distribution, life history, habitat requirements, and status of the Lost River and shortnose suckers. The CDFG is contracting Dr. Don Buth of the University of California, Los Angeles, for genetic studies of Lost River, shortnose, and other suckers in the basin in 1993. Approximately 124 shortnose suckers salvaged from Clear Lake are being held by CDFG at a hatchery site to provide a source of suckers for reintroduction if needed.

The U.S. Fish and Wildlife Service plans to open a new inter-agency office in Klamath Falls, Oregon to coordinate ecosystem recovery efforts in the upper Klamath Basin. This office will coordinate research and recovery actions of all agencies in the upper Klamath Basin. Researchers will be encouraged to publish the results of research done in coordination with recovery efforts and make results more available to the public. This office also will work with other agencies to establish information and education programs to inform the public about endangered and threatened species and recovery efforts in the basin.

Beginning in 1991, Reclamation also conducted salvages of suckers from the canals of the Klamath Project at the end of the irrigation season. In 1991, Reclamation began studying various aspects of the suckers' biology and habitat needs, with a focus on refugial habitats, water quality needs and tolerances, status and distribution, drought related salvage and water quality monitoring. Salvaged suckers from the irrigation systems have been returned to more permanent waters, and a small number of suckers from Clear Lake were sent to the Service's Dexter National Fish Hatchery, in Dexter, New Mexico. As of December 1992, 25 shortnose suckers and 16 Lost River suckers were being held at the Dexter hatchery. Reclamation will be carrying out many more studies and habitat restoration projects under the terms of the Service's July 22, 1992, biological opinion for long term operations of the Klamath Project. Most of the sucker populations are within Reclamation's Klamath Project area and the Service's biological opinion suggests or requires some of the same actions recommended in this recovery plan. The long-term biological opinion also sets minimum lake levels and other restrictions on Klamath Project operations that are not addressed in this plan. This recovery plan incorporates information from, but does not supersede, the long-term biological opinion. The scope of this recovery plan goes beyond effects of the Klamath Project and addresses effects of resource management in the upper Klamath Basin as part of an ecosystem recovery effort. Implementation of this recovery plan also should benefit game fish in the watershed, trout and salmon downstream, amphibians, reptiles, waterfowl and other wildlife.

Other Actions

The Klamath Tribe (Tribe) began monitoring the Upper Klamath Lake populations of suckers in 1983, with the goal of establishing the species' status and generating biological information to support the listing. The Tribe then passed a resolution prohibiting the take of Upper Klamath Lake suckers. Spawning gravel was added to Sucker Springs in 1987, 1991, and 1992 to expand the usable spawning habitat in these areas. Gravel placements have all been cooperative efforts involving the Tribe, USFWS, Reclamation, and/or ODFW. Large numbers of Lost River suckers were observed using the improved area in 1987, and some spawning activity was recorded in February 1992 (Buettner pers. comm.). In 1988, the Tribe began work on the hatchery facility on the Sprague River. This facility was built with the intent of raising fish for research and developing culture techniques. The Tribe currently is pushing for the development of a genetic management plan, and the potential hatchery supplementation of certain reduced stocks such as the Sucker Spring stock (Dunsmoor pers. comm.).

The City of Klamath Falls contracted Beak Consultants Inc. to study sucker populations in Copco Reservoir and the Klamath River in 1987 to assess potential impacts of the proposed Salt Caves hydroelectric project. Sewage treatment was upgraded to improve water quality. The City of Klamath Falls currently treats its sewage at a facility providing secondary level of treatment using activated sludge and discharges its treated effluent into Lake Ewauna. Storm water drains are separate from sewage lines and do not contribute to sewage inflow to the plant. Although the treatment plant's current capacity is 6.0 million gallons per day (mgd), a facility study is being performed to evaluate changes in its operations and size (City of Klamath Falls Public Works Dept., verbal communication). Waste discharge standards could be increased for the City's plant as a result of a requirement of the federal Water Quality Act of 1987.

The South Suburban Sanitary District (SSSD) sewage treatment facility also discharges into Lake Ewauna. Sewage is treated in a series of four lagoons containing activated sludge, aerated, chlorinated, and then passed through a marsh before release into the lake. Effluent standards for this facility are 30 mg/l Biological Oxygen Demand (an indicator of nutrient loading) and 85 mg/l of suspended solids, and 200 coliform/l. Dissolved oxygen concentration ranges from 2.0 mg/l to 5.0 mg/l in the summer months, and rises above 10.0 mg/l in winter months. ODEQ is refining these standards as a part of its permit issuance process, and may require the SSSD to develop an additional wetlands marsh on an adjacent 120 acre parcel (R. Rivenes, SSSD, personal communication).

Independent actions such as fencing and planting vegetation along portions of tributary streams (e.g., Wood and Sprague Rivers) already have been initiated by local landowners and private organizations. Wetlands are being restored on private lands in the basin through the Service's Partners for Wildlife program. Efforts like this should be encouraged with more assistance in planning and funding.

Some successful pilot projects have been taken to restore fish habitat in the Upper Basin. Fish passage continues to be improved by increment, and riparian restoration is showing strong potential as a tool to reverse water quality problems in Upper Klamath Lake. The treated reach of the Williamson River (above the Williamson Marsh) was wide and shallow due to overgrazing and erosion. Trees were felled, pulled into the stream, and secured by anchoring with cabled rocks. Silt began to be deposited at the edge of the stream and eventually stream width was reduced by half. The narrower channel substantially increased in depth. Funding for this Cooperative Resource Management Plan (CRMP) effort on private and public land came partially from the Oregon Governor's Watershed Enhancement Board (GWEB) program. Riparian planting has also been done on several miles of the upper Williamson (Dunsmoor pers. comm.).

Another successful CRMP project benefitting from GWEB funds has been initiated on Spencer Creek, an important spawning tributary above J.C. Boyle Dam (USBLM 1990c). Before treatment with fencing and bank stabilization with woody material, Spencer Creek warmed up 0.5 C per mile on USFS lands. Recovery has been dramatic (Fraser pers. comm.).

Part of Fishhole Creek, a tributary of the Sprague, was rehabilitated economically by using temporary electric fences along with rock check weirs, flood control spills, and bank stabilization plantings. As permanent fencing was determined to be an unacceptably expensive way to control livestock, the temporary electric fences proved to offer excellent cattle control and became the key to better livestock management on an adjacent meadow. Less that $400 was spent on the fencing materials in comparison to $2,000 for conventional fencing. Revegetation was also seen to be the long term key to restoration of excessively drained meadows. Partial funding came from the Agricultural Conservation Program of the U.S. Agricultural Stabilization and Conservation Service (ASCS) while the design was developed with assistance from the Soil Conservation Service (SCS) (Todd 1989).

The Klamath Basin Water Users Protective Association (Association) has prepared an Initial Ecosystem Restoration Plan for the Upper Klamath River Basin. The plan provides a summary of information and outlines the Association's recommendations for recovery of the suckers and the ecosystem. A number of those recommendations are incorporated into this recovery plan. They also funded biologists and technicians to work with Reclamation in collecting data on the suckers' biology and habitat needs, including information on larval migration and surveys of springs in Upper Klamath Lake.

Information for reporting dead, injured, or sick endangered suckers:

Upon locating a dead, injured, or sick endangered or threatened species specimen, initial notification must be made to the nearest Service Law Enforcement Office. In Oregon, contact the U.S. Fish and Wildlife Service, Division of Law Enforcement, District 1, P.O. Box 1910, Klamath Falls, Oregon 97601 (503/883-6900). In California, contact the U.S. Fish and Wildlife Service, Division of Law Enforcement, District 1, 2800 Cottage Way, Room E-1924, Sacramento, California 95825 (916/978-4861. Care should be taken in handling sick or injured specimens to ensure effective treatment and care and in handling dead specimens to preserve biological material in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

The Service should be notified of the finding of any endangered or threatened species found dead or injured in the upper Klamath

Basin. Notification should include the date, time, and precise location of the injured animal or carcass, and any other pertinent information. In Oregon, the Service contact person for this information is Mr. Russell D. Peterson (503/231-6179 and in California, the contact person is Mr. Wayne White (916/978-4613. Any Lost River suckers or shortnose suckers found dead or injured in California shall be turned into the CDFG. The agency contact is Ms. Susan Ellis (916/355-7097).

II. RECOVERY

A. Objective

The primary objective of this recovery plan is to restore the Lost River and shortnose sucker populations to delisting status. Detailed downlisting or delisting criteria can not be proposed at this time. Criteria will be determined after research provides necessary information on present populations and their habitats.

The interim objective is to establish at least one stable refugial population with a minimum of 500 adult fish for each unique stock of both Lost River and shortnose suckers.

Downlisting and delisting: Criteria for downlisting and delisting will be determined after research provides necessary information on present populations and potential carrying capacities. Criteria currently being evaluated for downlisting/delisting include:

1. Safe refuge populations have been established for all unique stocks or populations of Lost River and shortnose suckers.

