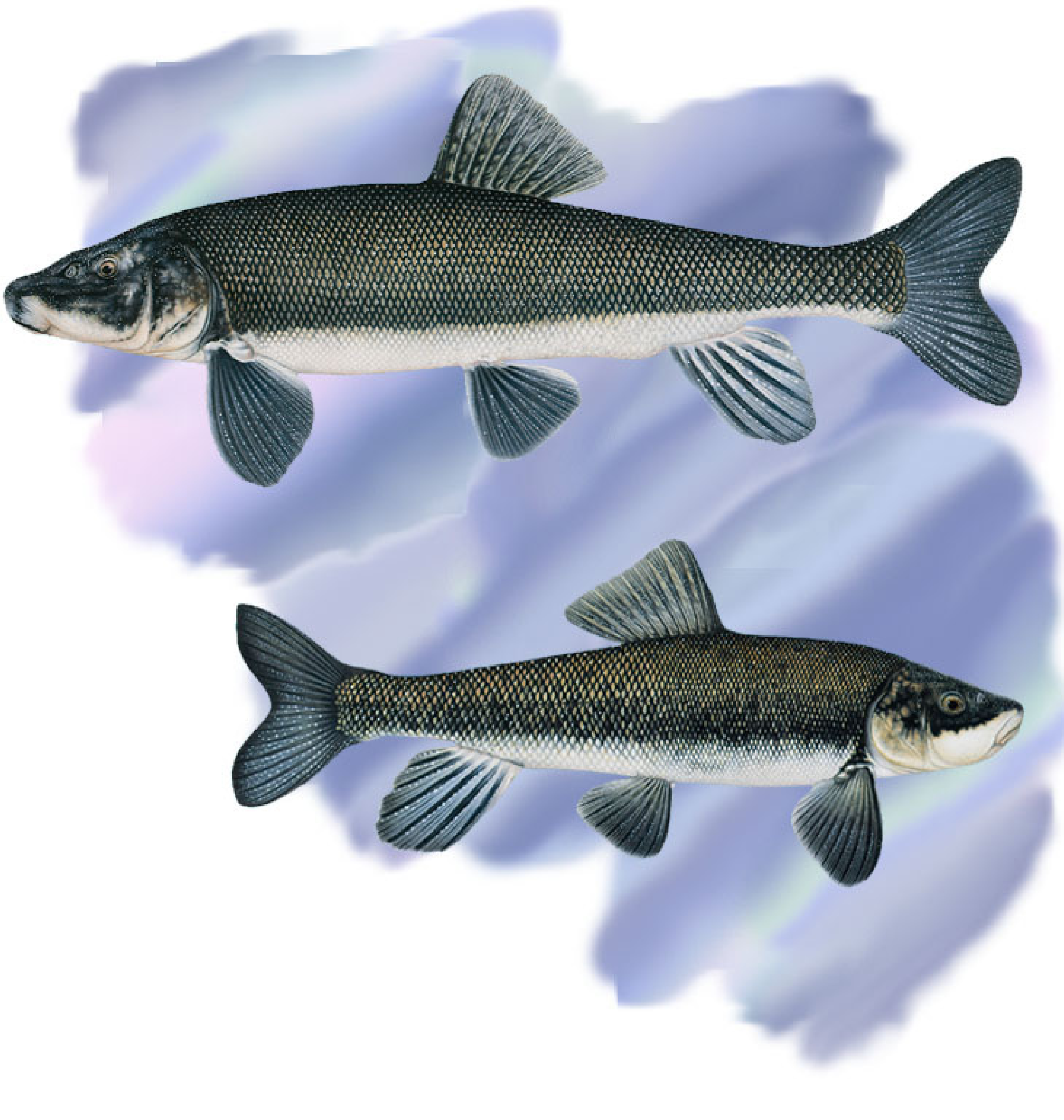
U.S. Fish & Wildlife Service

Draft Revised Recovery Plan for the Lost River Sucker and Shortnose Sucker

(Deltistes luxatus & Chasmistes brevirostris)



Cover Art:

Draft Revised Recovery Plan for the Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*)

Recovery Plan

First Revision

Original Version: March 1993

Pacific Southwest Region
U. S. Fish and Wildlife Service
Sacramento, California

Approved: ____
Regional Director, U.S. Fish and Wildlife Service, Region 8

Date: ____________________

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I. Disclaimer

Recovery plans delineate reasonable actions that are believed to be required to recover and protect listed species. We, the U.S. Fish and Wildlife Service, publish recovery plans, sometimes preparing them with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and other affected and interested parties. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Costs indicated for action implementation and time of recovery are estimates and subject to change. Recovery Plans do not obligate other parties to undertake specific actions, and may not represent the views nor the official positions or approval of any individuals or agencies involved in recovery plan formulation, other than the U.S. Fish and Wildlife Service. Recovery Plans represent our official position *only* after they have been signed by the Director or Regional Director as *approved*. Recovery plans are released for public comment and submitted to peer review before we adopt them as approved final documents. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and completion of recovery actions.

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Electronic copies of this document will be available at:

http://www.fws.gov/endangered/species/recovery-plans.html

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II. Acknowledgements

The recovery plan was prepared by Dr. Donald W. Sada, Desert Research Institute and Dr. Josh E. Rasmussen and Mark Buettner from the U.S. Fish and Wildlife Service, with the assistance of the Lost River and Shortnose Sucker Recovery Team, and in coordination with a recovery team subgroup comprised of stakeholders representing various interests in the area affected by the Recovery Plan.

The Service gratefully acknowledges the commitment and efforts of the members of the Shortnose Sucker and Lost River Sucker Recovery Team for their assistance during development of this revised recovery plan.

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III. Executive Summary

A. CURRENT SPECIES STATUS

We, the U.S. Fish and Wildlife Service (USFWS), listed Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) as endangered throughout their entire range on July 18, 1988 (USFWS 1988) under the Endangered Species Act of 1973, as amended. Both species are also listed as endangered by the States of Oregon and California. No critical habitat has been specified for these species. A recovery plan for both species was finalized on March 17, 1993 (USFWS 1993). A substantial amount of additional information is now available, and it is appropriate to revise the plan and incorporate this new information into the recovery program.

Populations declined prior to listing due to habitat loss (approximately 70 – 77 percent of historic range), restricted access to spawning habitat, and increased rates of mortality resulting from **entrainment**[1] in water management structures and severely impaired water quality. Regularly spawning populations now occur only in Upper Klamath Lake and Clear Lake Reservoir. However, populations in Upper Klamath Lake are characterized by low **recruitment**, reduced survivorship of adult fish, and reduced age-class diversity. Length-frequency analysis suggests that the last substantial recruitment to the spawning population occurred during the late 1990s. Current abundance of spawning individuals of both species in Upper Klamath Lake is estimated to be roughly 50 percent of 2001 abundances. Less information is available on Clear Lake Reservoir populations, which makes it difficult to accurately assess **demographics** and trends of these populations.

B. HABITAT REQUIREMENTS

Lost River and shortnose suckers have complex life histories that include stream/river, lake, marsh, and shoreline habitats. Both spawn during the spring over gravel substrates in habitats less than 1.3 meters (4 feet) deep in tributary

[1] Terms defined in the glossary (Appendix I) are indicated with bold formatting at the first instance of occurrence.

streams and rivers. A smaller but significant number of Lost River sucker also spawn over gravel substrates at shoreline springs along the margins of Upper Klamath Lake.

Larvae spend relatively little time in rivers or streams before drifting downstream to the lakes by mid-summer. Larval habitat is generally along the relatively shallow shoreline where emergent vegetation provides cover from predators, protection from currents and turbulence, and abundant food (including **zooplankton**, macroinvertebrates, and **periphyton**). **Juvenile** suckers utilize a wide variety of near and off-shores habitat including emergent wetlands and non-vegetated areas. They increasingly move off-shore into the lake as they grow. Adults occupy open water habitats.

C. LIMITING FACTORS

A main factor cited at the time of listing as contributing to population declines was loss or degradation of spawning, rearing, and adult habitats. The rate of habitat loss has slowed during recent years; nevertheless, only a fraction of the original habitat remains. Reductions in habitat quality compound the effects of reduced habitat quantity and availability on Lost River sucker and shortnose sucker abundance. Current factors limiting species recovery also include high mortality of larvae and juveniles due to minimal rearing habitat, entrainment in water management structures, poor water quality and negative interactions with introduced species. Adult populations are limited by the negligible recruitment to the population, as well as high levels of stress and mortality associated with severely impaired water quality. As a whole the species are potentially limited by the lack of connectivity.

D. RECOVERY GOAL

The goal of our recovery program is to arrest the decline and enhance Lost River sucker and shortnose sucker populations so that Endangered Species Act protection is no longer necessary.

E. RECOVERY OBJECTIVES

Demographic-based and threats-based objectives will facilitate recovery and enable attainment of the recovery goal. Demographic-based objectives include increasing larval production, individual survival and recruitment to spawning populations, and therefore abundance in spawning populations. The objectives of restoring spawning and nursery habitat, expanding reproduction, reducing the negative impacts from water quality on all life stages, clarifying the effects of other species on all life stages, reducing entrainment, and establishing auxiliary populations comprise the threats-based objectives.

F. RECOVERY STRATEGY

The recovery strategy is intended to produce and document healthy, self-sustaining populations by reduction of mortality, restoration of habitat, including spawning, larval and juvenile habitats, and increasing connectivity between spawning and rearing habitats. It also involves ameliorating adverse effects of degraded water quality, disease, and non-native fish. The plan provides areas of emphasis and guidelines to direct recovery actions. Recent, 5-year status reviews for each species assigned a recovery priority number of 4C for both species (USFWS 2007a, b). However, shortnose sucker were inaccurately assigned given that they do not belong to a **monotypic** genus. Instead, the recovery priority number for Lost River and shortnose sucker should be 4C and 5C, respectively. The only difference being that Lost River suckers belong to a monotypic genus, whereas shortnose sucker are a species in a **polytypic** genus. As a result, Lost River sucker merit a higher priority number.

G. RECOVERY UNITS

Establishing recovery units is a useful tool for species that occur in multiple populations where varying ecological conditions, threats, and management challenges exist. Recovery goals are set for each unit, and progress toward recovery is measured within each unit. Recovery criteria must be met in all recovery units for both species before downlisting or delisting will be considered. The recovery units for both species are the Upper Klamath Lake Unit and the Lost River Basin Unit. Each recovery unit also includes several management units. These management units allow for tailored management objectives and actions for individual populations or sub-populations.

Upper Klamath Lake Unit (designated for each species separately) includes all individuals residing in Upper Klamath Lake, its tributaries, or within any of the reservoirs along the Klamath River. This unit is comprised of four management units, depending on the species:

- Upper Klamath Lake and tributaries – River Spawning Individuals
- Upper Klamath Lake – Shoreline Spring Spawning Individuals
- Keno Reservoir
- Populations below Keno Reservoir

Recovery of the species in all of these management units is not necessary to achieve recovery of the species overall. For example, although the populations of suckers below Keno Reservoir provide some redundancy to populations in the other more important management units, they are sink populations that likely will never be viable, and therefore will not be actively managed for recovery.

Lost River Basin Unit (designated for each species separately): includes all individuals residing in the reservoirs and flowing water in this sub-basin. Four specific management units have been designated:

- Clear Lake Reservoir and tributaries
- Tule Lake
- Gerber Reservoir and tributaries
- Lost River Proper

H. RECOVERY CRITERIA

The recovery criteria comprise a combination of measures that must be taken to directly ameliorate or eliminate threats to the species for each of the above recovery units and to achieve numerical demographic targets. These criteria are described in detail in the 'Downlisting Criteria' and 'Delisting Criteria' sections of this document.

I. ACTIONS NEEDED

Actions needed to recover this species include the following:

Action 1: Restore or enhance spawning and nursery habitat in Upper Klamath Lake and Clear Lake Reservoir Systems
Action 2: Reduce negative impacts of poor water quality

Action 3: Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations
Action 4: Reduce the loss of individuals to entrainment
Action 5: Establish a **redundancy** and **resiliency** enhancement program
Action 6: Increase juvenile survival and recruitment to spawning populations
Action 7: Maintain and increase the number of recurring, successful spawning populations
Action 8: Establish a Klamath Basin Sucker Recovery Implementation Program

J. DATE OF RECOVERY

If actions are successfully implemented, Lost River sucker and shortnose sucker could recover in five to seven generations, based on the concept that a generation is the average time it takes for a female to become reproductive. This is typically seven years for Lost River sucker and five years for shortnose suckers. Therefore, we expect it will take roughly 30 to 50 years to achieve recovery for both species.

K. TOTAL ESTIMATED COST OF RECOVERY

We estimate that it will cost roughly $135 million to recover both of these species, as summarized below. Values in the table are given in thousands of dollars.

Fiscal Year	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	Action 7	Action 8
FY 1	0	0	0	50	160	110	500	60
FY 2	150	100	0	60	205	135	500	110
FY 3	500	215	0	500	155	260	500	125
FY 4	450	1,300	100	500	110	260	540	85
FY 5	1330	1,400	100	800	110	280	700	35
FY 6+	39,415	34,988	2,350	1,990	18,650	2,690	20,250	2,050
Total	41,845	38,003	2,550	3,900	19,390	3,735	22,990	2,465

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IV. Table of Contents

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V. List of Figures

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VI. List of Tables

VII. Background

A. OVERVIEW

We, the U.S. Fish and Wildlife Service (USFWS), listed Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) as endangered throughout their entire range on July 18, 1988 (USFWS 1988) under the Endangered Species Act of 1973, as amended. Both species are also listed as endangered by the States of Oregon and California. A recovery plan for both species was finalized on March 17, 1993 (USFWS 1993). A substantial amount of additional information has accumulated since then and it is appropriate to revise the plan and incorporate this new information into the recovery program. An independent review panel of 12 scientists was convened in 2004 to review research conducted since listing of the species and evaluate its relevance to the species' status (Independent Science Review Panel [ISRP] 2005). Biological and status information relevant to their listing was also considered in 5-year status reviews for each species (USFWS 2007a, b). Both species were assigned a Recovery Priority Number of 4C (indicating a high threat of extinction, low recovery potential, **monotypic**[2] genus, with conflict) in the 5-year status reviews. However, shortnose sucker were inaccurately assigned given that they do not belong to a monotypic genus. Instead, the recovery priority number for Lost River and shortnose sucker should be 4C and 5C, respectively. The only difference being that Lost River suckers belong to a monotypic genus, whereas shortnose sucker are a species in a polytypic genus. As a result, Lost River sucker merit a higher priority number.