2. Long-term water rights agreements secured to ensure quantities of water needed to support stable populations of suckers.

3. Water quality goals to be met to support stable populations of suckers.

4. Minimum numbers of adult Lost River and shortnose suckers will be determined for all unique stocks or populations. The recovery criteria should be reasonable, attainable, and adequate to maintain genetic diversity in Lost River and shortnose sucker populations, and the species should have a reasonable probability of surviving for 200 years.

5. In addition to the minimum numbers, the age structure of the sucker populations must reflect consistent recruitment with no more than a 4 year gap in recruitment of strong year classes. This age structure would provide a diversity of year-classes, maintain juveniles and adults in the populations at all times, and is similar to age structures of stable populations of other long-lived suckers.

6. Estimated numbers of adult Lost River and shortnose suckers and year classes of juveniles and adults have been stable or increasing during the previous 15 years.

7. The amount of habitat that is needed to support stable populations with all life stages of Lost River or shortnose suckers will be determined and set. Stable habitat would have no proposed changes that would adversely affect the habitat's ability to sustain stable populations of the suckers. This would require rehabilitation of habitat, and achievement of water quality and quantity goals established through the recovery plan.

B. Narrative Outline for Recovery Actions

1. Conserve genetic diversity of populations of Klamath Basin suckers.

Management of Klamath Basin suckers has been hindered by the lack of a clear understanding of the genetic relationships among four endemic Klamath Basin suckers, the Lost River sucker, shortnose sucker, Klamath largescale sucker (*Catostomus snyderi*), and Klamath smallscale sucker (*Catostomus rimiculus*). Management objectives are further complicated by the fact that sympatric populations differentiate into discrete stocks that can not be distinguished by morphological or meristic techniques (e.g., stream and spring-spawning suckers in Upper Klamath Lake). Establishing refugial populations or hatchery supplementation of these suckers to the wild depends on the ability of managers to maintain genetic variability among planted stocks and recognize and maintain discrete stocks. For these reasons, a comprehensive genetic management plan is essential to the long-term survival and recovery of endangered suckers.

11. Establish refugial populations

Water quality and watershed improvements will require many years of restoration efforts. During that time the sucker populations will be threatened by the possibility of fish kills and stress due to poor water quality, continued lack of recruitment, and other potential risks. Refugial populations of Lost River and shortnose suckers should be established and monitored to ensure the survival of these species and maintain genetic diversity while their native habitat is recovering. At least one refugial population should be established for each unique stock of both sucker species. All refugial populations should maintain at least 500 to 1000 individuals that represent, to the maximum extent possible, the complete gene pool of the source populations. All tasks under this objective are considered by the Service to be Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

111. Characterize the genetic component of the four Klamath Basin sucker species.

Consult with geneticists with expertise in conservation biology to determine which genetic characterization technique (e.g., starch gel electrophoresis, DNA analysis, morphological and meristic techniques) will yield the greatest amount of required information while sacrificing the least number of endangered fish.

Collect fish from the field or obtain museum specimens, as needed and contract with geneticists and/or taxonomists to analyze specimens. This task is also in the Water Users Plan.

112. Prepare a comprehensive genetic management plan for refugial populations.

Based on the results of task # 111, prepare a comprehensive genetic management plan to enhance the ability of managers to maintain genetic variability among planted stocks and recognize and maintain discrete stocks. The plan should include strategies to establish refugial populations and maintain genetic variability in all sucker populations.

113. Implement the genetic management plan.

Implement plan developed in task # 112.

1131. Establish at least one refugial populations for each unique brood stock of Upper Klamath Lake suckers.

Refuge sites will be selected and populations of Lost River and shortnose suckers established at these sites. Refuge sites should have good water quality and be within the Klamath River watershed, if possible. Refugial populations should be monitored and established with brood stock that will maintain genetic diversity in the populations. Stocks that are the most critically endangered should have the highest priority. If appropriate, refugial populations could be designated as experimental populations.

11311. Assess potential refugial sites for Upper Klamath Lake suckers.

Assess the potential for establishing populations of suckers in refugial areas such as Lake of the Woods, Nuss Lake, Spring Lake, Devil Lake, Sheepy Lake, Indian Tom Lake, and other lakes. Refugial sites should have good water quality, adequate habitat, and be within the Upper Klamath Lake or Klamath River watershed. Sheepy Lake, Nuss Lake and Spring Lake may already have Lost River and shortnose suckers and should be investigated before introducing additional fish. Sheepy

Lake, and Indian Tom Lake efforts would be considered reintroductions because they once supported populations of suckers.

11312. Select sites for refugial populations of Upper Klamath Lake suckers.

Select sites for refugial populations of both Lost River and shortnose suckers in the Upper Klamath Lake or Klamath River watersheds. Sites should be able to support a minimum of 500 to 1000 adult suckers.

11313. Secure refugial sites for upper Klamath Lake suckers.

Through agreements with cooperative landowners, willing seller acquisition, or long-term leases, secure the refugial sites where possible. Cooperative or voluntary agreements and long-term leases would be the preferred alternatives.

11314. Develop a plan to introduce Lost River and shortnose suckers from Upper Klamath Lake.

Develop a plan to introduce suckers from unique stocks in Upper Klamath Lake into refugial sites selected above. Stocks should be kept separate if possible. Refugial populations should be established for each unique brood stock so as to maintain genetic diversity in the populations.

11315. Implement the plan to introduce Lost River and shortnose suckers from Upper Klamath Lake.

Implement the plan developed in task # 11314.

1132. Establish at least one refugial populations for each unique brood stock of Clear Lake suckers.

Continuing drought conditions and reservoir drawdowns for irrigation threaten to desiccate Clear Lake or lower it's water elevations to levels that may not support suckers. If adequate lake levels can be maintained, then establishing refugial populations for Clear Lake would become a much lower priority. Refuge sites will be selected and populations of Lost River and shortnose suckers established at these sites. At least one refugial population should be established for each unique stock of both sucker species. All refugial populations should maintain at least 500 to 1000 individuals that represent, to the maximum extent possible, the gene pool of the source populations. Refuge sites should be within the Lost River watershed if possible. Refugial populations should be monitored and established with brood stock that will maintain genetic diversity in the populations.

11321. Assess potential refugial sites for Clear Lake suckers.

Potential refugia should have good water quality, adequate habitat and water depth during drought periods, and be within the Clear Lake or Lost River watershed. Several small reservoirs in the Lost River watershed should be investigated.

11322. Select sites for refugial populations of Clear Lake suckers.

Select sites for refugial populations of both suckers in the Lost River basin. Sites should be able to support a minimum of 500 to 1000 adult suckers.

11323. Secure refugial sites.

Through agreements with cooperative landowners, willing seller acquisition, or long-term leases, secure the refugial sites where possible. Cooperative or voluntary agreements and long-term leases would be the preferred alternatives.

11324. Develop a plan to introduce Lost River and shortnose suckers from Clear Lake into refugial sites.

Develop a plan to introduce suckers from unique stocks in Clear Lake into refugial sites selected above. Stocks should be kept separate if possible. Refugial populations should be established with brood stock that will maintain genetic diversity in the populations.

11325. Implement the plan to introduce Lost River and shortnose suckers from Clear Lake.

Implement plan developed in task # 11324.

12. Evaluate captive propagation.

Assess the need for captive propagation and potential for improving sucker stocks through supplementation. A similar task is also in the Water Users Plan.

121. Assess the need for captive propagation.

Evaluate the status of sucker populations and assess the need for captive propagation using the best available information and expertise. The Service will consider hatchery propagation as a last resort.

122. Investigate refining propagation techniques.

The Klamath tribe has made considerable progress with propagating both endangered sucker species in their hatchery. Propagation techniques must be refined and a genetic management plan incorporated if it is decided that such a program is to be implemented. Ideas such as capturing wild spawned larvae and rearing them in protected rearing habitats should be investigated. Other ideas presented in the Water Users Plan on improving survival of young suckers should also be considered.

13. Monitor refugia populations.

Monitor refugial populations of both suckers to assess their status and alert managers of changes in these populations that may preclude the use of these sites as refugia.

131. Develop a monitoring plan for refugial sites.

Develop a plan to monitor habitat conditions (such as water quality and quantity), population abundance, recruitment, and health in refugial populations.

132. Implement the monitoring plan for refugial sites.

Implement plan developed in task # 131.

2. Examine and enhance populations of Lost River and shortnose suckers

Examine and enhance populations of Lost River and shortnose suckers in the upper Klamath Basin, which includes the historic range of both species. For the purposes of this recovery plan, the upper Klamath Basin includes the watersheds of the Klamath and Lost Rivers downstream to and including Iron Gate Reservoir. Iron Gate Reservoir is the known downstream range extension of shortnose and possibly Lost River suckers. All tasks under this objective are considered by the Service to be Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

21. Develop effective sampling methods for all life stages and use to monitor the relative abundance of year-classes through time.