Early accounts note that these species were abundant and an important food resource for Native Americans and early settlers (Speir 1930). The species ascended the Williamson River in the thousands and were "taken and dried in great numbers by the Klamath and Modoc Indians." (Cope 1879:785). Bendire (1889) notes a similar spawning run up the Lost River emanating from Tule Lake. However, at the time of listing both species had declined dramatically, reducing spawning runs to a fraction of historical levels. Abundance, longevity, and frequency of spawning success and **recruitment** have probably all decreased in Upper Klamath Lake relative to pre-settlement conditions, and recent information indicates that populations continue to decline because of low recruitment (Janney et al. 2008).

[2] Terms defined in the glossary (Appendix I) are indicated with bold formatting at the first instance of occurrence.

Nevertheless, between 1999 and 2008, roughly 10,000 Lost River sucker were captured and tagged at shoreline-spring spawning sites, with another 15,000 handled as part of the spawning run up the Williamson River (Janney et al. 2009). During a similar time period, 1995 – 2008, approximately 14,000 shortnose sucker were captured, predominantly associated with the Williamson River (Janney et al. 2009). Although current distribution has changed little since listing, important changes in **demography** have been observed.

The following discussion summarizes characteristics of Lost River sucker and shortnose sucker biology, demography and distribution, population status, and threats that are most relevant to recovery. A substantial amount of additional information is available to the interested reader in Buettner and Scoppettone (1990, 1991), Scoppettone and Vinyard (1991), Markle and Cooperman (2002), National Research Council of the National Academies (NRC 2004), Independent Science Review Panel (2005), U.S. Fish and Wildlife Service (2007a, b), Janney *et al.* (2008), Barry *et al.* (2009), and associated literature.

B. SPECIES DESCRIPTION AND TAXONOMY

Both of these species are members of a group of suckers (Family Catostomidae), which predominantly utilize lake environments. Typically adults of this group, collectively known as “lake suckers,” are relatively large individuals (NRC 2004). Lake suckers differ **morphologically** from other suckers in having **terminal** or **sub-terminal mouths**. These species also generally possess numerous, branched **gill rakers** (Miller and Smith 1981). Both mouth position and gill raker structure suggest these species are adapted for feeding in a more forward manner on prey such as **zooplankton** rather than consuming prey from the substrate (Scoppettone and Vinyard 1991, NRC 2004).

The Lost River sucker was described as *Chasmistes luxatus* by Cope (1879) from specimens collected from Upper Klamath Lake. Later, Seale (1896) placed it in the new monotypic genus *Deltistes*, which reflects the distinctive triangular gill rakers (Scoppettone and Vinyard 1991). Its **taxonomy** remained uncertain until Miller and Smith (1967) examined fossil material and confirmed that other diagnostic characteristics were consistent with extinct members of the genus (Andreasen 1975). It is now recognized as the only **extant** member of the genus (Nelson et al. 2004). Lost River suckers are relatively large fish, up to 0.8 meter (2.6 feet) long and 4.5 kilograms (9.9 pounds) in weight, distinguished by an elongate body and sub-terminal mouth with a deeply notched lower lip that are relatively more **papillose** (Scoppettone and Vinyard 1991). They have dark backs and sides that fade to yellow or white on the belly.

The shortnose sucker was described by Cope (1879) as *Chasmistes brevirostris*. This genus includes three extant species of lake suckers in the western U.S. It is generally distinguished by a smaller head than Lost River sucker also with an **oblique**, terminal mouth, and thin, but fleshy, lips. The lower lip is deeply notched, giving the appearance of two separate lobes. Coloration is very similar to Lost River sucker, with dark back and sides and a silvery or white belly. They are generally smaller than Lost River suckers, but can still grow to about 0.65 meters (2.1 feet; Moyle 2002). Shortnose sucker are one of three extant species in the genus *Chasmistes* (Nelson et al. 2004), with the other two being the cui-ui sucker (*Chasmistes cujus*) in Pyramid Lake, Nevada and the June sucker (*Chasmistes liorus*) in Utah Lake, Utah (Cooke et al. 2005).

Hybridization was identified at the time of listing as a threat. Data suggest that hybridization among four Klamath Basin suckers (Lost River sucker, shortnose sucker, Klamath largescale sucker [*Catostomus snyderi*] and Klamath smallscale sucker [*Catostomus rimiculus*]) does occur (Dowling 2005, Tranah and May 2006). Specifically, morphological and molecular genetics research indicate that hybridization occurs between shortnose sucker and Klamath largescale suckers in Gerber Reservoir, and, less frequently, in Clear Lake Reservoir and the Lost River (Markle et al. 2005, Tranah and May 2006). Increased hybridization resulting from human intervention can be cause for concern for imperiled species, and may even lead to extinction (Rhymer and Simberloff 1996). However, data suggest that hybridization among Klamath Basin suckers, especially shortnose sucker and Klamath largescale sucker, is consistent with a pattern of historical hybridization, which is not uncommon for the sucker family (Dowling and Secor 1997, Dowling 2005, Tranah and May 2006). Even in the presence of hybridization all species continue to maintain unique morphological traits, although intermediate forms do occur as well (Dowling 2005, Markle et al. 2005). Further studies are needed to determine the extent and causes of hybridization.

C. DISTRIBUTION

Both Lost River sucker and shortnose sucker are **endemic** to the upper Klamath River Basin, including the Lost River and Lower Klamath Lake **sub-basins** (Figure 1). Historical distribution of these species is known primarily from incidental records by early explorers and newspaper reports, and so it is often difficult to precisely estimate historical distribution. We do know that the quantity of suitable stream/river, lake, and marshland habitats has been drastically reduced (USFWS 2007a, b). Currently the total area of lake habitat available for Lost River sucker and shortnose sucker is about 32,000 hectares (79,000 acres), of which approximately 80 percent is in Upper Klamath Lake, which covers approximately 26,000 hectares (64,000 acres).

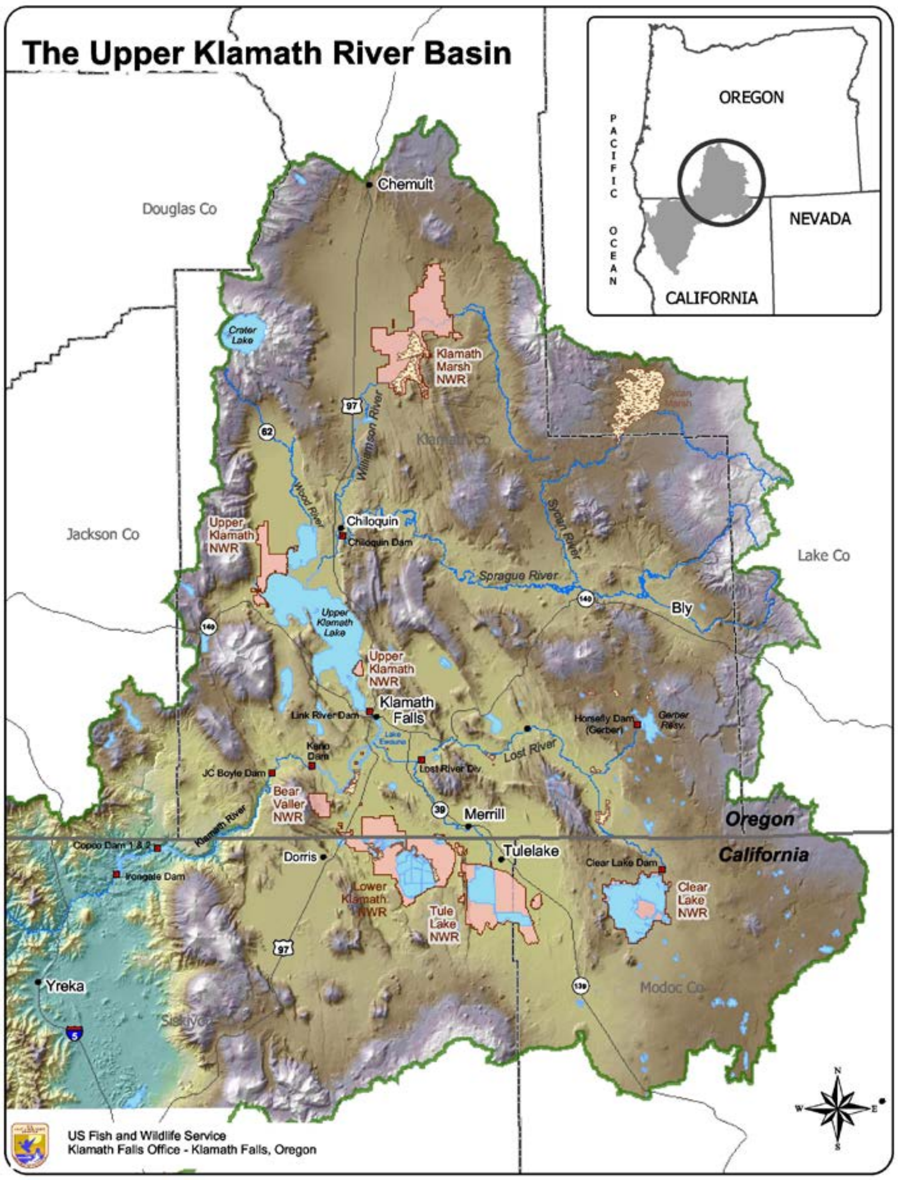

Figure 1 Upper Klamath Basin.

At the time of listing, Lost River sucker and shortnose sucker were known from Upper Klamath Lake and its tributaries and outlet (Klamath Co., Oregon; Figure 1), including a “substantial population” of shortnose sucker in Copco Reservoir (Siskiyou Co., California), as well as collections of both species from Iron Gate Reservoir (Siskiyou Co., California) and J.C. Boyle Reservoir (Klamath Co., Oregon), and Lost River sucker from

Sheepy Lake and Lower Klamath Lake (Siskiyou Co., California). Remnants and/or highly hybridized populations were also stated to occur in the Lost River system (Klamath Co., Oregon, and Modoc and Siskiyou Co., California) including both species in Clear Lake Reservoir (Modoc Co., California) and Lost River sucker in Tule Lake (Siskiyou Co., California; USFWS 1988). Although not stated explicitly, the reference in the listing to "highly hybridized populations" (USFWS 1988:27130) in the Lost River Basin probably refers to shortnose sucker within Gerber Reservoir (Klamath Co., Oregon). At the date of this revision the overall distribution has not changed at the sub-basin scale, but occurrences of shortnose sucker within Tule Lake have also been documented. Currently, Clear Lake Reservoir and Upper Klamath Lake and their tributaries support the largest populations. Populations in Klamath River below Keno Dam and in the Lost River drainage below Clear Lake Dam are comprised mostly of adults. These populations are probably functioning as **sink populations**, as they are not likely self-sustaining because of low recruitment due to the lack of access to spawning habitats (Moyle 2002, NRC 2004). All life stages of listed suckers have been found in Link River, the outlet of Upper Klamath Lake, in recent years (Bureau of Reclamation [BOR] 2000, Piaskowski 2003, PacifiCorp 2004).

Fisheries surveys in Keno Reservoir have been conducted infrequently and have generally been short in duration (Oregon Department of Fish and Wildlife [ODFW]1996, Piaskowski 2003, PacifiCorp 2004). The only intensive monitoring effort was conducted by Terwilliger *et al.* (2004). Larvae and age-0 suckers were generally most abundant in the upper part of Keno Reservoir and decreased downstream. Based on recent sampling efforts conducted by the Bureau of Reclamation (2008 – 2010) **juvenile, sub-adult** and adult suckers may occur in higher numbers than previously thought (T. Tyler, Klamath Basin Area Office, Bureau of Reclamation, pers. comm. 2010).

Known areas of concentrated Lost River sucker spawning in the Williamson and Sprague Rivers include the lower Williamson River from **river mile** 6 to the confluence of the Sprague River (river mile 11), lower Sprague River below Chiloquin Dam area, and in the Beatty Gap area of the upper Sprague River (river mile 75; Buettner and Scoppettone 1990, Tyler et al. 2004, Ellsworth et al. 2007). Other areas in the Sprague River watershed where Lost River sucker may spawn include the lower Sycan River and in the Sprague River near the Nine Mile area (Ellsworth et al. 2007). A smaller but significant number of Lost River sucker also spawn over gravel at shoreline springs along the margins of Upper Klamath Lake (Buettner and Scoppettone 1990, NRC 2004). **Mark-recapture** data indicate that the two stocks maintain a high degree of fidelity to spawning areas and seldom interbreed (Hayes et al. 2002, Barry et al. 2007a), although lack of genetic distinction suggests that some mixing may occur (Dowling 2005). Historically, suckers were known to spawn at many shoreline springs, including Harriman Springs and Barkley Spring (Andreasen 1975, NRC 2004). However, significant spawning aggregations currently occur at Sucker Springs, Cinder Flats, Silver Building Springs, and Ouxy Springs. Fewer individuals are also known to spawn at Boulder Springs. Spawning at these springs is very sensitive to lake levels; as levels decline much of the spawning habitat quickly becomes unavailable.

Shortnose sucker from Upper Klamath Lake also currently spawn primarily in the lower Williamson and Sprague Rivers (Tyler et al. 2004, Ellsworth et al. 2007). However, the few adult shortnose sucker captured at shoreline spawning areas in Upper Klamath Lake indicate that some shortnose sucker spawning is likely to still occur at these locations (Hayes et al. 2002, Barry et al. 2007a, b). A small number of suckers, approximately 70 individuals and primarily shortnose suckers, were captured during spring sampling in 1996, 1999, and 2000 near the mouth of the Wood River in Agency Lake, presumably preparing to spawn (BOR 2001). Investigations have not located suckers in Upper Klamath Lake tributaries other than the Williamson, Sprague, and Wood Rivers; although, some have reported much broader historical distribution of spawning among Upper Klamath Lake tributaries (Stine 1982).

A small group of Lost River sucker apparently resides in the Sprague River near Beatty. A few adult Lost River sucker were first encountered during the summer of 2001 during fish survey work in the Sprague River (L. Dunsmoor, Klamath Tribes, pers. comm. 2007). In 2007 and 2008, we located small groups of adult Lost River sucker above the confluence of the Sycan River and below Beatty Gap and near the community of Sprague River (M. Buettner, U.S. Fish and Wildlife Service, pers. comm. 2009). Although a substantial fish survey effort was conducted on the Sprague River in 2007 by us and Oregon State University, no adult shortnose sucker were collected.

Historically, large sucker spawning migrations occurred from Tule Lake up the Lost River to near Olene and Big Springs near Bonanza (Bendire 1889, Howe 1969). Such migrations are currently blocked by Anderson Rose Dam. There is weak evidence, however, of resident populations in the river (above Malone Dam for example) and Clear Lake Reservoir tributaries (Buettner and Scoppettone 1991). Populations of Lost River sucker and shortnose sucker residing in Clear Lake Reservoir are known to spawn in Willow Creek (Buettner and Scoppettone 1991, Barry et al. 2007a); however it is also possible, but currently unknown, if areas other than Willow Creek are used for spawning. Little information exists on the spawning areas for populations from Gerber Reservoir; however surveys of spawning areas in during the spring 2006 detected more than 1,700 suckers ascending Ben Hall Creek and Barnes Valley Creek (Barry et al. 2007a).

D. HABITAT CHARACTERISTICS

Upper Klamath Lake is a large natural lake that was modified with a control structure in 1919 (Table 1). The watershed encompasses about 9,800 square kilometers (3,800 square miles), ranges in elevation from 1,250 meters (4,100 feet) to over 2,700 meters (9,000 feet), and has an average annual precipitation of approximately 68 centimeters (27 inches; Boyd et al. 2002) . Its three major tributaries are the Sprague, Williamson, and Wood Rivers, all of which flow into the northern portion of the lake (Figure 1). The lake itself is relatively shallow throughout, but the Eagle Ridge trench on the west side of the lake can reach depths of 12 meters (40 feet). Approximately 6,500 hectares (16,000 acres) of wetlands remain connected to the lake (Snyder and Morace 1997, Aquatic Science Resources 2005). The outlet river of Upper Klamath Lake, the Link River, flows a short distance before entering Lake Ewauna. This habitat functions primarily as a corridor for large numbers of larval and juvenile suckers entrained in the downstream flow moving through the Link River Dam (Gutermuth et al. 2000, Foster and Bennetts 2006, Tyler 2007). The river may also potentially permit movement of adults upstream toward spawning habitats during spring. Such movements are ultimately dependent on passage through the Link River Dam by means of a fish ladder (Piaskowski 2003). Only seven individuals were detected between 2005 – 2007 in the fish ladder (Korson et al. 2008), but 25 individuals were detected in the fish ladder in 2010 (T. Tyler, pers. comm. 2010). This increase may indicate an improved ability to detect such movements as the number of tagged fish increases.

Lake Ewauna is a naturally occurring lake, but it has become functionally indistinguishable from a downstream impoundment, the Keno Reservoir. This reservoir experiences extremely poor water conditions annually (Sullivan et al. 2008, Kirk et al. 2010). Dissolved oxygen levels of less than 1 milligram/liter, well below the minimum criterion of 4 milligrams/liter, occur regularly (Kirk et al. 2010).

Clear Lake Reservoir (Figure 2), also a modified natural lake, was modified by a control structure in 1910, which increased the size of the lake (Table 1); although, it remains relatively shallow throughout. It is located in the upper reaches of the Lost River watershed, which covers 2,100 square-kilometers (700 square-miles) and ranges in elevation from approximately 1,400 meters to 1,900 meters (4,500 feet to 6,100 feet; BOR 1970). Annual precipitation is approximately 33 centimeters (13 inches). The lake has one major tributary, Willow Creek (Buettner and Scoppettone 1991, Scoppettone et al. 1995, Barry et al. 2009). Upstream stock ponds and diversions reduce inflows somewhat, and over half of the annual inflow is lost to seepage and evaporation (BOR 1970). During the 65-year period prior to 1970, annual net inflow fluctuated between 22,200 cubic decameters and 460,000 cubic decameters (approximately 18,000 acre-feet to 370,000 acre-feet; BOR 1970). The lake has never reached its capacity of 555,000 cubic decameters (450,000 acre-feet), but averages approximately 2.4 meters (7.8 feet) in depth (BOR 1970, NRC 2004).

Hydrographs of both Clear Lake and Upper Klamath Lake exhibit patterns of a snow-melt driven system with highest inflows and levels during spring and early summer, but groundwater is also a significant contributor to Upper Klamath Lake (Risley et al. 2005, Gannett et al. 2007). However, Clear Lake Reservoir and Upper Klamath Lake are managed to store water for irrigation. Clear Lake Reservoir is highly sensitive to drought and downstream water delivery because of its small watershed, low precipitation, minimal groundwater input, and high evaporation rates (NRC 2004).

Water quality conditions in Upper Klamath Lake are attributed to high nutrient loading. The lake was highly productive or **eutrophic** prior to settlement by Europeans in the mid-19th century, but it has become **hypereutrophic** from loading attributed to a combination of external (pumping of diked wetlands, farm/ranch run-off, and roads) and internal (lake sediments) sources (Snyder and Morace 1997, Boyd et al. 2002, Independent Multidisciplinary Science Team IMST 2003, Bradbury et al. 2004, Eilers et al. 2004, NRC 2004, Graham et al. 2005). Much of the nutrient load entering Upper Klamath Lake comes from **non-point sources** (Boyd et al. 2002). Nevertheless, on average, approximately 60 percent of the biologically available phosphorus is derived from internal loads, such as lake sediment.

Table 1 Basic information on the lakes and reservoirs of the upper Klamath Basin, adapted from Table 3-1 from The National Research Council of the National Academies (2004:96). One hectare is equivalent to approximately 2.47 acres, and 1 meter is equivalent to approximately 3.3 feet.

	Size before 1900 (hectares)		Size since 1960 (hectares)			
Lake Name	Minimum	Maximum	Minimum	Maximum	Volume[a] (acre-feet)	Mean Depth[b] (meters)
Lakes and reservoirs used for water storage and routing						
Upper Klamath[c]	31,600	44,900	22,700	27,100	603,000	2.7
Lower Klamath[d]	34,400	38,100	1,900	1,900	< 20,000	< 1.2
Clear Lake Reservoir[d]	6,100	6,100	3,400	10,400	527,000	6.1
Tule Lake[d]	22,300	44,500	3,800	5,300	50,000	1.2
Gerber Reservoir[d]	n/a	n/a	450	1,600	94,000	7.3
Reservoirs used for power production						
Keno[e,f]	n/a	n/a	1,000	1,000	18,500	2.1
J.C. Boyle[f]	n/a	n/a	170	170	1,700	1.2
Copco No. 1[f]	n/a	n/a	400	400	46,900	14.3
Copco No. 2[f]	n/a	n/a	16	16	70	0.6
Iron Gate[f]	n/a	n/a	380	380	58,800	18.9

[a] At current maximum depth. Historic volumes are not readily available.

[b] Mean depths are typically lower than shown in the table, which are based here on current maximum volume.

[c] Including Agency Lake, from Table 2-1 of Welch and Burke 2001(2001). Current maximum elevation is 4143.3. Area and volume data from U.S. Fish and Wildlife Service (2002).

[d] From Bureau of Reclamation (2001, Table 4.1)

[e] Including Lake Ewauna. Keno has no turbines.

[f] From Pacific Corp (2000), pp. 2-16 and 2-17.

Abbreviations: n/a, not applicable

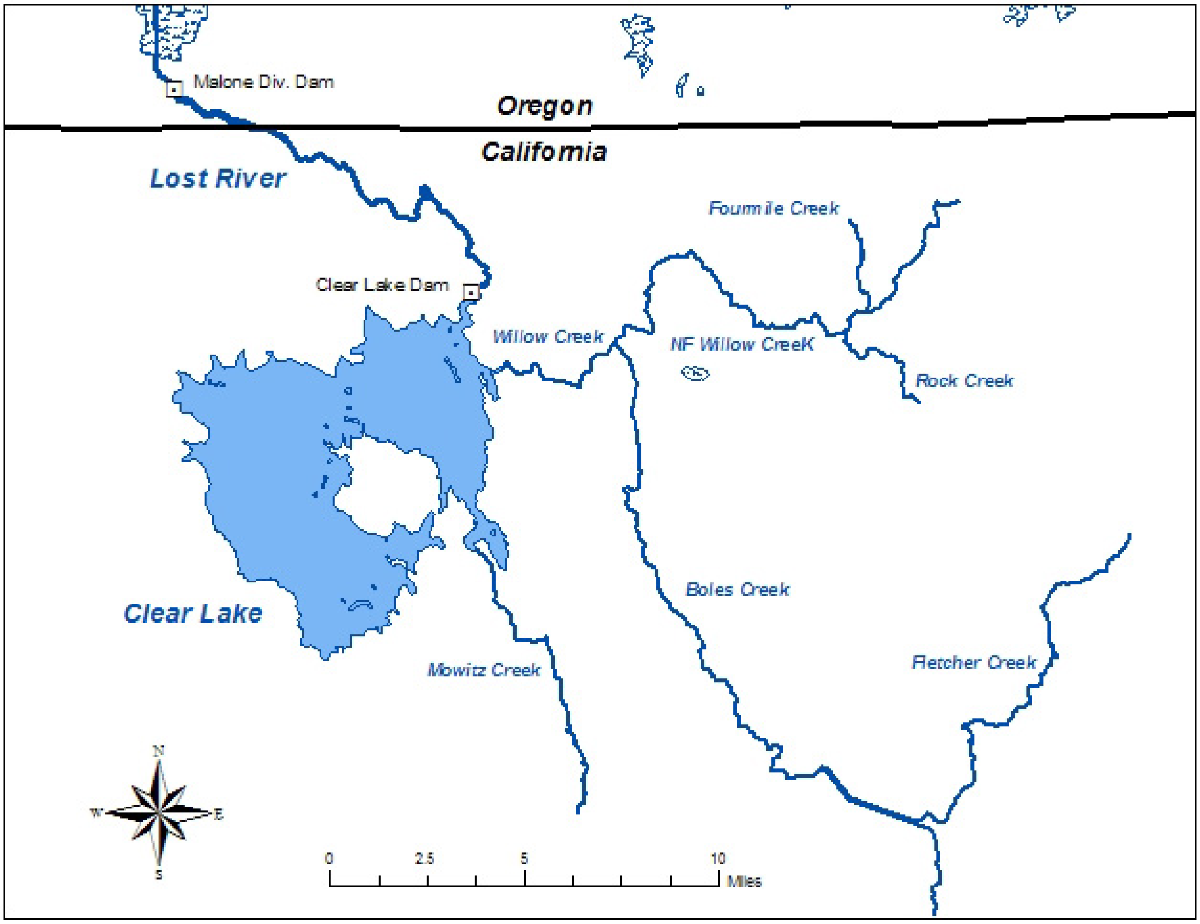

Figure 2 Vicinty map of Clear Lake Reservoir Watershed.

Sedimentation rates within Upper Klamath Lake dramatically increased during the 20th century, and these "modern" sediments are higher in nitrogen and phosphorus than pre-settlement sediment (Eilers et al. 2001) and are a significant contributor to the internal source of nutrients. Because the system now has a significant internal source of phosphorous, some authors express pessimism regarding prospects for remediation even if external sources are reduced (NRC 2004). However, Oregon Department of Environmental Quality believes that reduction in total phosphorus loading can improve water quality to the point that Total Maximum Daily Load standards can eventually be attained (Boyd et al. 2002). Likewise, the Sprague River, the primary spawning habitat for suckers in Upper Klamath Lake and the largest tributary to the Williamson River, is listed as water quality impaired for nutrients, temperature, sediment, and dissolved oxygen under the section 303d of the Clean Water Act.

Poor water quality in Upper Klamath Lake is particularly associated with high abundance of the blue-green algae *Aphanizomenon flos-aque*. Core samples of bottom sediments indicate that *Aphanizomenon flos-aque* was not present in Upper Klamath Lake prior to the 1900s (Bradbury et al. 2004, Eilers et al. 2004). Its appearance is believed to be associated with increases in productivity of the lake (NRC 2004). This algae now dominates the algal community from June to November, and, because of the high phosphorus concentrations and its ability to fix nitrogen, is able to reach seasonally high **biomass** levels that eventually produce highly degraded water quality (Boyd et al. 2002). Once the **algal bloom** subsides decomposition of the massive amounts of biomass can lower dissolved oxygen to levels harmful or fatal to fish (Perkins et al. 2000a, Boyd et al. 2002, IMST 2003, NRC 2004, Wood et al. 2006). Additionally, other **cyanobacteria** (*Microcystis* sp.) may produce toxins harmful to sucker liver tissue (Vanderkooi et al. 2010).

Water quality data for Clear Lake Reservoir is limited (BOR 1994, Hicks 2001), but it appears to be less productive than Upper Klamath Lake, and therefore does not experience similar algal blooms. Data collected during 1991 to 1995 near Clear Lake Dam and within the east and west lobes of the reservoir indicate that dissolved oxygen levels rarely declined below 4 milligram/liter, and temperatures rarely exceeded 26 degrees Celsius (79 degrees Fahrenheit; Hicks 2001). Likewise, aquatic vegetation is much less abundant in Clear Lake Reservoir than in Upper Klamath Lake (NRC 2004).

E. LIFE HISTORY AND ECOLOGY

Given the apparent similarities between the species, information on the **life history** and **ecology** of the species presented here is presumed to be pertinent to both, unless specified.