Year-class strength is unknown for up to 9 years while the fish mature and this hampers biologists ability to determine what is limiting recruitment to adulthood or the success of recovery efforts. Sampling methods must be improved to allow more precise monitoring of sucker populations. This task is also in the Water Users Plan.

211. Develop effective sampling methods for all life stages of suckers.

Sampling methods have been developed but could be improved for adult and young-of-the-year suckers. Methods of sampling the age classes in between have not been developed. More precise monitoring of sucker populations are needed.

212. Investigate alternative methods for ageing suckers that would be non-lethal.

Currently used methods of ageing suckers requires removing otoliths or opercles to reliably age all but very young fish. Alternative methods such as sectioning fin rays should be investigated to develop a non-lethal means of obtaining age and growth information. Recent age and growth information has not been available for any significant numbers of suckers from most sucker populations in the upper Klamath Basin. Every opportunity to collect age and growth information from sucker mortalities or through non-lethal methods, should be taken to update our knowledge of the age structure and growth trends in all present and future sucker populations. Suckers collected during sampling efforts must be aged to accurately monitor year classes through time. A similar task also is recommended in the Water Users Plan.

213. Develop a plan to monitor relative abundance of all life stages for all sucker populations.

The relative abundance of larval, juvenile, and adult Lost River and shortnose suckers in all populations should be monitored to provide information on life history, population dynamics, and document results of habitat and population recovery actions. This information would be necessary for any future modeling efforts. Implement sampling methods developed in task # 211 to monitor relative abundance of sucker populations in the upper Klamath Basin.

214. Implement the plan to monitor relative abundance of all life stages for all sucker populations.

Implement plan developed in task # 213.

22. Investigate and reduce, where possible, potential threats to recruitment in sucker populations.

Increased competition and predation caused by introduced species, reduction and degradation of spawning and rearing habitat, poor water quality, and entrainment or other losses due to water diversions have been proposed as factors that could limit recruitment of suckers. These factors should be investigated for all sucker populations.

221. Investigate potential recruitment bottlenecks in Upper Klamath Lake.

This research would investigate possible reasons for recruitment problems in Upper Klamath Lake in recent years. Research needs to be oriented towards identifying ecological mechanisms that result in recruitment bottlenecks for these species. This research must take the form of specific, detailed investigation of life histories and requirements of suckers (particularly early life stages) and sympatric species. Furthermore, long-term monitoring of at least early life stages and spawning adults should be implemented as soon as possible, because patterns will not emerge until we have years of data relating larval production to subsequent recruitment (to at least the juvenile stage). Monitoring meshed with appropriate research is the only way to produce the type of information upon which intelligent management activities can be based.

222. Investigate the lack of recruitment at Copco Reservoir.

This research would investigate possible reasons for the lack of recruitment at Copco Reservoir over the last 22 years, such as predation, water quality, and reservoir fluctuations.

223. Determine which reservoirs in the Klamath and Lost River systems support viable, self-supporting populations of suckers.

Some reservoirs in the Lost River system appear to have self-supporting populations of shortnose suckers with good recruitment and length-frequency distributions. Other reservoirs support suckers, but may rely on upstream sources for recruitment. Waters impounded by Malone, Harpold, Wilson, Keno, and J.C. Boyle dams should be investigated. This research will determine which reservoirs have self-supporting populations and what may be preventing this in other reservoirs.

224. Determine the effects of introduced species on sucker populations.

Increased competition and predation caused by introduced species has been proposed as a factor in the decline of the suckers. Species such as brown bullhead, fathead minnow, Sacramento perch, yellow perch, pumpkinseed, and green sunfish, bluegill, largemouth bass, and brown trout have become established and abundant in parts of the upper Klamath Basin. This research will determine the effects of these introduced species on sucker populations in Upper Klamath Lake, Klamath River impoundments, and the Lost River system. A similar task is also recommended in the Water Users Plan.

225. Reduce losses of fish due to water diversions.

Diversions of water out of streams and lakes also can entrain suckers, which can be killed by pumps or trapped in the irrigation canals. Any suckers in the water delivery systems, including canals, drains, fields, headgates, and turnouts potentially could be killed or harmed due to low water quality, chemical vegetation control, entrainment in pumps, increased predation, and desiccation (USFWS 1992). Entrainment of larval suckers has been documented at Clear Lake and Gerber dams (Buettner pers. comm.) and the A Canal headworks (Markle 1992). Entrainment also occurs at the PacifiCorp hydroelectric diversion near the Link River Dam. Suckers have been observed in the Eastside Diversion Canal when it was shut down for maintenance (Fortune pers. comm.). Entrainment is likely at many other water diversion sites in the basin. Methods to reduce these losses should be investigated and implemented.

2251. Assess losses of fish due to water diversions.

Sample water diversions to determine the extent of losses during periods of time when adult, larval, and juvenile suckers would have the most potential to be diverted. Diversions such as the A Canal, PacifiCorp hydropower, Sprague River Dam, Tule Lake Pump D, and lower Williamson River water diversions should have the highest priority. Diversions of water for other uses such as algae harvesting should be include in the assessment.

2252. Develop a plan to reduce losses of fish due to water diversions.

If significant numbers of suckers are being lost to water diversions, investigate methods to reduce entrainment such as screening, changing timing of diversions, relocation of intakes, or other methods. Ideas from a similar task in the Water Users Plan should be investigated.

2253. Implement plan to reduce losses associated with water diversions.

Implement plan developed in task # 2252.

226. Compare survival of larval and juvenile suckers in different habitat types in the upper Klamath Basin.

Larval and juvenile suckers have been observed in a variety of habitat types. Investigate survival rates in different habitat types. Preliminary research by Klamath tribe biologists indicates that survival of larval suckers may be higher in some habitat types than others. Survival could be increased through habitat management with information from this research. A similar task is also recommended in the Water Users Plan.

23. Conduct research on sucker populations in the upper Klamath Basin.

Much information is needed on populations of Lost River and shortnose suckers over their range. Life history and habitat information is lacking for most populations.

231. Determine distribution and abundance of suckers in the upper Klamath Basin.

Distribution and abundance of Lost River and shortnose suckers is unknown or uncertain in much of the upper Klamath Basin. This research will determine the presence and status of sucker populations in the basin.

2311. Determine distribution and abundance of suckers in Upper Klamath Lake.

This research will update the distributions and status of sucker populations in Upper Klamath Lake. A similar task also is recommended in the Water Users Plan.

2312. Determine distribution and abundance of suckers in the river and reservoirs downstream of Upper Klamath Lake.

A population of shortnose suckers is known in Copco Reservoir but distribution and abundance of Lost River and shortnose suckers is unknown in the rest of the river system below Upper Klamath Lake. This research will determine the presence and status of sucker populations in the Klamath River system below Upper Klamath Lake. A similar task is also recommended in the Water Users Plan.

2313. Determine distribution and abundance of suckers in Clear Lake and upstream reservoirs after drought conditions.

Populations of Lost River and shortnose suckers were known to exist in some small reservoirs in the Willow Creek watershed prior to the present drought. Some of these reservoirs may have desiccated or reached very low water levels during the summer of 1992. A survey to determine if these upstream populations still survive will determine what, if any, reservoirs in the Willow Creek watershed can serve as refugia during drought conditions. Populations in Clear Lake have also gone through an extended period of low water conditions and need to be surveyed.

2314. Determine distribution and abundance of suckers in Gerber Reservoir and small reservoirs in Lost River system.

Populations of suckers may exist in many of the reservoirs on the Lost River. This research would determine the distribution and abundance of Lost River and shortnose suckers in Gerber Reservoir and the Lost River system.

2315. Determine distribution and abundance of populations of both sucker species in Tule Lake.

This research would determine the distribution and abundance of Lost River and shortnose suckers in Tule Lake. A similar task is also recommended in the Water Users Plan.

2316. Determine distribution and abundance of populations of both sucker species in other waterbodies in the upper Klamath Basin.

This research would determine the distribution and abundance of Lost River and shortnose suckers in potential habitats that have not been thoroughly surveyed for suckers. Sheepy, Nuss, and Spring Lakes are potential habitats that have not been adequately sampled for suckers.

232. Determine physiological tolerances of both sucker species to a combination of existing or potential water quality stresses.

By identifying the physiological tolerances of the suckers to potential combinations of water quality stresses such as high temperature, high pH, low dissolved oxygen, high ammonia levels, etc., existing habitat limitations can be more accurately determined and goals for water quality improvements can be set. A similar task also is in the Water Users Plan.

233. Determine habitat requirements of suckers in the upper Klamath Basin.

Previous studies in the basin have investigated distribution, life history, abundance, morphology, and habitat utilization of suckers. This research would determine and expand information on habitat utilization and preference.

2331. Determine habitat requirements of suckers in Upper Klamath Lake.

Previous studies have investigated distribution, abundance, and habitat utilization. This research would determine and expand knowledge of sucker habitat utilization and preference in Upper Klamath Lake and it's tributaries.