Lost River sucker and shortnose sucker exhibit many adaptations characteristic of long-lived species, with maximum ages of up to 57 and 33 years respectively (Scoppettone 1988, Buettner and Scoppettone 1990, 1991, Terwilliger et al. 2010). Juveniles grow rapidly until reaching sexual maturity sometime between four and nine years for Lost River sucker and four and six years for shortnose sucker (Perkins et al. 2000b). In ecological terms this is known as the generation time. Adults tend to have high survival rates enabling populations to outlive unfavorable periods, like droughts. Once achieving sexual maturation, Lost River sucker are expected to live on average 12.5 years (D. Hewitt, U.S. Geological Survey, pers. comm., 2011) based on methodology developed by Hoenig (1983). Similarly, shortnose sucker adults are estimated to live on average 7.4 years after having joined the adult population. Thus, for those individuals surviving to adulthood, we expect an average total life span of 20 years for Lost River sucker and 12 years for shortnose sucker, based on the average time to maturity and average adult life spans. Females produce a large number of eggs, 44,000 to 236,000 for Lost River sucker and 18,000 to 72,000 for shortnose sucker per year, of which only a small percentage survive to become juveniles (NRC 2004). The vast majority of individuals spawn every year (D. Hewitt and S. Burdick, U.S. Geological Survey, pers. comm., 2010). Larger, older females often produce substantially more eggs and, therefore, can contribute relatively more to production than a recently matured female.

Spawning occurs from February through May over gravel substrates in habitats less than 1.3 meters (4.3 feet) in rivers and shoreline springs (Buettner and Scoppettone 1990). Females broadcast their eggs which are fertilized most commonly by two accompanying males, but the number may be as high as seven (Buettner and Scoppettone 1990). The fertilized eggs settle within the top few inches of the substrate until hatching, around one week later. Approximately 10 days after hatching, when larvae reach about 7 to 10 millimeters (0.2 inches to 0.6 inches) **total length** and are still mostly transparent with a small yolk sac, they emerge out of the gravel (Coleman et al. 1988, Buettner and Scoppettone 1990).

Generally, larvae spend little time in rivers after **swim-up**, but quickly drift downstream to the lakes. In the Williamson River, larval movement away from the spawning grounds begins in April and is typically completed by July. Downstream movement mostly occurs at night near the water surface (Klamath Tribes 1996, Tyler et al. 2004, Ellsworth et al. 2010). The downstream drifting of the larvae that occurs during the daytime appears to be relatively distributed throughout the water column (Ellsworth et al. 2010). Once in the lake, larvae inhabit near-shore areas (Cooperman 2004, Cooperman and Markle 2004). Larvae density is generally higher within and adjacent to **emergent vegetation** than in areas devoid of vegetation (Klamath Tribes 1996, Cooperman and Markle 2004, Crandall et al. 2008). Emergent vegetation provides cover from predators and habitat for prey such as zooplankton, **macroinvertebrates**, and **periphyton** (Klamath Tribes 1996, Cooperman and Markle 2004, Crandall 2004). Such areas also may provide refuge from wind-blown current and turbulence, as well as areas of warmer water temperature which may facilitate larval growth (Crandall 2004, Cooperman et al. 2010).

Larvae transform into juveniles by mid-July at about 25 millimeters (0.98 inches) total length. Juvenile suckers primarily use relatively shallow (less than approximately 1.2 meters [3.9 feet]) vegetated areas, but may also begin to move into deeper, un-vegetated off-shore habitats (Buettner and Scoppettone 1990, Terwilliger et al. 2004, Hendrixson et al. 2007a, b, Burdick et al. 2008, Bottcher and Burdick 2010, Burdick and Brown 2010). One year old juveniles occupy shallow habitats during April and May, but may afterwards move into deeper areas along the western shore of Upper Klamath Lake until dissolved oxygen levels become reduced (Bottcher and Burdick 2010, Burdick and Vanderkooi 2010).

It is assumed that sub-adults (individuals which display all of the characteristics of adults with the exception of reproductive maturity) utilize habitats similar to adults (NRC 2004). Adult suckers inhabit water depths of 1 to 4.5 meters (3.3 – 14.8 feet), but appear to prefer depths from 1.5 to 3.4 meters (4.9 – 11.2 feet; Peck 2000, Reiser et al. 2001, Banish et al. 2009). Adult Lost River sucker and shortnose sucker are widely distributed in Upper Klamath Lake during the fall and winter (USFWS 2002, NRC 2004) but in the spring, congregations form in the north-east quadrant of the lake prior to moving into tributaries or shoreline spawning areas for spawning (Janney et al. 2009).

In general, lake suckers (including Lost River sucker and shortnose sucker) are relatively tolerant of degraded water quality conditions. They tolerate higher pH, temperature, un-ionized ammonia concentrations, and lower dissolved oxygen concentrations than many other fishes (Saiki et al. 1999, Meyer and Hansen 2002, NRC 2004). Nevertheless, water quality in Upper Klamath Lake and the Lost River often becomes poor enough to adversely affect both species, especially in summer (NRC 2004). Adults are primarily found in the northern portion of the lake above Bare Island during summer months (Peck 2000, Banish et al. 2009). Reasons for this summer distribution are probably related to better water quality near spring-fed Pelican Bay and the Williamson River (Reiser et al. 2001, USFWS 2002, Banish et al. 2009). During the summer and early fall, Upper Klamath Lake water quality conditions periodically deteriorate to stressful and even lethal levels for suckers as a result of decomposition of massive algae blooms and resultant low levels of dissolved oxygen (Loftus 2001). A multiple-year radio telemetry study documented Lost River sucker and shortnose sucker concentrating in or near Pelican Bay (in the northwest corner of Upper Klamath Lake) during periods of poor water quality, presumably to seek areas of better water quality (Banish et al. 2009).

Fewer specifics are known about Clear Lake Reservoir Lost River sucker and shortnose sucker populations. Life-history characteristics of these populations are similar to those in Upper Klamath Lake, with some notable differences. Annual variability in the number of individuals participating in spawning runs into Willow Creek can be attributed to spring time discharge; large runs occur during years of high flow. Likewise, spawning runs for both shortnose sucker and Lost River sucker are generally about one month earlier in Clear Lake Reservoir than river spawning fish from Upper Klamath Lake. This may be related to the small watershed supporting the lake, which effectively reduces the length of higher flows during the spring spawning period (Scoppettone et al. 1995). Barry *et al.* (2009) found that growth rates of both species in Clear Lake Reservoir were substantially greater than observed in Upper Klamath Lake. Also, there is evidence of some juvenile and adult rearing in tributaries to Clear Lake Reservoir (Buettner and Scoppettone 1991, Perkins and Scoppettone 1996). Although, it is possible that some adults simply become stranded during the spawning season as flows in Willow Creek may recede rapidly.

Lost River sucker and shortnose sucker have an evolutionary history with predatory species, including lamprey (*Lampetra* species), Klamath redband trout (*Oncorhynchus mykiss* sub-species), sculpin (*Cottus* species), and chubs (Cyprinidae), which may also compete with some life stages of suckers. In addition, approximately 20 fish species have been accidentally or deliberately introduced into the upper Klamath River basin, and comprised about 85 percent of fish biomass in Upper Klamath Lake when the suckers were listed (Scoppettone and Vinyard 1991, NRC 2004). The non-native fish species most likely to affect Lost River sucker and shortnose sucker are the fathead minnow (*Pimephales promelas*) and yellow perch (*Perca flavescens*). These fishes are believed to prey on young suckers and compete with them for food or space (Markle and Dunsmoor 2007). For example, fathead minnows were first documented in the Klamath Basin in the 1970s and are now the numerically dominant fish in Upper Klamath Lake (Andreasen 1975, Simon and Markle 1997). Additional **exotic**, predatory fishes found in sucker habitats, although typically in relatively low numbers, include bullheads (*Ameiurus* species), largemouth bass (*Micropterus salmoides*), crappie (*Pomoxis* species), green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*), and Sacramento perch (*Archoplites interruptus*; Koch et al. 1975, Logan and Markle 1993). Effects on suckers by these latter species are unknown.

Likewise, a number of pathogens or parasites have been identified from **moribund** suckers in Upper Klamath Lake, including anchor worm (*Lernaea* species; a parasitic **copepod**), *Trichodina* species (an external ciliate protozoan), and the bacterium *Flavobacterium columnare*, which produces Columnaris or “gill rot” disease, among others (Holt 1997, Foott 2004, Foott et al. 2010). *F. columnare* can damage gills and produce body lesions, and results in respiratory problems, internal salt concentration imbalances, or provide an entry route for lethal systemic pathogens (2005).

Sufficient information on disease and parasites are lacking for Clear Lake Reservoir. During 1992, a year of extremely low water levels, adult suckers showed signs of stress and a high incidence of anchor worm and lamprey infestation compared to fish sampled during 1993 through 1995 when water levels were higher (BOR 1994).

F. POPULATION DEMOGRAPHY AND TRENDS

In general, assessing the health of a population often includes estimation of how many individuals there are, what is the relative composition of the population by different groups, for example sexes or different age groups, and whether the numbers are increasing or decreasing (trend). With these tools, conclusions may be drawn not only on the current factors affecting the population, but often predictions can also be formulated about the future status of the population. Nevertheless, both demographic and overall population trend analysis are very sensitive to differences in methodology. For example, sampling gear, such as a specific type of net or trap, that poorly captures a specific size group may skew the resulting conclusions.

To gather demographic data on the relative composition of age classes for fish it is typical to examine various hard structures, which often record growth patterns in the form of annual rings, similar to tree rings. However, use of the most reliable hard structures, often **otoliths** (ear stones) or **opercles,** require sacrificing the fish (Belk 1998, Terwilliger et al. 2010). Because this can detrimentally affect small populations, length is often used as a surrogate for age, assuming that individuals continue to grow throughout their life. For lake suckers reduced growth rates often occur after sexual maturity (Figure 3) producing a poor correlation between size and age for older fish (Belk 1998). For example, a 10-year old female shortnose sucker in Clear Lake Reservoir could measure anywhere from approximately 315 millimeters to 450 millimeters fork length (Figure 3). Though a useful tool, hard structures often yield imprecise measurements with some amount of error, and such data, especially for individuals older than 10 years, are therefore best considered as estimates of age and not necessarily exact measurements (D. Hewitt, pers. comm., 2010). Nevertheless, given limited available data, below we discuss age structure of Lost River sucker and shortnose sucker populations within the context of length frequency as well as ages determined from hard structures extracted from dead fish. Likewise, because of difficulty in sampling all life stages, information presented here primarily reflects spawning or adult populations, but also includes some non-reproductive individuals collected during fish kill events.

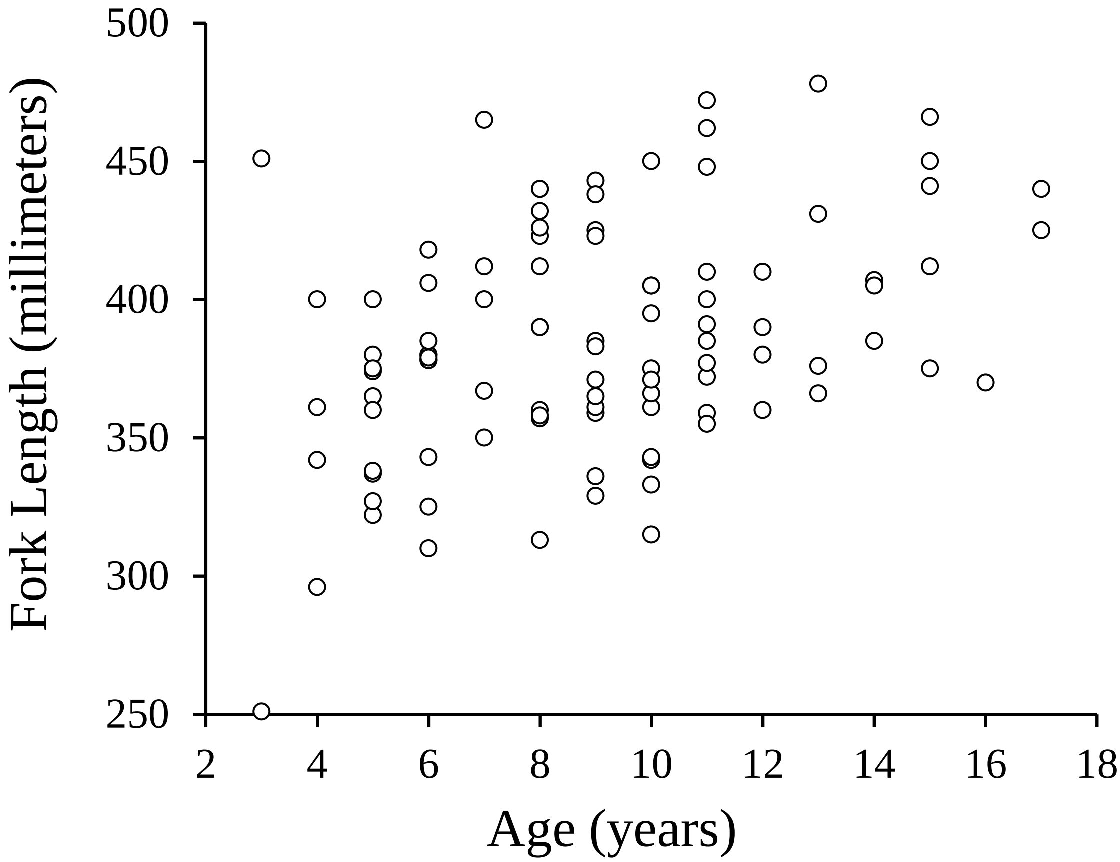

Figure 3 Size at a given age for female shortnose sucker in the Clear Lake Reservoir System. Age determined from otolith examination of fish collected 1989 through 1993 (D. Markle, Oregon State University, unpubl. data 2010). Each symbol represents an individual female.

Additionally, a number of methods can be used to estimate the size of animal populations. Selection of an appropriate method must consider life history, habitat characteristics, effectiveness of capture methods, sensitivity of a species to handling, and required accuracy. Accurate estimates are most easily made in situations where the number of populations are relatively small and occupy a discrete, closed environment where the ability to count each individual is great. Accuracy decreases as habitat size and rarity increase because the probability of encountering each individual becomes increasingly small. Under such conditions, the error of an estimate can become unacceptably large, rendering the estimate effectively meaningless.

1. Upper Klamath Lake

Accurately determining age class distribution is often a challenge because of sample size and methods (such as non-randomly selecting individuals). However, because both species are long-lived and many age classes may be poorly or unrepresented while others may be very abundant, relatively large length – and sex-stratified random samples are required to determine accurate age class distributions (D. Markle, Oregon State University, pers. comm., 2010). Data produced from otoliths of fish collected during an April 1970 creel survey conducted by the Oregon Department of Fish and Wildlife provide insight into historic Lost River sucker age class structure in Upper Klamath Lake (Terwilliger et al. 2010), even though the data are somewhat limited in scope. Seventy-four spawning Lost River sucker ranging in age from approximately 8 to 57 years old were analyzed (Figure 4). In more recent data derived from fish kills during 1986, 1995, and 1997, the distribution ages of examined Lost River sucker were predominantly limited to less than 10-year-old fish, although some older individuals were also part of the sample (Figure 4). Distribution of ages of shortnose sucker collected during the same fish kills exhibit similar patterns (D. Hewitt, unpubl. data). However, in each of these instances the non-random sample resulting from opportunistic sampling of individuals from fish kill events or creels limits our ability to make general conclusions about overall population age distributions during these periods.

At the time of listing, Upper Klamath Lake spawning populations of Lost River sucker, and presumably shortnose sucker, received little recruitment and were dominated by older individuals (Scoppettone and Vinyard 1991, Janney and Shively 2007, Janney et al. 2008). A 1986 survey of 190 Lost River sucker opercles from Upper Klamath Lake revealed an age distribution of individuals between 8 and 43 years (Scoppettone and Vinyard 1991). The majority of individuals were 16 to 30 years old, and only 9 were less than 16 years old. Similarly, ages, determined from opercles, of 19 shortnose sucker from Copco Reservoir in 1987 ranged from 16 to 33 (mean = 23 years) suggesting that shortnose sucker populations were also comprised primarily of older individuals (Scoppettone and Vinyard 1991).

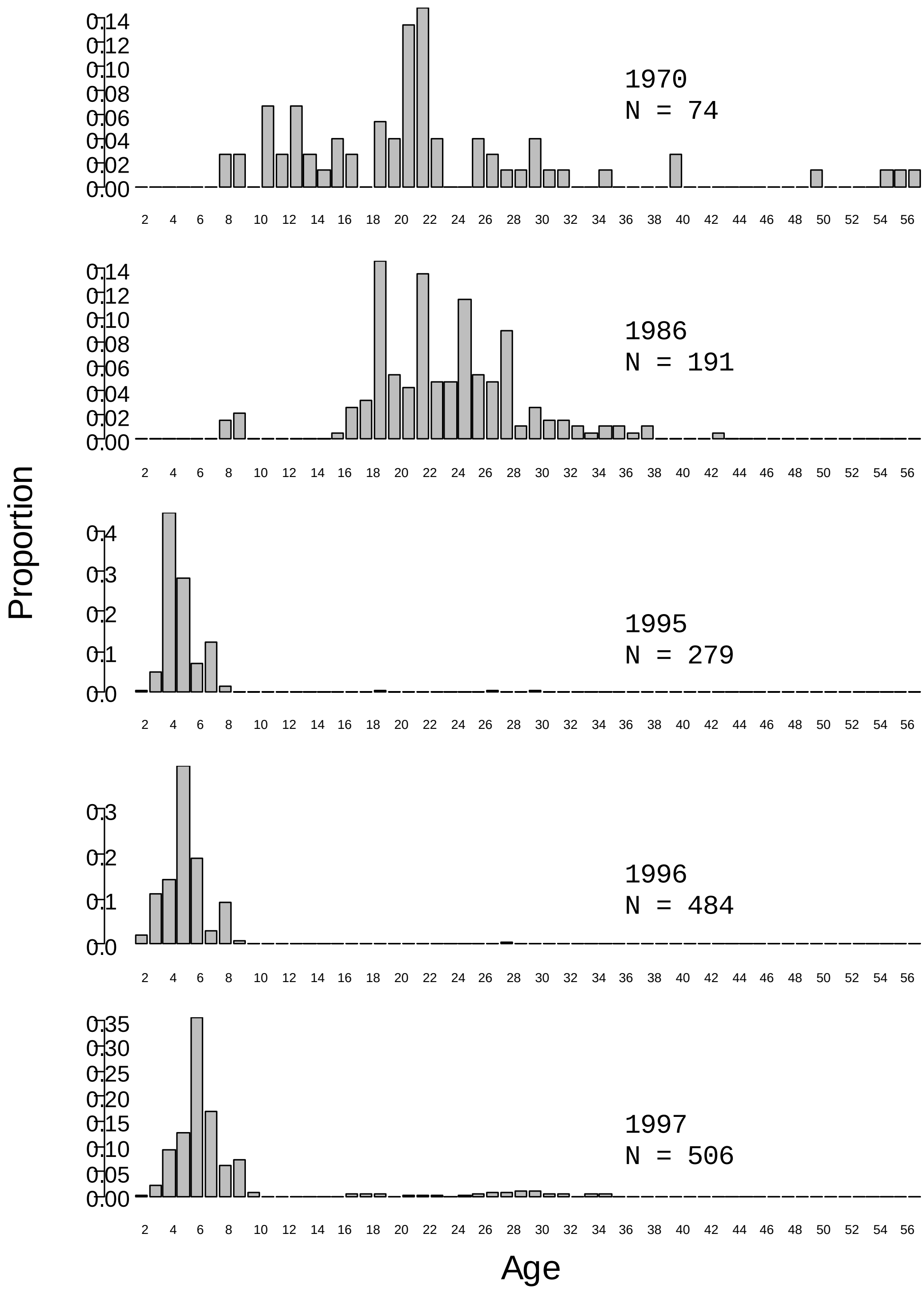

Figure 4 Proportion of ages of Lost River sucker from Upper Klamath Lake collected during a 1970 creel survey (otoliths; ODFW, unpubl. data, Terwilliger et al. 2010) and fish kills which occurred during 1986, 1995, 1996 and 1997 (opercles; Coleman et al. 1988, D. Hewitt, USGS, unpubl. data). Data from 1970 and 1986 were read by a single individual, while data from 1995 – 1997 were read by two individuals, and disagreements (24 percent of the fish) were averaged and rounded up.

Recent size distribution trends reveal that spawning populations are comprised mostly of similarly-aged, older individuals. Lost River and shortnose sucker spawning populations in Upper Klamath Lake transitioned from populations dominated by old, larger adult fish with little size diversity in the late 1980s and early to mid-1990s, to populations dominated by young, smaller adult fish and very few large individuals by the late 1990s (Janney et al. 2008). This marked shift in size structure to smaller individuals can only be explained by substantial recruitment to these populations sometime during the mid-1990s in combination with adult mortality that accounts for the rapid decline in the frequency of large and presumably old individuals. However, since the late 1990s populations of both species have exhibited an increasing trend in length (5 to 12 millimeters increase in median fork length per year; Janney and Shively 2007, Janney et al. 2008). During this period, 1995 through 1997, significant fish kills of suckers in Upper Klamath Lake were documented each year. Over 7,000 dead suckers, ranging in age from 2 years old to 33 years old were collected during the late summer months of these three years (D. Hewitt, USGS, unpubl. data. 2010, Perkins et al. 2000a). Collections of dead suckers were comprised predominantly of adult-sized suckers, with the exception of 1997, which included relatively smaller Lost River sucker (330 to 400 millimeters fork length) and shortnose sucker (290 to 330 millimeters fork length; Perkins et al. 2000a).

Between 1999 and 2008, roughly 10,000 Lost River sucker were captured and tagged at shoreline-spring spawning sites, with another 15,000 handled as part of the spawning run up the Williamson River (Janney et al. 2009). During a similar time period, 1995 – 2008, approximately 14,000 shortnose sucker were captured, predominantly associated with the Williamson River spawning runs (Janney et al. 2009). Nevertheless, the size of Upper Klamath Lake and the relative scarcity of Lost River sucker and shortnose sucker in the lake make it difficult to accurately estimate their abundance. Means to detect trends within these populations are therefore necessary to monitor population status.

Since 1995, more detailed demographic information has been compiled through an extensive mark-recapture program using **Passive Integrated Transponder tags** in Upper Klamath Lake and more recently in Clear Lake Reservoir (Janney et al. 2008, Janney et al. 2009). This program is designed to monitor demography of adult spawning populations of Lost River sucker and shortnose sucker and detect trends in spawning population size and composition. One way ecologists determine population trend is by estimating annual survival, mortality, and recruitment rates, which can be used to estimate **realized population change** rates (represented as λ). When λ is greater than one the population is increasing, and when λ is less than one the population is decreasing. A λ equal to one indicates a stable population. When λ is known from a number of contiguous sample events, the realized change in the size of a population proportional to some previous period can be estimated. A detailed description of these variables, their estimates, how they are calculated for Lost River sucker and shortnose sucker populations in Upper Klamath Lake, and challenges to provide statistical rigor to their estimates are presented in Appendix II.

Mark-recapture studies in Upper Klamath Lake from 2002 to 2007 produce annual survival probabilities for shoreline spring-spawning Lost River sucker that range between 0.80 and 0.95 (mean = 0.90; Table 2). Lost River sucker spring-spawning abundance in 2007 is estimated to be 56 percent and 75 percent of 2002 abundances for males and females respectively (Figure 5), although the exact abundances are unknown and these values represent estimates of realized population change. Estimates of river-spawning shortnose sucker annual survival probabilities are even lower; from 2001 to 2007 annual survival probabilities of river-spawning shortnose sucker ranged between 0.68 and 0.94 (mean = 0.82; Table 2). The spawning population abundances in 2007 of male and female river-spawning shortnose sucker were 42 percent and 48 percent Figure 5, relative to 2001. Similar data are not currently available for Upper Klamath Lake Lost River sucker river-spawning fish or for Clear Lake Reservoir Lost River sucker and shortnose sucker populations. This information will be obtainable when the number of tagged fish is sufficiently large to provide precise, statistically rigorous estimates and enough annual samples are conducted.

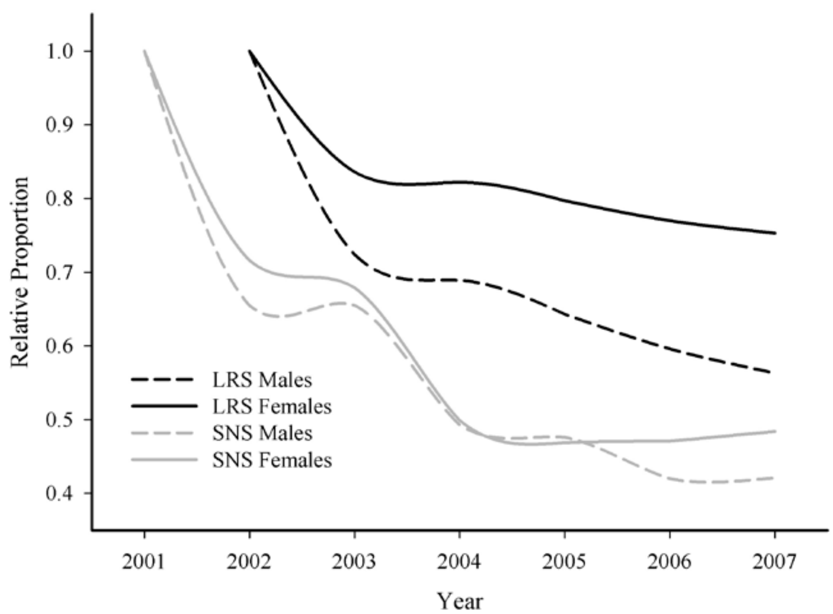

Figure 5 Realized change in populations proportional to 2001 for river spawning shortnose suckers (SNS) and 2002 for spring-spawning Lost River suckers (LRS) as determined by mark-recapture studies (Janney and Hewitt, unpubl. data).

Table 2 Estimated survival and annual rate of population change (λ) for Upper Klamath Lake shoreline spring habitat spawning male and female Lost River sucker and for Williamson/Sprague spawning male and female shortnose sucker (Janney and Hewitt, U.S. Geological Survey, unpubl. data 2009). All estimates are provisional and are subject to change with the collection of more data or refinements to the analysis strategy. Standard errors of estimates and a detailed description of how these factors were calculated are presented in Appendix II.

	Lost River Sucker				Shortnose sucker			
	Male		Female		Male		Female	
Year	Survival	λ	Survival	λ	Survival	λ	Survival	λ
2001	NA	NA	NA	NA	0.691	0.766	0.675	0.735
2002	0.795	0.820	0.863	0.892	0.771	0.855	0.894	0.974
2003	0.857	0.883	0.907	0.937	0.902	1.000	0.871	0.949
2004	0.923	0.952	0.951	0.983	0.679	0.753	0.675	0.735
2005	0.905	0.933	0.939	0.970	0.870	0.965	0.862	0.939
2006	0.899	0.927	0.935	0.966	0.795	0.882	0.923	1.005
2007	0.917	0.945	0.947	0.978	0.905	1.004	0.944	1.028
		0.56[a]		0.75[a]		0.42[b]		0.48[b]

[a] The relative change in spawning population size compared to the first year, 2002.
[b] The relative change in spawning population size compared to the first year, 2001.