2332. Determine habitat requirements of suckers in the Lost River system.

Previous studies in the Lost River system have investigated distribution, abundance and morphology of suckers. This research would determine habitat utilization and preference for Clear Lake, Gerber Reservoir, Harpold Reservoir, Tule Lake, and tributaries of these lakes or reservoirs.

3. Rehabilitate watershed conditions to improve lake and river habitats.

Suspected watershed factors that may have contributed to the decline of the Lost River and shortnose sucker include the degradation and loss of wetlands and riparian habitat that helped maintain water quality and spawning habitat, and degraded water quality (hyper-eutrophication and increased sedimentation) in lakes and streams due to land management practices. Holistic resource management practices could improve overall watershed conditions. The survival and recovery of these species depends on the ability to rehabilitate watershed conditions to improve water quality and improve habitat throughout their current range. All tasks under this objective except tasks # 34 - 3432 are considered by the Service to be Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly. Tasks # 34 - 3432 are related to spawning habitat and are considered Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

31. Monitor habitat and water quality conditions for all populations of suckers.

The habitat and water quality conditions should be monitored and coordinated with changes in relative abundance of larval, juvenile, and adult Lost River and shortnose suckers in all populations to provide information on population dynamics and document results of habitat and population recovery actions. A similar task is also in the Water Users Plan.

311. Develop a plan to monitor habitat and water quality conditions for all populations.

The habitat conditions and water quality should be monitored to provide information on habitat dynamics and document results of habitat and population recovery actions.

312. Implement the plan to monitor habitat, water quality conditions for all sucker populations.

Implement plan developed in task # 311.

32. Improve water quality in the upper Klamath Basin.

Sedimentation, chemical contamination, erosion, high nutrient concentrations, and the resulting growth of algae and aquatic macrophytes are problems in many areas of the upper Klamath Basin. Independent actions such as fencing and planting vegetation along portions of tributary streams such as the Wood and Sprague Rivers have already been initiated by other agencies and local landowners. To rehabilitate stream spawning habitat and upper Klamath Basin water quality, more research, changes in land management, and riparian and wetlands restoration should be incorporated in holistic resource management practices to improve the watershed conditions.

321. Conduct an external nutrient loading study.

The U.S. Bureau of Reclamation has funded a 5-year study to be conducted in coordination with the U.S. Geological Survey and Klamath Tribe to determine the source and relative magnitudes of nitrogen and phosphorus loading in ground and surface water discharge from natural and disturbed lands (primarily agricultural and forestry disturbances). The study will also examine the role that reservoir water surface regulation has played in moving nutrients through Upper

Klamath Lake, and nutrient availability. A similar task is also in the Water Users Plan.

322. Conduct an internal nutrient loading study.

Design and conduct an internal nutrient loading study to examine the movement and availability of nitrogen and phosphorus within the lake and effects on water quality.

323. Develop a nutrient budget for Upper Klamath and Agency Lakes.

Develop a complete nutrient budget to identify the major sources and sinks of phosphorus and nitrogen loading in Upper Klamath and Agency Lakes. Use this information to assist in preparing the long-term marsh restoration plan.

324. Establish water quality goals

Using existing water quality data and new information from nutrient loading, wetland rehabilitation pilot projects, sucker tolerance research, and other sources; develop water quality goals for the recovery of Lost River and shortnose sucker populations and their habitat.

325. Rehabilitate riparian habitat.

Reestablishing stable riparian habitat along most tributaries in the upper Klamath Basin would reduce temperatures, erosion, sedimentation, and nutrient loading in the basin's lakes and streams. In addition to their role in sediment and nutrient abatement, the role of healthy riparian systems as water reservoirs should not be ignored. A healthy riparian system stores water and modifies the microclimate so that less is lost to evaporation. A riparian system reduces the impacts of floods on in-channel habitats and organisms, and provides habitat complexity that greatly benefits fish production. Additional hydrologic modification by riparian systems includes flood storage and base flow augmentation. A similar task is also in the Water Users Plan.

3251. Identify riparian land parcels for rehabilitation.

Identify areas of degraded riparian habitat in the upper Klamath Basin that have the most potential or greatest need for rehabilitation.

3252. Prioritize sites for riparian rehabilitation.

Prioritize sites identified in task # 3251 for riparian rehabilitation.

3253. Select riparian management areas.

Select areas for Riparian Management Units (RMUs) and riparian rehabilitation.

3254. Establish Riparian Management Units (RMU).

Establish RMUs for rehabilitating riparian habitat and delineate boundaries.

32541. Identify riparian landowners.

Identify landowners in high priority areas for rehabilitation of riparian habitat.

32542. Secure riparian habitat for rehabilitation.

Through cooperative landowners, willing seller acquisition, or long-term leases, secure the riparian corridors where possible. Cooperative or voluntary agreements and long-term leases would be the preferred alternatives.

32543. Develop riparian management unit rehabilitation plans.

Develop plans to improve riparian habitat in the upper Klamath Basin. Set measurable restoration goals and investigate all possible management tools for areas needing rehabilitation. Include workshops to inform potential cooperators of riparian benefits and potential funding sources.

32544. Implement riparian rehabilitation plans.

Implement plans developed in task # 32543.

326. Rehabilitate wetlands in the upper Klamath Basin.

Upper Klamath Basin wetlands have been reduced by 75 to 90 percent from over 350,000 acres prior to 1905 (USFWS 1989). Conversion of these wetlands to crop-lands and irrigated pasture is thought to have increased organic nutrient input to rivers and lakes, and decreased marshland area that once functioned to retain these nutrients. Excessive nutrient supply to these lakes is the primary agent responsible for their current hypereutrophic status. Thousands of acres of wetlands would be needed to significantly impact water quality in a watershed the size of the upper Klamath Basin. Every effort should be made to correct the sources of excess nutrient loading and not rely entirely on wetlands to act as treatment facilities for upstream problems. Reducing nutrient input, restoring water quality, increasing the water storage capacity of lakes, and creating habitat for all life-stages of endangered suckers, is critical to their long-term survival and recovery. The goal is to create wetland ecosystems that will reduce nutrient loading, increase habitat diversity, and improve water quality. Waterfowl and other species also would benefit. A similar task is also in the Water Users Plan.

3261. Identify land parcels for wetland rehabilitation.

Identify land parcels with potential for rehabilitation of wetlands. Target areas include the Williamson River delta, the west side of Agency Lake, the Wood River drainage, the Sprague River drainage, Tule Lake area, Lower Klamath Lake area, and several other scattered parcels.

3262. Conduct wetland rehabilitation pilot projects.

Conduct pilot projects to determine appropriate methods for wetlands rehabilitation and amounts needed to meet water quality and habitat goals in Upper Klamath Lake, Agency Lake, Tule Lake, Lower Klamath Lake and the Klamath River. Ideas from a similar task in the Water Users Plan should be investigated.

32621. Select sites for pilot wetland rehabilitation.

Select sites for pilot wetland rehabilitation and delineate boundaries. Selected sites should reflect potential and priorities assigned in previous tasks.

32622. Identify landowners of pilot wetland rehabilitation sites.

Identify landowners in areas selected for pilot wetland rehabilitation projects.

32623. Secure areas for pilot wetland rehabilitation projects.

Begin a program to secure available lands for wetland habitats. While the total amount of necessary wetland rehabilitation is not known, initial efforts to secure and enhance key wetland areas for pilot projects should proceed with the understanding that a large acreage of wetlands involved in pilot projects, will likely be needed to measure the wetlands ability to improve water quality and habitat conditions in the upper Klamath Basin. Through cooperative landowners, willing seller acquisition, long-term leases or conservation agreements, secure the areas for wetland rehabilitation. Cooperative or voluntary agreements and long-term leases would be the preferred alternatives. The acres secured should be used as sites for pilot wetland rehabilitation projects to determine additional acres needed for task # 3263.

32624. Develop plans for pilot wetland projects.

Several large projects in different parts of the watershed should be identified for this purpose. Benefits of increased habitat diversity and improved rearing habitat should also be considered. Large pilot projects will be necessary to assess the potential of different types of wetlands in large and diverse watersheds. Existing wetlands should be used, but additional pilot projects on different types of agricultural land should be developed to determine the feasibility of restoring agricultural land to wetlands. This will allow researchers to test alternative techniques for rehabilitation of parcels with different land management practices and nutrient loading potentials. Ideas from a similar task in the Water Users Plan should be investigated.

32625. Implement the plan for wetland rehabilitation pilot projects.

Conduct pilot projects to determine appropriate methods for wetlands rehabilitation and amounts needed to meet water quality and habitat goals in Upper Klamath Lake, Agency Lake, Tule Lake, Lower Klamath Lake and the Klamath River. Ideas from a similar task in the Water Users Plan should be investigated.