2. Clear Lake Reservoir

Clear Lake Reservoir currently supports the only known spawning populations of Lost River sucker and shortnose sucker in the Lost River system. Adults of both species occur in other portions of the drainage, but spawning is irregular or populations are potentially hybridized with Klamath largescale suckers, as is the case for shortnose sucker in Gerber Reservoir). Less is known about shortnose sucker and Lost River sucker demography and trends in Clear Lake Reservoir than in Upper Klamath Lake because monitoring studies have been sporadic over the past 35 years, and studies similar to those conducted by Janney *et al.* (2008) in Upper Klamath Lake were not initiated in Clear Lake Reservoir until 2006 (Barry et al. 2009). Early data suggested that Clear Lake Reservoir populations were in decline (Andreasen 1975, Koch et al. 1975); however, monitoring from 1989-2000 indicate that populations are relatively stable with a somewhat diverse age structures (Buettner and

Scoppettone 1991, BOR 1994, Scoppettone et al. 1995). Fifteen age classes were documented in the shortnose sucker population during 1989 (Figure 6-A) and nine during 1993 (Figure 6-B). Similar data are not currently available for Lost River sucker since they are captured less frequently than shortnose sucker and appear to be less abundant in Clear Lake Reservoir. In general, growth rates for both sexes of both species appear to be 2 – 4 times higher than Upper Klamath Lake counterparts (Barry et al. 2009, Janney et al. 2009), which may be partly attributable to at least some recurring recruitment and therefore relatively younger populations in Clear Lake Reservoir. Also, sex ratios of shortnose sucker are strongly skewed in favor of females over males, often 2:1.

Combined, more than 10,000 Lost River sucker and shortnose sucker have been captured and tagged in Clear Lake Reservoir since 1993. These data reflect periods of recruitment failure and success similar to patterns in Upper Klamath Lake populations (Barry et al. 2009). Populations in the early- to mid-1990s showed little evidence of recruitment and consisted mostly of large fish, but apparent recruitment events occurred in the late-1990s and early-2000s. Length-frequencies from 2005 – 2009 reveal evidence of shortnose sucker recruitment, but recruitment into the Lost River sucker population has been sparse over that period.

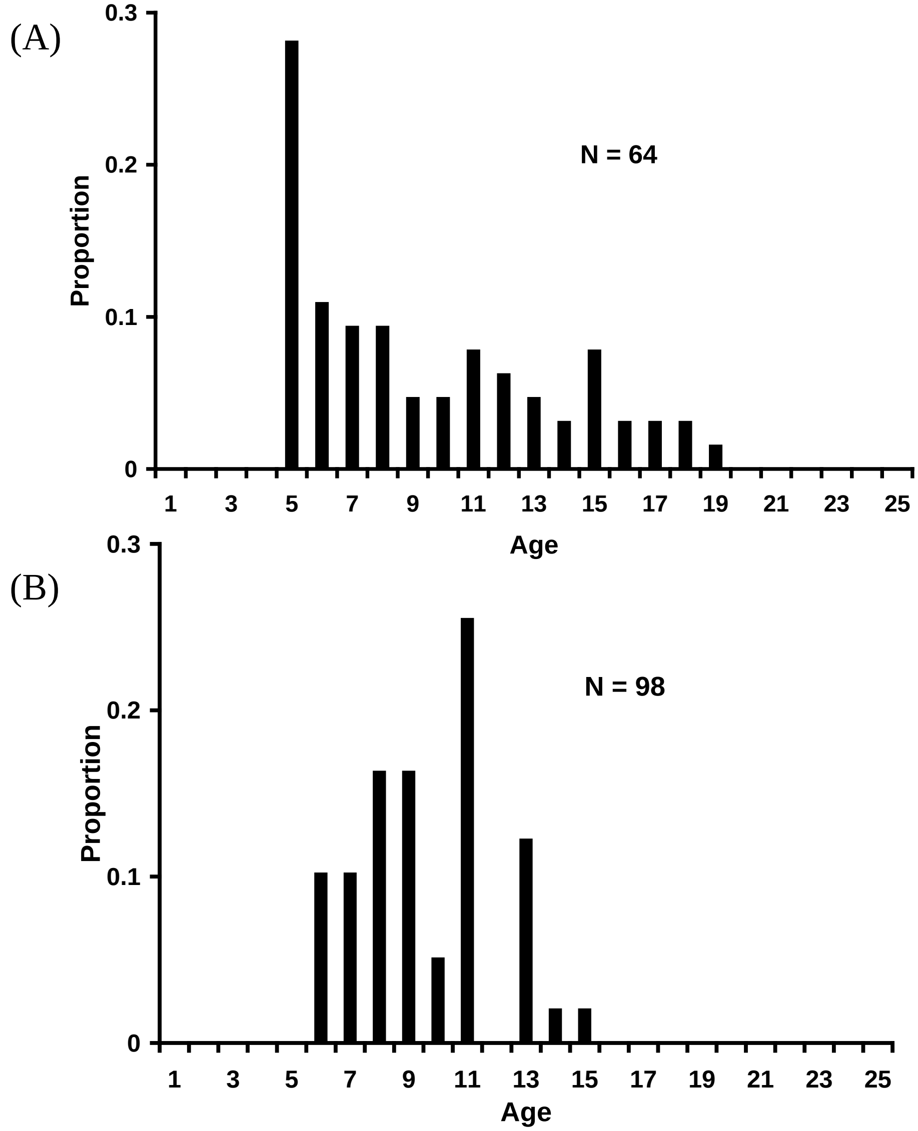

Figure 6 Shortnose sucker age distribution compiled from Clear Lake Reservoir fish sampled during (A) 1989 (Buettner and Scoppettone 1991), and (B) 1993 (U.S. Geological Survey, unpubl. data).

G. REASONS FOR LISTING AND CONTINUED THREATS

Reasons for listing as well as threats to the continued survival of Lost River sucker and shortnose sucker are reviewed in a number of reports and peer reviewed articles (USFWS 1988, Markle and Cooperman 2002, NRC 2004, ISRP 2005, USFWS 2007a, b). The following discussion is a brief summary of the interacting influences of physical, chemical, and biological factors that continue to threaten current Lost River sucker and shortnose sucker status.

In determining whether to list, delist, or reclassify (change from endangered to threatened status, or vice versa) a species under section 4(a) of the ESA, we evaluate five major categories of threats to the species: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. The following is a summary of factors that supported Lost River sucker and shortnose sucker listing (USFWS 1988) and that were addressed in the 5-year status reviews (USFWS 2007a, b) for each species:

1. Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range

Loss and alteration of habitats (including spawning and rearing habitats) were major factors leading to the listing of both species (USFWS 1988) and continue to be significant threats to recovery. As noted above, both species utilize the spectrum of aquatic habitats during some stage of the life cycle, including river or stream habitats, open-water lake habitats, and the wetlands areas along banks and shores. However, negative impacts and alterations to each of these different habitats have occurred, and continue to threaten the recovery of these species. Suitable habitat has drastically declined due to conversion of wetlands to agricultural use and construction of irrigation and hydroelectric facilities, both of which drained lakes and wetlands, created barriers preventing access to spawning habitat, and caused mortality by entraining fish. For example, approximately 61,000 hectares (150,700 acres; approximately 77 percent) of sucker habitat were lost by lowering Tule and Lower Klamath Lakes (NRC 2004).

Barriers that limit or prevent access to spawning habitat were identified as a threat when we listed Lost River sucker and shortnose sucker. Chiloquin Dam was cited as the most influential barrier because it restricted access to potentially 95 percent of historic river spawning habitat in the Sprague River (USFWS 1988). However, this dam was removed in 2008, providing access to approximately 78 kilometers (56 miles) of river for spawning. At the time of this revision, data are insufficient to assess the actual realized benefit to spawners, but studies are ongoing. Nevertheless, many other large and small diversion structures remain throughout the range of these species including the Sprague River, although specific direct and indirect negative impacts are difficult to quantify (NRC 2004). For example, several large dams (such as the Link River Dam and Anderson Rose Dam) potentially inhibit upstream movements. Likewise, suckers attempting to run up the Lost River are restricted to below the Anderson-Rose Dam, a short distance upstream from Tule Lake (Appendix C of USFWS 2002).

Another equally important barrier is limited hydrologic connection to spawning or rearing habitat often resulting from an interaction of irrigation diversions and climate. For example, low lake levels adversely affect Clear Lake Reservoir sucker populations by limiting access to Willow Creek, the only known spawning tributary (Buettner and Scoppettone 1991). Likewise, the amount of suitable shoreline spring spawning habitat in Upper Klamath Lake is significantly affected by even minor changes in lake elevation, but it is unknown exactly how such levels directly affect annual productivity. Several shoreline spring-spawning populations, including Harriman Springs and Barkley Springs, have been lost or significantly altered due to railroad construction (Andreasen 1975, USFWS 1988, NRC 2004).

Historically, wetlands comprised hundreds of thousands of hectares throughout the range of the species (Akins 1970, Bottorff 1989, Gearhart et al. 1995), some of which likely functioned as crucial habitat for larvae and juveniles. Other wetlands may have played vital roles in the quality and quantity of water. Loss of ecosystem functions such as these, due to alteration or separation of the habitat, is as detrimental as physical loss of the habitat. For example, increases in sediment input to the lake and occurrence of *Aphanizomenon flos-aquae* coincide with modification of riparian and wetland areas associated with Upper Klamath Lake (Bradbury et al. 2004). In Upper Klamath Lake, approximately 70 percent of the original 20,400 hectares (50,400 acres) of wetlands surrounding Upper Klamath Lake, including the Wood River Valley (Figure 7), was diked, drained, or significantly altered between 1889 and 1971 (Bottorff 1989, Gearhart et al. 1995). Additionally, of the approximately 10,174 hectares (25,141 acres) of wetlands still connected to Upper Klamath Lake, relatively little functions as rearing habitat for larvae and juveniles, partly due to lack of connectivity with current spawning areas.

Certainly not all modification or curtailment of sucker habitat is solely from **anthropogenic** causes; climatic trends, resulting from both anthropogenic causes and natural variation, also play an important role. Since 1960, eight of the ten lowest inflows into Upper Klamath Lake occurred between 1991 and 2009 (Bureau of Reclamation, unpubl. data, 2010). Upper Klamath Lake levels are affected by drought, because it is shallow (average depth in summer = 2.2 meters [7.1 feet]), and because during droughts larger irrigation diversions are needed to offset low soil moisture in agricultural fields and wildlife refuges. Affected by the same regional droughts, Clear Lake Reservoir is even more sensitive to droughts given the limited local precipitation and **bathymetry** of the lake itself. Severe or prolonged droughts likely negatively impact all Lost River sucker and shortnose sucker life stages throughout their range (Cooperman and Markle 2004, Helser et al. 2004, Loftus and Reiser 2004).

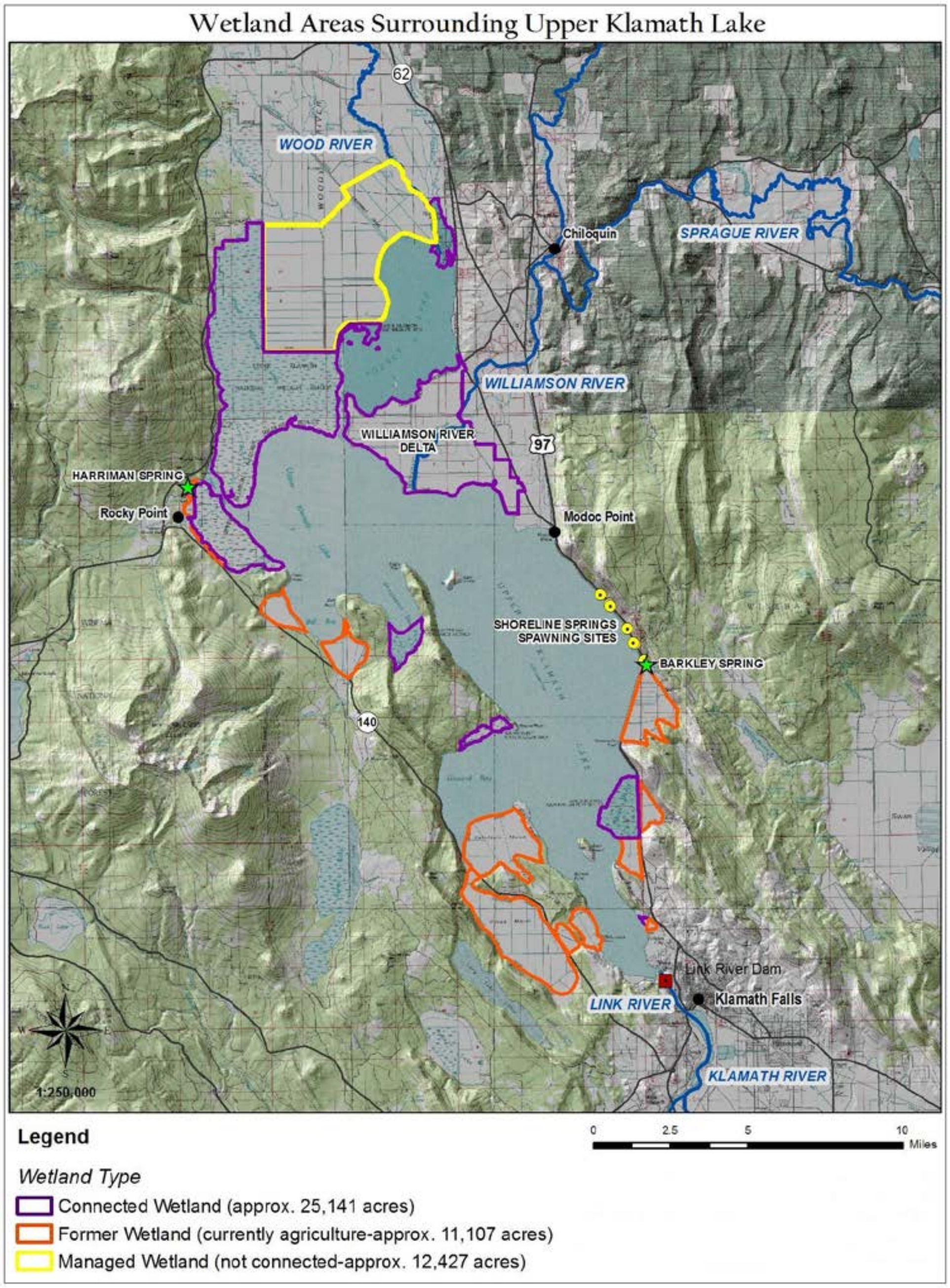

Figure 7 Map showing historical Upper Klamath Lake wetlands and their current connectivity to the lake. Yellow points identify locations of current shoreline-spring spawning locations.

2. Factor B: Overutilization for commercial, recreational, scientific, or educational purposes

Overharvest contributed to declining population levels prior to listing, but harvest of any kind has been restricted since 1987 (USFWS 2007a, b). However, if one or both of these species recover sufficiently to be removed from the endangered species list, recreational harvest may again affect these species. Regulated collections of these species for scientific purposes continue, and although not considered a current threat to population status, the demographic effects of these collections need to be regularly evaluated.

3. Factor C: Disease or predation

Non-native fishes were identified as a potential threat at the time of listing through predation or as sources of exotic diseases/parasites, although no direct evidence was cited. Since then, controlled experiments have demonstrated that adult fathead minnows prey on sucker larvae (Markle and Dunsmoor 2007). In Upper Klamath Lake, higher fathead minnow abundances were associated with lower sucker survival rates (Markle and Dunsmoor 2007). Likewise, as indirect evidence, higher larval sucker survival rates were also associated with greater water depth and shoreline vegetative cover, habitat which help larvae avoid predation (Markle and Dunsmoor 2007). These data suggest that predation by overly-abundant fathead minnows may be an important threat to larval sucker survival, and that loss of emergent wetland habitat may exacerbate this. Other non-native fishes may also pose a threat to Lost River sucker and shortnose sucker; however, little **quantitative** information exists to indicate their influence on sucker abundance and distribution.

Parasites were not identified as a threat at the time of listing, but information suggests they could be a threat to the suckers. Anchor worm parasitism on **age-0** suckers appears to be highly variable from year to year in Upper Klamath Lake (ISRP 2005, Bottcher and Burdick 2010). From 1994-1996, the percent of age-0 suckers parasitized by anchor worms ranged from 0 percent to 7 percent, but during 1997 through 2000 it increased to between 9 and 40 percent. In 2008 only four percent of captured juvenile suckers were infected with parasites, but this jumped to 18 percent in 2009 (Bottcher and Burdick 2010). Parasites can lead to direct mortality, provide a route for pathogens to enter fish (since they create a wound), or can make fish more susceptible to predation (Robinson et al. 1998). We don’t currently have enough information to accurately assess the degree to which parasites negatively impact sucker survival and productivity.

Of recent interest are the effects of microcystin, an algal toxin that affects the liver. In a 2007 survey, 49 percent of a sample of juvenile suckers (n = 47) collected at 11 shoreline sites exhibited indications of microcystin exposure (Vanderkooi et al. 2010). However, these data are preliminary and further investigations are required. For example, the means by which the toxin is introduced into the body remains unknown. One hypothesis is that the toxin is indirectly ingested when suckers consume midge larvae (Chironomidae), which feed on the algae.

4. Factor D: Inadequacy of existing regulatory mechanisms

Many federal and state regulations directly and indirectly affect the Lost River sucker and shortnose sucker, but the primary areas of regulatory authority are the Endangered Species Acts enacted by the Federal Government, and the States of Oregon and California. Both species are listed as endangered by each of these entities (USFWS 1988, California Department of Fish and Game [CDFG] 2010, ODFW 2010). In general, such authorities prohibit activities that will harm the species' chances of survival and/or recovery. For example, the Federal Endangered Species Act broadly prohibits import, export, take (to harass, kill, capture, etc. [Section 3 of the Endangered Species Act]), and possession of endangered species. However, the term "take" as defined individually by the States of Oregon and California is somewhat narrower, but conveys the same intent to prohibit killing and/or possession of endangered species (Callens 2004, State of California 2009).

Under Section 7 of the Federal Endangered Species Act, federal agencies seeking to implement an action that may affect, either directly or through modification of critical habitat, the Lost River sucker or the shortnose sucker must consult with the U.S. Fish and Wildlife Service. In 2008, we issued a Biological Opinion addressing the effects of the Klamath Project, operated by the U.S. Department of Interior Bureau of Reclamation, on the Lost River sucker and the shortnose sucker (USFWS 2008). At that time we concluded that the actions proposed by the Bureau of Reclamation to operate the Klamath Project were not "likely to jeopardize the continued existence of LRS [Lost River sucker] and SNS [shortnose sucker], and [are] not likely to destroy or adversely modify proposed critical habitat for these species" (USFWS 2008:159).

Other regulatory mechanisms relevant to these species also exist, including the National Environmental Policy Act, as amended, the Clean Water Act, and the Porter-Cologne Water Quality Control Act, which establishes a water quality control board for the state of California (State Water Resources Control Board 2009). A total maximum daily load and water quality management plan establishes water quality standards for Upper Klamath Lake and its tributaries (Boyd et al. 2002). Water quality management plans, including total maximum daily load, are being cooperatively developed by the States of Oregon and

California for areas within the Klamath Basin, including Link River and the Lost River sub-basin (Kirk et al. 2010).

Based on the protections provided by these current regulatory mechanisms, we do not consider the inadequacy of regulatory mechanisms to be a threat to either the Lost River or shortnose sucker.

5. Factor E. Other natural or manmade factors affecting its continued existence

Species characterized by disjunct, fragmented populations with few individuals are inherently at risk. **Demographic and environmental stochasticity** and catastrophic events can have far greater effects on populations with very low numbers (Lande 1988). Likewise, when populations are fragmented it can be difficult for recolonization if populations become extirpated or for suitable genetic exchange among populations to occur (Fagan 2002). Genetic heterozygosity (a measure of genetic diversity) is often considered an important factor enabling species or populations to adapt or respond to changing environments. This measure of genetic health was on average 35 percent lower for 170 threatened taxa compared to related non-threatened taxa (Speilman et al. 2004). These inherent factors due simply to the size and distribution of the species are a significant threat for Lost River sucker and shortnose sucker and place the species at risk of extinction.

a) Water Quality

Most water bodies currently occupied by Lost River sucker and shortnose sucker do not meet water quality standards for nutrients, dissolved oxygen, temperature, and pH set by the States of Oregon and California (Boyd et al. 2002, Kirk et al. 2010). These conditions (primarily in summer) have caused several incidents of mass adult mortality, which appears to be a consequence of inadequate amounts of dissolved oxygen. The occurrence of mass mortality of fish in Upper Klamath Lake is not new; however, it is believed that the increased dominance of *Aphanizomenon flos-aque* in the system may lead to increased regularity of extreme events (NRC 2004). Although conditions are most severe in Upper Klamath Lake and Keno Reservoir, fish throughout the basin are vulnerable to water-quality-related mortality (USFWS 2007a, b). Degraded water quality conditions may also weaken fish and increase their susceptibility to disease, parasites and predation (Holt 1997, Perkins et al. 2000a, ISRP 2005).

As discussed under Factor C, new information indicates that adverse water quality events can increase the extent to which pathogens and parasites negatively impact sucker survival. Although fish die-offs that occurred in Upper Klamath Lake in the 1990s were likely a response to **hypoxia** (low levels of dissolved oxygen), disease outbreaks also probably contributed to mortality during these events (Perkins et al. 2000a, NRC 2004).

Water quality remains one of the most important **proximate factors** threatening sucker existence; however, the uncertainty surrounding many of the potential **ultimate factors** (for example, the complex interactions of factors causing poor water quality), including wetland reduction, natural nutrient loads, non-point sources, and water management, also make it one of the most difficult threats to address.

b) Entrainment

Movement of fish into irrigation systems through unscreened diversions was identified as a threat to the suckers at the time of listing (USFWS 1988). At that time thousands of suckers, including some adults, were entrained into the A-Canal, the largest diversion in the upper basin located near the Link River Dam. Although some of these fish were salvaged, many likely died (NRC 2004). The impact of entrainment into the irrigation system of the Klamath Project was reduced by construction of screening facilities over the A-Canal; although larvae are still at risk. Under the present design, fish screened from entering the A-Canal are returned via pipeline to Upper Klamath Lake at a point that is near the river gates of the Link River Dam (Marine and Gorman 2005). Further investigations are needed to determine the overall effects and stress on transferred fish and if fish expelled through the pipeline remain in Upper Klamath Lake or are subsequently entrained by flows through the Link River Dam (USFWS 2007a, b).

Substantial entrainment occurs at the river gates of the Link River Dam (Marine and Lappe 2009). Currently these gates have no structures to prevent drawing fish downstream. During the late summer of 2006, over 3,500 age-0 juvenile suckers were collected in the Link River just below the dam with intermittent sampling of a fraction of the channel (Tyler 2007). The Committee on Endangered and Threatened Fishes in the Klamath River Basin of the National Research Council recommended screening to prevent downstream losses at Link River Dam (NRC 2004). Gutermuth *et al.* (2000) also documented tens of thousands of young suckers entrained at the PacifiCorp hydropower canals and turbines associated with the Link River Dam. Nonetheless, further research is required to better quantify the threats these structures pose to recovery.

Most suckers that pass through the gates at Link River Dam, or that survive passage through the hydroelectric facilities, are believed to be lost from the breeding population. Most likely, these fish either die in poor summer water quality conditions in Keno Reservoir, or pass further downstream into reservoirs along the Klamath River, from which upstream passage is blocked. A fish ladder was constructed at Link River Dam in 2004 through which adult suckers have been documented moving upstream through Link River. As of 2008, only seven individuals had been documented as passing through the ladder (Korson et al. 2008); however, at least 20 individuals were documented in the ladder during 2010 (T. Tyler, pers. comm. 2010).

In addition to major diversion points, several hundred small, typically unscreened diversions in tributary streams and rivers and the lakes proper may also affect Lost River sucker and shortnose sucker. Their influence on sucker abundance and recovery is unknown.

c) Climate Change

Climate variability, such as fluctuations between wet and dry periods, is part of natural processes; however, climatic models suggest that much of the recent trends in climate is driven by anthropogenic causes (Barnett et al. 2008). Since the 1950s, western North America generally has exhibited trends toward less snowfall, earlier snowmelt, and earlier peak spring runoff, much of which cannot be attributed to natural fluctuations (Hamlet et al. 2005, Stewart et al. 2005, Knowles et al. 2006). Furthermore, models indicate that these trends are likely to continue into the future (Barnett et al. 2008).

It is difficult to predict how such climatic changes will affect Lost River sucker and shortnose sucker (Matthews and Marsh-Matthews 2003). Certainly these species have evolved under variable climates with relatively dry periods (Dicken and Dicken 1985, Negrini 2002); however, given the current lack of recruitment, lack of population connectivity (even in wet years), and the overall low number of individuals, we consider populations of these species to be vulnerable to negative impacts from climate change, either from distinct droughts or from extended periods of declining trends of water quantity or from shifts in timing of melt and runoff. If current trends continue into the future, important changes which may threaten the continued existence of these species(for example, refugia availability, food web alterations, and run timing) are likely to occur (Dahm et al. 2003, Magoulick and Kobza 2003).

H. PAST CONSERVATION EFFORTS

Although the current population status of Lost River sucker and shortnose sucker indicates that they continue to be endangered and at risk of extinction, we, together with many other entities, have accomplished much to reduce threats to these species over the last 15 years. In most instances, considerable time is necessary to determine the efficacy of recovery actions. For example, actions to increase reproduction and recruitment into adult populations require at least five years for shortnose sucker and nine years for Lost River sucker to be properly assessed. Similarly, it will take time for incremental improvements in habitat to be manifested by healthy populations.

We have worked with other agencies and stakeholders to recover the endangered suckers since 1994. Approximately 300 on-the-ground restoration projects, including 90 wetland, 130 riparian, 45 in-stream, 25 upland, and 15 fish passage projects have been funded and implemented in the Upper Klamath Basin that directly or indirectly benefit Lost River sucker and shortnose sucker. Many of the projects included elements of more than one category of restoration project type taking a holistic or ecosystem approach based on the assumption that restoration of natural ecosystem functioning will ultimately benefit multiple species, including listed suckers. These projects have had significant cost share from multiple sources, including Federal programs such as the Service's Partners for Fish and Wildlife, Jobs in the Woods, and the Oregon Resources Conservation Act Program, as well as state and private grant programs and contributions from landowners.

Major sucker recovery oriented projects completed include: screening of irrigation diversions, eliminating barriers to fish passage, and restoration of rearing and spawning habitat (Table 3). For example, restoration of the Williamson River Delta has provided approximately 2,500 hectares (~6, 000 acres) that can serve as rearing habitat for the largest spawning populations of both species, although much of the area is deeper than it was historically due to subsidence. Following restoration, larvae quickly moved into the restored area (Crandall et al. 2008) and exhibited evidence that conditions were favorable for rearing, such as sufficient growth and feeding (Erdman and Hendrixson 2009). A related project supporting recovery of these species is the removal of Chiloquin Dam in 2008. Approximately 120 kilometers (75 miles) of potential spawning and migration corridor has been made available. These two projects should provide an enormous benefit to the river spawning populations of both species in Upper Klamath Lake, although it is too early to assess the exact results of these projects. Additionally, screening of the A-canal in 2002 is a significant accomplishment towards reducing entrainment of fish greater than 30 millimeters (1.2 inches) into the irrigation systems of the Klamath Project. Prior to placement of the screen, tens of thousands to hundreds of thousands of juveniles were estimated to be entrained into the irrigation canals at this point each year (Gutermuth et al. 2000, Bennetts et al. 2004). A dramatic decline of suckers captured as part of end-of-year salvage efforts in the A-canal (from nearly 6,000 before screening to only 3 in 2004) indicated that the screen was functioning successfully (Kyger and Wilkens 2011). This enabled the U.S. Bureau of Reclamation to reduce end-of-year salvage in certain areas, and redirect resources to other areas of effort.

Table 3 A summary of some recent major restoration projects benefitting Lost River sucker and shortnose sucker populations. Many of these projects were cooperative efforts of many state and federal agencies, non-profit organizations, and private landowners.