3263. Develop a long-term plan for wetland rehabilitation.

Develop a long-term plan to rehabilitate sufficient wetland habitat to improve water quality and provide better habitat for the endangered suckers. The long-term plan should be developed in coordination with the Service, U.S. Bureau of Reclamation, U.S. Soil Conservation Service, U.S. Forest Service, U.S. Geological Survey, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Department of Water Resources, California Department of Fish and Game, Klamath Basin Steering Committee, the Klamath Tribe, county governments, and other agencies with statutory responsibilities for protection of State and Federally listed endangered species or improving water quality. The plan should include water quality goals, acreage goals, an implementation time schedule, and a budgeting strategy that will assure adequate funding levels to secure, rehabilitate and protect wetland habitat. Thousands of acres of wetlands would be needed to significantly impact water quality in a watershed the size of the upper Klamath Basin. Incorporate information from the pilot projects to determine the types and amounts of wetlands to rehabilitate. Ideas from a similar task in the Water Users Plan should be investigated. Include workshops to inform potential cooperators of wetland restoration benefits and potential funding sources.

3264. Implement the long-term plan for wetland restoration.

Implement the long-term plan developed in the task above.

327. Reduce impacts of other upland management practices such as forestry, grazing, and farming to improve watershed conditions and water quality.

Other land management practices can increase the potential for nutrient loading and habitat degradation. Task # 321 will determine effects of different types of land management for external nutrient loading in Upper Klamath Lake. Reducing these impacts will aid riparian and wetland enhancements in improving water quality.

3271. Develop a plan to reduce impacts of other upland management practices such as forestry, grazing, and farming.

Develop a plan to organize existing government and private programs, and local expertise in efforts to reduce impacts of other upland management practices such as forestry, grazing, and farming in the basin. The existing programs and their funding should be coordinated.

3272. Implement the plan to reduce impacts of other upland management practices such as forestry, grazing, and farming in the basin.

Implement plan developed in task # 3271.

328. Reduce impacts of chemicals used in the basin.

The potential for disastrous contaminant spills exists in much of the upper Klamath Basin, as many roadways and railroad tracks cross or run parallel with waters of the basin. Large amounts of chemicals are applied and transported in the watershed for agricultural uses, industrial uses, control of mosquitoes and other pests, forestry practices, fire control, and other uses. The reconnaissance investigation of water quality in the Klamath Basin by USGS, *et al.* in 1991 found that organochlorine pesticides are still detectable in bottom sediments at many locations due to past pesticide applications. Chemicals currently used for pest control such as malathion, are very toxic to aquatic organisms.

3281. Reduce the potential for contaminant spills and be capable of minimizing effects of spills that occur.

The potential for disastrous contaminant spills exists in much of the upper Klamath Basin, as many roadways and railroad tracks cross or run parallel with waters of the basin. Safety precautions and cleanup strategies should be reviewed or developed to deal with this potential problem.

32811. Develop a plan to help prevent and deal with contaminant spills.

Develop a plan to help prevent and ameliorate major spills in the upper Klamath Basin. A similar task also is recommended in the Water Users Plan.

32812. Implement the plan to deal with contaminant spills.

Implement plan developed in task # 32811.

3282. Reduce impacts of chemicals applied in the basin

Large amounts of chemicals are applied in the watershed on an annual basis for agricultural uses, control of mosquitoes and other pests, forestry and forest fire control, and other uses. Many of these chemicals are sprayed from airplanes over wide areas and find their way into waterways directly or from surface and sub-surface flow.

32821. Assess impacts of chemicals applied in the basin to aquatic organisms.

Assess potential effects of past and current applications of chemicals in the basin. Large amounts of chemicals are applied in the watershed on an annual basis for agricultural uses, control of mosquitoes and other pests, forestry and forest fire control, and other uses.

32822. Develop a plan to reduce potential effects of chemicals applied in the basin.

Develop a plan to reduce potential effects of chemicals applied in the basin. Develop guidelines for application of pesticides and other chemicals to reduce their effects on aquatic organisms.

32823. Implement the plan to reduce potential effects of chemicals applied in the basin.

Implement plan developed in task # 3283.

33. Secure adequate water levels and flows for suckers in the upper Klamath Basin.

A review of current water conservation practices, water storage, and recommended measures for improvement will be necessary to guarantee that sufficient water remains to meet the needs of endangered suckers, the agricultural community, and downstream users during drought periods.

331. Investigate additional water storage in the upper Klamath Basin.

Additional water storage in the Upper Klamath Lake watershed has potential to allow better management of Upper Klamath Lake levels for fish and wildlife, serve as a marsh restoration pilot project, sucker rearing areas, or other beneficial uses. Investigate the feasibility of water storage in the Klamath River watershed, including proposals such as the Geary Ranch site in the Water Users Plan.

332. Assess the potential for water exchanges from the Four-Mile Transbasin Diversion.

Water from Four-Mile Lake is diverted out of the Upper Klamath Lake watershed. Assess the potential for returning at least some of this water to it's natural watershed. Changes in timing and volumes of water through this diversion could also improve conditions in Upper Klamath Lake. A similar task also is recommended in the Water Users Plan.

333. Determine minimum pool and instream flow requirements for stable sucker populations in the upper Klamath Basin.

This research will determine minimum pool elevations in lakes and reservoirs and instream flow requirements for streams that are needed to support sucker populations in the upper Klamath Basin.

334. Secure adequate water levels and flows for stable sucker populations in the Upper Klamath Lake basin.

In addition to water quality problems, water quantities can be limiting during droughts. Irrigation demands could threaten sucker and other wildlife populations when water supplies are limited. Adequate water levels and flows for suckers in the Upper Klamath Lake basin should be secured to assure stable populations and habitat.

3341. Determine the relationship between lake volume and water quality in upper Klamath Lake basin.

This research would investigate the relationship between Upper Klamath Lake's water volume and water quality. Reduced water depths and volume could result in greater extremes in water temperatures and related changes in dissolved oxygen concentrations, algal growth, pH, concentration of nutrients, and other factors. This information could be used to improve water quality and refine minimum lake elevation requirements.

3342. Develop a plan to secure adequate water levels and flows for suckers in the Upper Klamath Lake basin.

A water conservation plan that establishes water savings goals and time schedules for successful implementation should be developed and implemented in coordination with existing plans (such as the Oregon Water Resources Department's water conservation program). The plan should investigate measures recommended in the Water Users Plan, such as upgrading existing open water conveyance structures to closed conveyance structures, and installing alternative irrigation systems. Water rights issues must be addressed and settled (in compliance with state laws) if the water supply cannot meet the minimum lake levels and flows determined in task # 333.

3343. Implement the plan to secure adequate water levels and flows for Upper Klamath Lake.

Implement plan developed in task # 3342.

335. Secure adequate water levels and flows for stable sucker populations in Clear Lake.

The original intent of Clear Lake Dam was to create an evaporative basin that would allow conversion of downstream wetlands to agricultural use. Construction of the dam served to flood the existing marsh in the eastern part of the Clear Lake basin and created a large, shallow lake that is an inefficient water storage basin. Irrigation water demands often exceed the firm annual yield and could compromise lake levels for suckers and other wildlife at Clear Lake. Extreme low lake elevations, such as those reached in the 1930's should be avoided to reduce potential for desiccation, winter kills, crowding, and water quality problems.

3351. Investigate alternative ways to balance water demands for Clear Lake.

In 1972, the U.S. Bureau of Reclamation completed a preliminary design plan and analysis (Reclamation 1992) to construct the "Boundary Dam" downstream of Clear Lake in Lost River channel to provide more efficient water storage. None of the proposed plans were economically feasible, but variations of Plan C which sought to balance the irrigable acres with the existing water supplies may be more economically feasible at this time. Reinvestigate the biological, hydrological and economical efficacy and feasibility of balancing water supplies and demands in the Lost River drainage.

3352. Develop a plan to secure adequate water levels and flows for stable sucker populations in Clear Lake.

A water conservation plan that establishes water savings goals and time schedules for successful implementation should be developed and implemented. The plan should investigate measures recommended in the Water Users Plan, such as upgrading existing open water conveyance structures to closed conveyance structures, and installing alternative irrigation systems to improve efficiency. Water rights issues must be addressed and settled (in compliance with state laws) if the water supply cannot meet the minimum lake levels and flows determined in task # 333.

3353. Implement plan to secure adequate water levels and flows for stable sucker populations in Clear Lake.

Implement plan developed in task # 3352

336. Secure adequate water levels and flows for stable sucker populations in Tule Lake.

Areas of Tule Lake with water depths greater than 2 feet are very limited during portions of the year. Notes from the refuge manager in the late 1960's indicates fish kills due to winter losses or winter icing. Sump rotation or other options could provide more deep water habitat for fish and more productive marsh habitat for waterfowl. However, engineering and potential water quality problems need to be investigated before implementing these projects. A similar task is also recommended in the Water Users Plan.

3361. Develop a plan to secure adequate water levels and flows for stable sucker populations in Tule Lake.

Develop a plan to improve habitat in Tule Lake by increasing the water depth in parts of the lake and critical flows in the Lost River.

3362. Implement the plan to secure adequate water levels and flows for stable sucker populations in Tule Lake.

Implement plan developed in task # 3361

34. Improve spawning habitat quality and quantity in upper Klamath Basin.

Improve spawning habitat quality and quantity in rivers and springs in Upper Klamath Lake watershed.

341. Provide fish passage around the Sprague River Dam and improve downstream spawning habitat.

The construction in 1914 to 1918 of the Sprague River Dam, near Chiloquin, Oregon, may have reduced availability of approximately 95 percent of the potential spawning range of Lost River and shortnose suckers in the Sprague River drainage. Fish passage for both upstream and downstream migrations must be provided for all species of migrating fish and spawning substrate must be restored to improve spawning habitat in the Sprague River. A similar task also is recommended in the Water Users Plan.

3411. Examine effectiveness and feasibility of alternate strategies to provide fish passage around Sprague River Dam.

Conduct a feasibility study that would determine whether dam removal, installation of improved fish ladders, or other alternatives would most effectively provide fish passage. Investigate recommendations in the Water Users Plan. A plan for removal of the dam must include a hydrological assessment to determine the effects of sediment release downstream on endangered suckers, trout, and other aquatic species. A plan for installation of fish ladders would require a working demonstration that they can be successfully negotiated by endangered suckers and a provision for supplementation and maintenance of downstream spawning gravel.

3412. Implement the most effective strategy to provide fish passage upstream of the Sprague River Dam.

Removal of the Sprague River Dam would require that an alternate water diversion structure for the Modoc Point Irrigation District would have to be provided. Installation of fish ladders would require replacement and maintenance of downstream gravel in perpetuity.

342. Improve spawning habitat at springs for lake-spawning populations.

Lake-spawning populations are presently known from Sucker Springs and Ouxy Springs. It is likely that other springs in Upper Klamath Lake once provided spawning habitat for distinct populations of endangered suckers. To prevent the extinction of remaining spring-spawning populations, restore and enhance spring spawning habitat.

3421. Identify existing and potential spring spawning sites in Upper Klamath and Agency Lakes.

Conduct a survey of Upper Klamath and Agency Lake springs to determine where suitable spawning habitat exists and if endangered sucker populations are presently using these springs or have potential for sucker spawning. A preliminary survey by Reclamation with assistance from the Klamath Basin Water Users Protective Association, has recently discovered several potential sites.

3422. Secure spawning sites at springs in Upper Klamath and Agency Lakes.

Through agreements with cooperative landowners, willing seller acquisition, or long-term leases, secure the habitat and water needed for suckers spawning at springs. Cooperative or voluntary agreements and long-term leases would be the preferred alternatives.

3423. Determine preferred physical, hydrological, and water quality parameters for spawning at springs.

Observe spawning activity in spring habitats to determine at what water depth, gravel substrate size, water temperature, pH, and dissolved oxygen concentration, spawning occurs. Determine the corresponding relative success of larval emergence for each of these parameters. A similar task also is recommended in the Water Users Plan.

3424. Develop a plan to improve springs for spawning.

Develop a plan that incorporates information from the two previous tasks to improve springs for spawning habitat. To increase the available spawning habitat within the lake, Barkley Spring and other springs should be restored or enhanced. Effects on other aquatic organisms in the area to be restored must be considered. These improved habitats should be monitored in the spawning season to determine whether adults will naturally seek new spawning substrate. If not, suckers should be introduced to restored springs using methods that will not adversely effect the source populations and will promote genetic diversity in the new populations. Ideas from a similar task in the Water Users Plan should be investigated.

3425. Implement the plan to enhance spring spawning habitat.

Implement plan developed in task # 3424.

343. Improve spawning habitat in Lost River below Anderson Dam.

Tule Lake is part of the Lost River system, but access to most of the river is restricted by the Anderson Rose Dam. Spawning activity was observed just below this dam in 1991. Spawning habitat is reportedly poor in most of the Lost River below Anderson Rose Dam. This habitat improvement should include improving substrate conditions and requiring minimum flows during the spawning period. A similar task is also recommended in the Water Users Plan.

3431. Develop a spawning habitat improvement plan for the lower Lost River.

Develop a plan to improve spawning conditions in the Lost River below Anderson Rose Dam.

3432. Implement the plan for spawning habitat improvement in the lower Lost River.

Implement plan developed in task # 3431

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I. IMPLEMENTATION SCHEDULE

The table that follows is a summary of scheduled actions and costs for this recovery program. It is a guide to meet the objectives of the Lost River and Shortnose Sucker Recovery Plan. This table indicates the priority in scheduling tasks to meet the objectives, which agencies are responsible to perform these tasks, a time-table for accomplishing these tasks, and the estimated costs to perform them. Implementing Part III is the action of this plan, that when accomplished, will satisfy the recovery objective. Initiation of these actions is subject to the availability of funds.

Priorities in Column 1 of the following implementation schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

Lost River and Shortnose Sucker
Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
		Needs 1: Establish safe refugial populations								
1	111	Characterize the genetic component of the four Klamath Basin sucker species	4	BR*	70.0	30.0	20.0	10.0	10.0	
				FWS	40.0	20.0	20.0			
				ODFW	10.0	10.0				
				CDFG	20.0	20.0				
				KT	20.0	10.0	10.0			
1	112	Prepare a comprehensive genetic management plan for refugial populations	1	BR*	15.0					15.0
				FWS	5.0					5.0
				ODFW	2.0					2.0
				CDFG	2.0					2.0
				KT	1.0					1.0
1	11311	Assess potential refugia for Upper Klamath Lake suckers	1	FWS*	30.0	30.0				
				BR	30.0	30.0				
				FS	10.0	10.0				
				ODFW	10.0	10.0				
				CDFG	10.0	10.0				
				KT	5.0	5.0				
1	11312	Select sites for refugial populations of Upper Klamath Lake suckers	1	FWS*	2.0	2.0				
				BR	2.0	2.0				
				FS	0.0					
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
1	11313	Secure refugial sites for Upper Klamath Lake suckers	5	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				ODFW	0.0					

Lost River and Shortnose Sucker
Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	11314	Develop a plan to introduce Lost River and shortnose suckers from Upper Klamath Lake	1	FWS*	5.0		5.0			
				BR	5.0		5.0			
				ODFW	0.0					
				KT	0.0					
1	11315	Implement the plan to introduce Lost River and shortnose suckers from Upper Klamath Lake	5	FWS*	0.0		TBD	TBD	TBD	TBD
				BR	0.0					
				ODFW	0.0					
				KT	0.0					
1	11321	Assess potential refugial sites for Clear Lake suckers	1	FWS*	30.0	30.0				
				BR	30.0	30.0				
				FS	10.0	10.0				
				CDFG	10.0	10.0				
				ODFW	10.0	10.0				
1	11322	Select sites for refugial populaotions of Clear Lake suckers	1	FWS*	5.0	5.0				
				BR	5.0	5.0				
				FS	0.0					
				CDFG	0.0					
				ODFW	0.0					
1	11323	Secure refugial sites for Clear Lake suckers	5	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				FS	0.0					
				CDFG	0.0					
				ODFW	0.0					

Lost River and Shortnose Sucker
Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	11324	Develop a plan to introduce Lost River and shortnose suckers from Clear Lake into refugial sites	1	FWS*	5.0		5.0			
				BR	5.0		5.0			
				FS	0.0					
				CDFG	0.0					
				ODFW	0.0					
1	11325	Implement the plan to introduce Lost River and shortnose suckers from Clear Lake	5	FWS*	0.0		TBD	TBD	TBD	TBD
				BR	0.0					
				FS	0.0					
				CDFG	0.0					
				ODFW	0.0					
1	121	Assess the need for captive propagation	1	FWS*	5.0	5.0				
				BR	5.0	5.0				
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
1	122	Investigate refining propagation techniques	5	FWS*	80.0	20.0	20.0	20.0	10.0	10.0
				BR	80.0	20	20	20	10	10
				KT	50.0	10	10	10	10	10
1	131	Develop monitoring plan for refugial sites	1	BR*	5.0	5.0				
				FWS	5.0	5.0				
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
1	132	Implement the monitoring plan for refugial sites	Continuous	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					

Lost River and Shortnose Sucker
Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
		Subtotal costs needs 1			634.0	359.0	120.0	60.0	40.0	55.0
		Needs 2: Conduct research on sucker populations and habitat needs								
1	211	Develop effective sampling methods for all life stages of suckers	3	FWS*	100.0	50.0	30.0	20.0		
				BR	100.0	50.0	30.0	20.0		
				ODFW	30.0	20.0	10.0			
				CDFG	30.0	20.0	10.0			
				KT	20.0	10.0	10.0			
1	212	Investigate alternative methods for ageing suckers that would be non-lethal	3	FWS	35.0	15.0	10.0	10.0		
1	213	Develop plan to monitor relative abundance of all life stages for all sucker populations	1	FWS*	10.0			10.0		
				BR	10.0			10.0		
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
1	214	Implement plan to monitor relative abundance of all life stages for all sucker populations	Continuous	FWS*	0.0				TBD	TBD
				BR	0.0					
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
1	221	Investigate recruitment bottlenecks in Upper Klamath Basin	5	FWS*	150.0	30.0	30.0	30.0	30.0	30.0
				BR	200.0	40.0	40.0	40.0	40.0	40.0
				KT	50.0	10.0	10.0	10.0	10.0	10.0
				ODFW	50.0	10.0	10.0	10.0	10.0	10.0
				FS	50.0	10.0	10.0	10.0	10.0	10.0

Lost River and Shortnose Sucker
Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	222	Investigate lack of recruitment at Copco Reservoir	3	PP*	180.0	80.0	50.0	50.0		
				FWS	30.0	10.0	10.0	10.0		
				CDFG	30.0	10.0	10.0	10.0		
1	223	Determine which reservoirs in the Klamath and Lost River systems support viable, self--supporting populations of suckers	3	BR*	70.0	30.0	20.0	20.0		
				FWS	30.0	10.0	10.0	10.0		
				CDFG	15.0	10.0	5.0			
				ODFW	15.0	10.0	5.0			
1	224	Determine effects introduced species on sucker populations	3	FWS*	60.0	20.0	20.0	20.0		
				BR	70.0	30.0	20.0	20.0		
				ODFW	20.0	10.0	5.0	5.0		
				CDFG	20.0	10.0	5.0	5.0		
				KT	20.0	10.0	5.0	5.0		
1	2251	Assess losses of fish due to water diversions	3	BR*	110.0	50.0	30.0	30.0		
				ID	30.0	10.0	10.0	10.0		
				PP	90.0	30.0	30.0	30.0		
1	2252	Develop plan to reduce losses of fish due to water diversions	1	BR*	30.0				30.0	
				ID	10.0				10.0	
				PP	30.0				30.0	
				FWS	0.0					
1	2253	Implement plan, to reduce losses of fish associated with water diversions	10	BR*	0.0					TBD
				ID	0.0					
				PP	0.0					

Lost River and Shortnose Sucker
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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	226	Compare survival of larval and juvenile suckers in different habitat types in the Upper Klamath Basin	3	BR*	70.0	30.0	20.0	20.0		
				FWS	40.0	20.0	10.0	10.0		
				KT	15.0	5.0	5.0	5.0		
				CDFG	15.0	5.0	5.0	5.0		
				ODFW	15.0	5.0	5.0	5.0		
1	2311	Determine distribution and abundance of suckers in Upper Klamath Lake	2	FWS*	40.0				20.0	20.0
				BR	40.0				20.0	20.0
				ODFW	10.0				5.0	5.0
				KT	10.0				5.0	5.0
1	2312	Determine distribution and abundance of suckers in the river and reservoirs downstream of Upper Klamath Lake	5	BR*	100.0	20.0	20.0	20.0	20.0	20.0
				FWS	50.0	10.0	10.0	10.0	10.0	10.0
				ODFW	10.0	10.0				
				CDFG	10.0	10.0				
1	2313	Determine distribution and abundance of suckers in Clear Lake and upstream reservoirs after drought conditions	2	BR*	40.0	20.0	20.0			
				FWS	20.0	10.0	10.0			
				CDFG	5.0	5.0				
				FS	10.0	10.0				
1	2314	Determine distribution and abundance of suckers in Gerber Reservoir and small reservoirs in the Lost River system	2	BR*	60.0	30.0	30.0			
				FWS	20.0	10.0	10.0			
				ODFW	10.0	5.0	5.0			
				CDFG	10.0	5.0	5.0			
				BLM	10.0	5.0	5.0			
1	2315	Determine distribution and abundance of populations of both sucker species in Tule Lake	2	BR*	70.0	40.0	30.0			
				FWS	10.0	5.0	5.0			
				CDFG	10.0	5.0	5.0			

Lost River and Shortnose Sucker
Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	2316	Determine distribution and abundance of populations of both suckers species in other waterbodies in the upper Klamath Basin	2	BR*	60.0	30.0	30.0			
				FWS	20.0	10.0	10.0			
				ODFW	10.0	5.0	5.0			
				CDFG	10.0	5.0	5.0			
1	232	Determine physiological tolerances of both sucker species to a combination of existing or potential water quality stresses	1	BR*	91.6	91.6				
				FWS	0.0					
1	2331	Determine habitat requirements of suckers in Upper Klamath Lake	3	BR*	70.0	30.0	20.0	20.0		
				FWS	20.0	10.0	10.0			
				KT	10.0	5.0	5.0			
				ODFW	10.0	5.0	5.0			
				FS	10.0	5.0	5.0			
				BLM	10.0	5.0	5.0			
1	2332	Determine habitat requirements of suckers in the Lost River System	5	BR*	110.0	30.0	20.0	20.0	20.0	20.0
				FWS	50.0	10.0	10.0	10.0	10.0	10.0
				ODFW	15.0	5.0	5.0	5.0		
				CDFG	15.0	5.0	5.0	5.0		
		Subtotal costs needs 2			2906.6	1111.6	775.0	530.0	280.0	210.0
		Needs 3: Habitat and watershed improvement								
1	311	Develop a plan to Monitor habitat and water quality conditions for all populations	1	BR*	5.0	5.0				
				FWS	5.0	5.0				
				ODFW	5.0	5.0				
				CDFG	5.0	5.0				
				KT	5.0	5.0				
				FS	5.0	5.0				
				BLM	5.0	5.0				

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	312	Implement the plan to monitor habitat, water quality conditions for all sucker populations	Continuous	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
				FS	0.0					
				BLM	0.0					
1	321	Conduct an external nutrient loading study	5	BR*	945.0	240.0	300.0	200.0	105.0	100.0
				USGS	0.0					
				KT	0.0					
1	322	Conduct an internal nutrient loading study	5	BR	200.0	80.0	40.0	40.0	20.0	20.0
				USGS	0.0					
				KT	0.0					
1	323	Develop a nutrient budget for Upper Klamath and Agency Lakes	2	BR*	0.0					
				USGS	0.0					
				KT	0.0					
1	324	Establish water quality goals	1	BR*	5.0					
				FWS	5.0					
				USGS	2.0					
				CDFG	2.0					
				ODFW	2.0					
				ODEQ	2.0					
				NRWQCB	2.0					

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Recovery Plan Implementation Schedule

PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	3251	Identify reparian land parcels for rehabilitation	1	BR*	10.0	10.0				
				FWS	5.0	5.0				
				ODFW	5.0	5.0				
				CDFG	5.0	5.0				
				FS	10.0	10.0				
				BLM	10.0	10.0				
				SCS	5.0	5.0				
				KT	2.0	2.0				
1	3252	Prioritize sites for riparian rehabilitation	1	FWS*	5.0	5.0				
				SCS	5.0	5.0				
1	3253	Select Riparian Management areas	1	FWS*	5.0	5.0				
				SCS	0.0					
1	32541	Identify riparian landowners	1	SCS*	5.0	5.0				
				BR	5.0	5.0				
				FWS	5.0	5.0				
1	32542	Secure riparian habitat for rehabilitation	15	BR*	0.0	TBD	TBD	TBD	TBD	TBD
				FWS	0.0					
				SCS	0.0					
				FS	0.0					
				BLM	0.0					
				ODFW	0.0					
				CDFG	0.0					
				ID	0.0					

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	32543	Develop riparian management unit rehabilitation plans	2	BR*	10.0		5.0	5.0		
				FWS	10.0		5.0	5.0		
				SCS	0.0					
				FS	10.0		5.0	5.0		
				BLM	10.0		5.0	5.0		
				ODFW	0.0					
				CDFG	0.0					
				ID	0.0					
				KT	0.0					
1	32544	Implement riparian rehabilitation plans	Continuous	BR*	0.0			TBD	TBD	TBD
				FWS	0.0					
				SCS	0.0					
				FS	0.0					
				BLM	0.0					
				ODFW	0.0					
				CDFG	0.0					
				ID	0.0					
				KT	0.0					
1	3261	Identify land parcels for wetland rehabilitation	1	BR*	10.0	10.0				
				FWS	10.0	10.0				
				SCS	5.0	5				
				FS	5.0	5.0				
				BLM	5.0	5.0				
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	32621	Select sites for pilot wetland rehabilitation	1	BR*	5.0	5.0				
				FWS	5.0	5.0				
				ODFW	0.0					
				CDFG	0.0					
				KT	0.0					
1	32622	Identify landowners of pilot wetland rehabilitation sites	1	FWS*	5.0	5.0				
				BR	5.0	5.0				
1	32623	Secure areas for pilot wetland rehabilitation project	5	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				SCS	0.0					
				BLM	0.0					
				FS	0.0					
				ODFW	0.0					
				CDFG	0.0					
1	32624	Develop plans for pilot wetland project	1	BR*	10.0					
				FWS	10.0					
				SCS	0.0					
				BLM	5.0					
				FS	5.0					
				ODFW	0.0					
				ODEQ	0.0					
				CDFG	0.0					
				KT	0.0					

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	32625	Implement the plan for wetland rehabilitation pilot projects	15	BR*	0.0					
				FWS	0.0					
				SCS	0.0					
				BLM	0.0					
				FS	0.0					
				ODFW	0.0					
				ODEQ	0.0					
				CDFG	0.0					
1	3263	Develop a long-term plan for wetland rehabilitation	1	BR*	20.0					
				FWS	10.0					
				SCS	0.0					
				BLM	0.0					
				FS	0.0					
				ODFW	0.0					
				ODEQ	0.0					
				OWRD	0.0					
				CDFG	0.0					
				KT	0.0					
				CG	0.0					
				ID	0.0					
1	3264	Implement the long-term plan for wetland rehabilitation	15	BR*	0.0					
				FWS	0.0					
				SCS	0.0					
				BLM	0.0					
				FS	0.0					
				ODFW	0.0					
				ODEQ	0.0					
				CDFG	0.0					
				CG	0.0					

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	3271	Develop a plan to reduce impacts of other upland management practices such as forestry, grazing, and farming	1	BR*	5.0	5.0				
				FWS	2.0	2.0				
				SCS	5.0	5.0				
				BLM	2.0	2.0				
				FS	2.0	2.0				
				CG	2.0	2.0				
1	3272	Implement the plan to reduce impacts of other upland management practices such as forestry, grazing, and farming in the basin	Continuous	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				SCS	0.0					
				BLM	0.0					
				FS	0.0					
				CG	0.0					
1	32811	Develop a plan to help prevent and deal with contaminant spills	1	EPA*	5.0	5.0				
				BR	5.0	5.0				
				FWS	5.0	5.0				
				ODEQ	5.0	5.0				
1	32812	Implement the plan to deal with contaminant spills	Continuous	EPA*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				ODEQ	0.0					
1	32821	Assess the impacts of chemicals applied in the basin to aquatic organisms	3	BR*	700.0	300.0	200.0	200.0		
				FWS	60.0	20.0	20.0	20.0		
				USGS	60.0	20.0	20.0	20.0		
				ODEQ	60.0	20.0	20.0	20.0		
				NRWQCB	90.0	30.0	30.0	30.0		

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	32822	Develop a plan to reduce potential effects of chemicals applied in the basin	1	BR*	10.0				10.0	
				FWS	10.0				10.0	
				SCS	0.0					
				FS	0.0					
				ODEQ	5.0				5.0	
				NRWQCB	5.0				5.0	
1	32823	Implement the plan to reduce potential effects of chemicals applied in the basin	3	BR*	0.0					TBD
				FWS	0.0					
				SCS	0.0					
				FS	0.0					
				ODEQ	0.0					
				NRWQCB	0.0					
1	331	Investigate additional water storage in the Upper Klamath Basin	2	BR	50.0	25.0	25.0			
1	332	Assess the potential for water exchange from the Four-Mile Transbasin Diversion	1	BR	5.0	5.0				
1	333	Determine minimum pool and instream flow requirements for stable sucker populations in the upper Klamath Basin	6	BR*	290.0	100.0	50.0	50.0	30.0	30.0
				FWS	120.0	50.0	20.0	20.0	10.0	10.0
				ODFW	65.0	20.0	15.0	15.0	5.0	5.0
				CDFG	65.0	20.0	15.0	15.0	5.0	5.0
1	3341	Determine the relationship between lake volume and water quality in Upper Klamath Lake basin	5	BR*	700.0	200.0	200.0	100.0	100.0	100.0
				FWS	0.0					
				KT	0.0					

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	3342	Develop plan to secure adequate water levels and flows for suckers in the Upper Klamath Lake basin	1	BR*	30.0					
				FWS	10.0					
				FS	0.0					
				ODFW	0.0					
				OWRD	0.0					
				KT	0.0					
				ID	0.0					
1	3343	Implement the plan to secure adequate water levels and flows for Upper Klamath Lake	10	BR*	0.0					
				FWS	0.0					
				FS	0.0					
				ODFW	0.0					
				OWRD	0.0					
				KT	0.0					
				ID	0.0					
1	3351	Investigate alternative ways to balance water demands for Clear Lake	2	BR*	30.0					
				FWS	0.0					
				ODFW	0.0					
				CDFG	0.0					
				BLM	0.0					
				FS	0.0					
				OWRD	0.0					
				CDWR	0.0					
1	3352	Develop a plan to secure adequate water levels and flows for stable sucker populations in Clear Lake	1	BR*	30.0					
				FWS	0.0					
				ODFW	0.0					
				CDFG	0.0					
				BLM	0.0					
				FS	0.0					
				ID	0.0					
				CDWR	0.0					
				OWRD	0.0					

Lost River and Shortnose Sucker
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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
1	3353	Implement plan to secure adequate water levels and flows for stable sucker populations in Clear Lake	10	BR*	0.0					
				FWS	0.0					
				ODFW	0.0					
				CDFG	0.0					
				BLM	0.0					
				FS	0.0					
				CDWR	0.0					
				ID	0.0					
				OWRD	0.0					
1	3361	Develop a plan to secure adequate water levels and flows for stable sucker populations in Tule Lake	1	BR*	30.0					
				FWS	0.0					
				CDWR	0.0					
				CDFG	0.0					
1	3362	Implement the plan to secure adequate water levels and flows for stable sucker populations in Tule Lake	10	BR*	0.0					
				FWS	0.0					
				CDWR	0.0					
				CDFG	0.0					
2	3411	Examine effectiveness and feasibility of alternate strategies to provide fish passage around Sprague River Dam	1	BR*	40.0	40.0				
				FWS	10.0	10.0				
				ODFW	10.0	10.0				
				KT	0.0					
				ID	0.0					
2	3412	Implement the most effective strategy to provide fish passage upstream of Sprague River Dam	Continuous	BR*	0.0		TBD	TBD	TBD	TBD
				FWS	0.0					
				ODFW	0.0					
				KT	0.0					
				ID	0.0					

Lost River and Shortnose Sucker
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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97
2	3421	Identify existing and potential spring spawing sites in Upper Klamath & Agency Lakes	3	BR*	75.0	25.0	25.0	25.0		
				FWS	0.0					
				KT	0.0					
				ODFW	0.0					
2	3422	Secure spawning sites at springs in Upper Klamath and Agency Lakes	5	BR*	0.0				TBD	TBD
				FWS	0.0					
2	3423	Determine preferred physical, hydrological, and water quality parameters for spawning at springs	3	BR*	45.0	20.0	15.0	10.0		
				FWS	20.0	10.0	5.0	5.0		
				KT	15.0	5.0	5.0	5.0		
				ODFW	0.0					
2	3424	Develop a plan to improve springs for spawning	1	BR*	30.0				30.0	
				FWS	0.0					
				KT	0.0					
				ODFW	0.0					
2	3425	Implement the plan to enhance spring spawning habitat	3	BR	0.0					TBD
2	3431	Develop a spawning habitat improvement plan for the lower Lost River	1	BR*	20.0	20.0				
				FWS	0.0					
				CDFG	0.0					
2	3432	Implement the plan for spawning habitat improvement in the lower Lost River	Continuous	BR	0.0		TBD	TBD	TBD	TBD
		Subtotal costs needs 3			4165.0	1480.0	1025.0	795.0	335.0	270.0
		Total costs			7705.6	2950.6	1920.0	1385.0	655.0	535.0

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PRIORITY	TASK	TASK DESCRIPTION	TASK DURATION YEARS	RESPONSIBILITY	Costs in Thousands TOTL.COST	FY93	FY94	FY95	FY96	FY97

TBD = Costs to be determined after plans are done or decissions are made on how to secure habitat.

Continuous = Task will be implemented on an annual basis once it is begun

Ongoing = Task is currently being implemented and will continue until action is no longer necessary for recovery

Total costs = Projected cost of task from strart to task completion.

Responsible Parties:

* = lead agency

BLM = Bureau of Land Management
CDFG = California Department of Fish & Game
ID = Irrigation Districts
KT = Klamath Tribe
NRWQCB = Northcoast Regional Water Quality Control Board
CDWR = California Department of Water Resources
ODEQ = Oregon Department of Environmental Quality
ODFW = Oregon Department of Fish & Wildlife
OWRD = Oregon Water Resources Department
PP = PacifiCorp, Pacific Power & Light Company
SCS = Soil Conservation Service
BR = Bureau of Reclamation
FS = United States Forest Service
FWS = U. S. Fish and Wildlife Service
USGS = U.S. Geological Survey
CG = County governments
EPA = Environmental Protection Agency

APPENDIX A

Individuals Contacted During Technical/Agency Review of Short Nosed Sucker and Lost River Sucker

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