Project	Year Completed	Potential Benefits
Reducing Entrainment		
A-canal	2002	Retain more larvae and juveniles in Upper Klamath Lake by limiting entrainment into the canal
Clear Lake Dam	2003	Retain more larvae, juveniles, and adults in Clear Lake Reservoir by limiting entrainment into the canal
Modoc Irr. Dis. Williamson River Div.	2007	Reduce larval mortality due to entrainment
Geary Canal	2009	Retain more larvae and juveniles in Upper Klamath Lake by limiting entrainment into the canal
Eliminating Barriers		
Link River Dam fish ladder	2004	Restore connectivity of sucker populations in Upper Klamath Lake and Lake Ewauna by allowing for adult passage upstream, which may then contribute to spawning populations.
Chiloquin Dam	2008	Opening 120 km (75 mi) of historic spawning habitat in the Sprague River
Providing Habitat		
Williamson River Delta Restoration	2008	Provide ~2,500 hectares (6,000 acres) of potential rearing habitat for larvae and juvenile suckers in Upper Klamath Lake

In addition to these major accomplishments, many other smaller projects have been completed. Since Lost River sucker and shortnose sucker listing, private landowners, the Oregon Department of Fish and Wildlife, Bureau of Reclamation, Natural Resources Conservation Service, the U.S. Fish and Wildlife Service, and others have built or funded construction of many new fish screens in the upper basin. As a result, the threat of entrainment (loss of fish as result of being drawn into water management structures) is now lower than at the time of listing. Needs for additional screening and passage for suckers are now coordinated in the upper basin through a working group led by Bureau of Reclamation (BOR 2007).

In 2004, a report by the National Research Council of the National Academies concluded that to achieve a lasting resolution of Klamath Basin water issues must be dealt with in an integrated and comprehensive way to achieve lasting restoration (NRC 2004). Representatives of the States of California and Oregon, the President's Klamath River Basin Working Group, and the Environmental Protection Agency have signed the Klamath River Watershed Coordination Agreement. The respective agencies agreed to place a high priority on their Klamath Basin activities, and to coordinate and communicate with one-another and with tribal governments, local governments, private groups and individuals to resolve water quantity/quality problems in the basin. For example, water quality management plans were developed which provide targets and guidance on improvements for water quality in the Sprague River and Upper Klamath Lake, and many wetland and riparian restoration projects are now designed to address Total Maximum Daily Load issues.

In 2004, Oregon State University Agricultural Extension Service and the Klamath Watershed Council (now Klamath Watershed Partnership) began a series of monthly meetings with rural landowners in the Sprague River Valley to discuss watershed restoration goals. With the help of the Service, Natural Resources Conservation Service and the Klamath Soil & Water Conservation District, this effort has effectively connected landowners with appropriate state and federal resource conservation programs. As a result, landowners holding more than 70 percent of the private lands within the Sprague River Valley are partnering with local, state and/or federal agencies on land conservation and natural resource actions, some of which may benefit listed suckers. The efforts of the Klamath Watershed Partnership have brought additional fiscal partners (for example, Oregon Department of Agriculture, Klamath County, and Oregon Watershed Enhancement Board) into the conservation partnership. These partnership-forming actions will continue and build on themselves and enable more restoration to be done in the future.

The tributaries in the Wood River Valley supply a large portion of the inflow to Upper Klamath Lake. This valley also supports about half of the livestock in the Upper Basin and is responsible for approximately 30 percent of the external phosphorus loading to the lake. Because of this, it was identified by Oregon Department of Environmental Quality as a priority water quality impaired area. The Klamath Basin Rangeland Trust has been active in the Wood River Valley encouraging landowners to adopt sustainable land and water management practices. Since 2002, the number of landowners who partner with this organization on conservation and restoration activities has increased to include a significant portion of the agricultural lands in the watershed.

The above discussion underscores that landowners and agencies are involved in activities that improve sucker habitat and support sucker recovery. The high rate of participation in federal and state conservation programs by ranchers and farmers in the Sprague and Wood River Valleys suggests that essential elements of habitat recovery on private land (such as voluntary participation and adequate funding) should allow for effective recovery actions to occur.

Klamath River Basin stakeholders, including the States of Oregon and California, the Karuk, Klamath, and Yurok Tribes, several counties, 26 parties associated with the Klamath Reclamation Project or irrigators above Upper Klamath Lake, and 7 other conservation organizations, signed the Klamath Basin Restoration Agreement (KBRA) in early 2010. This agreement "is intended to result in effective and durable solutions which: (i) restore and sustain natural production and provide for Full Participation in Harvest Opportunities of fish species throughout the Klamath Basin; (ii) establish reliable water and power supplies which sustain agricultural uses and communities and National Wildlife Refuges; (iii) contribute to the public welfare and the sustainability of all Klamath Basin communities…"(KBRA 2010:4). Although further events such as legislation and funding authorizations must occur prior to full implementation, we believe that implementation of this agreement will produce substantial progress toward the recovery of Lost River sucker and shortnose sucker.

Despite the progress in many important areas, there is still a need for additional habitat restoration in the Upper Klamath Basin. Many programs, including our Partners for Fish and Wildlife Program, the National Resource Conservation Service wetlands reserve program, and organizations such the National Fish and Wildlife Foundation and the Oregon Watershed Enhancement Board, among others, can play an important role in achieving suitable and sustainable habitat conducive for the recovery of these species.

VIII. Recovery Program

This section describes the Lost River sucker and shortnose sucker recovery program by outlining a strategy, identifying where recovery will occur (recovery units), defining the recovery goal and objectives, and delineating criteria to down list Lost River sucker and shortnose sucker to threatened and to remove them from the list of threatened and endangered species (delist the species).

A. RECOVERY PRIORITY NUMBER

Recent 5-yr status reviews of each species assigned a recovery priority number of 4C to each species (USFWS 2007a, b). However, this was an inaccurate assignment for the shortnose sucker. Instead, the recovery priority numbers for Lost River sucker and shortnose sucker should be 4C and 5C, respectively. These priority numbers indicate that both species have a high degree of threat and a low potential for recovery. However, given that Lost River suckers belong to a monotypic genus (*Deltistes*) while shortnose sucker belong to a polytypic genus (*Chasmistes*), the recovery priority for Lost River sucker is slightly higher. The "C" in the recovery priority number indicates that conflict exists with "construction or other development projects or other forms of economic activity" (USFWS 1983:43104).

B. RECOVERY STRATEGY

The most pressing threat to these species is the lack of both **resiliency** and **redundancy** due to severe reduction of viable populations range wide. Of the few populations that do remain from historic distributions, most are very restricted and many lack the ability to successfully reproduce. Reproducing populations are only known to exist in Upper Klamath Lake, Clear Lake Reservoir, and Gerber Reservoir (shortnose sucker only). This condition means that a threat to any single reproducing population becomes a threat to the entire species. Populations in Upper Klamath Lake are able to spawn, but are threatened by a uniformly aged population, due to relatively few or no individuals progressing from larvae to spawning adults. The actual causes of this lack of recruitment are complex and poorly understood, but include loss of spawning and nursery habitat, degradation of juvenile and adult habitat, loss of individuals to sink populations or mortality, and, potentially, negative interactions with introduced and/or predatory species. The limited amount of information on populations in Clear Lake Reservoir prevent rigorous assessment of status and trends, but many characteristics of the lake (such as susceptibility to drought and only one known spawning stream) raise concerns of potential stochastic loss of the populations.

Similar threats face the shortnose population in Gerber Reservoir, with the added complexity of hybridization with Klamath largescale sucker.

In general, the strategy to recover these species is to ameliorate negative impacts on viable populations throughout the species' range in order to restore natural population dynamics in the upper Klamath Basin systems, primarily populations of Upper Klamath Lake and Clear Lake Reservoir. This will include efforts to prevent extinction through establishment of viable auxiliary populations, determine the specific threats to and needs of distinct portions or populations of the species (see Recovery Units in this document), reduce threats to the extent possible through restoration or manipulation, and promote the growth of populations. We believe that with successful implementation of actions associated with the specific objectives enumerated below, Lost River sucker and shortnose sucker populations will obtain healthy, self-sustaining demographic characteristics and age structure; however, should these measures fail or be ineffective, as indicated by continued population declines, a program to enhance redundancy and resiliency through controlled propagation may be needed to prevent extinction in the near-term. It is our policy to use controlled propagation as part of a recovery strategy "only when other measures employed to maintain or improve a listed species' status in the wild have failed, are determined to be likely to fail, are shown to be ineffective in overcoming extant [existing] factors limiting recovery, or would be insufficient to achieve full recovery" (USFWS and National Oceanic and Atmospheric Administration 2000:56920). Given the potential difficulties and drawbacks of intensive hatchery rearing (Belk et al. 2008, Rasmussen et al. 2009) this option is considered a last resort to guard the species from imminent extinction. Artificial propagation programs have likely contributed to continued persistence of several related species, though, none of the programs has been sufficiently successful to achieve delisting; see Andersen et al. (2007) for a summary of the importance of rearing programs to recovery of the endangered June sucker (*Chasmistes liorus*).

C. RECOVERY UNITS

Given differences in population dynamics, life history and genetics between populations in the Klamath River Basin and the Lost River Sub-basin, each species is classified into two recovery units (Upper Klamath Lake and Lost River), which are further divided into management units. Such divisions are intended to insure conservation of unique genetic and life history traits (for example, shoreline-spring spawning), or allow for recovery actions or criteria specific to a population. These units are not regulatory in nature, but are identified solely to facilitate recovery and management. It is recognized that Lost River sucker and shortnose sucker are different species and likely to occupy somewhat different niches in the ecosystem; nevertheless, ecological similarities between the species are also quite strong. Therefore, recovery units and management units are designated separately for each species, but unit boundaries, actions and criteria will be considered the same unless specifically stated. Management units permit us to compartmentalize distinct portions of recovery units to enable application of unique and specific management approaches. All recovery units must be recovered sufficiently to permit delisting; however, this does not mean that each management unit will necessarily be conserved for a unit to be considered to have recovered. This structure allows us to tailor management plans and actions to the needs of management unit specifically.

1. Upper Klamath Lake Recovery Unit

This recovery unit includes individuals residing in Upper Klamath Lake, its tributaries, the Link River, Keno Reservoir, and reservoirs located along the Klamath River to Iron Gate Reservoir. Management units are designated as follows:

- *Upper Klamath Lake-River*: Individuals residing in Upper Klamath Lake and areas associated with tributary spawning (current and future),

- *Upper Klamath Lake-Spring*: Individuals residing in Upper Klamath Lake associated with shoreline spring spawning locations (current and future),

- *Keno Reservoir*: Individuals residing between Link River Dam and Keno Dam (including Link River, Lake Ewauna, and Keno Reservoir), and

- *Klamath River*: Individuals residing in flowing water or reservoirs between Keno Dam and Iron Gate Dam.

Overlap between the Upper Klamath Lake – River and Upper Klamath Lake – Spring management units is significant with the primary distinction being spawning location; however, this difference in life history is important enough to recognize and manage separately.

2. Lost River Recovery Unit

This recovery unit includes individuals residing in lakes, sumps, reservoirs, or flowing waters found in the Lost River sub-basin in the following management units:

- *Clear Lake Reservoir*: Individuals residing in Clear Lake Reservoir and tributaries,

- *Tule Lake*: Individuals residing in Tule Lake, and the Lost River downstream from the Anderson-Rose Diversion Dam,
- *Gerber Reservoir*: Individuals residing Gerber Reservoir and tributaries, and
- *Lost River*: Individuals residing in Lost River proper downstream of Clear Lake Dam to Anderson Rose Dam, including Miller Creek downstream of Gerber Dam.

D. RECOVERY GOAL, OBJECTIVES, AND CRITERIA

1. Recovery Goal

The ultimate goal of the recovery program is to arrest the decline and enhance Lost River sucker and shortnose sucker populations so that ESA protection is no longer necessary. To obtain this goal it is necessary to produce naturally self-sustaining populations, which possess healthy long-term demographic traits and trends.

2. Recovery Objectives

Based on the broad recovery strategy and current threats to the species the following objectives are identified:

a) Threat-based Objectives

i. Restore or enhance spawning and nursery habitat in Upper Klamath Lake and Clear Lake Reservoir systems.

ii. Reduce negative impacts of poor water quality

iii. Clarify and reduce the effects of non-native organisms on all life stages

iv. Reduce the loss of individuals to entrainment

v. Establish a redundancy and resiliency enhancement program

b) Demographic-based Objectives

i. Maintain or increase larval production

ii. Increase juvenile survival and recruitment to spawning populations

iii. Protect existing and increase the number of recurring, successful spawning populations. (In this context recurring is defined as at least five consecutive years, and successful is defined as production of individuals attaining the juvenile stage.)

3. Recovery Criteria

An endangered species is defined in the Endangered Species Act as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. When we evaluate whether or not a species warrants downlisting or delisting, we consider whether the species meets either of these definitions. A recovered species is one that no longer meets the Act's definitions of threatened and endangered. Determining whether a species should be downlisted or delisted requires consideration of the same five categories of threats which were considered when the species was listed and which are specified in section 4(a)(1) of the Endangered Species Act.

Recovery criteria are conditions that, when met, are likely to indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Recovery criteria are provided below for each listed species covered in this draft recovery plan. Because the appropriateness of downlisting or delisting is assessed by evaluating the five threat factors identified in the Endangered Species Act, the recovery criteria below pertain to and are organized by these factors. These recovery criteria are our best assessment at this time of what needs to be completed so that the species may be downlisted to threatened status or removed from the list entirely. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is very likely to change as more is learned about the species and its threats, it is possible that a status review may indicate that downlisting or delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met and a status review may indicate that downlisting or delisting is not warranted; for example, a new threat may emerge that is not addressed by the recovery criteria below and that causes the species to remain threatened or endangered.

E. DOWNLISTING CRITERIA—LOST RIVER SUCKER AND SHORTNOSE SUCKER

Recovery occurs when threats outlined in the Reasons for Listing and Continued Threats sections have been ameliorated based on the criteria enumerated below. Recovery in this case is not defined in terms of absolute numbers of individuals but by the achievement of natural, self-sustaining demography, as determined through monitoring. Similarities in shortnose sucker and Lost River sucker life history, demographics and ecology, makes it possible to identify similar criteria for each species; however, species specific criteria are noted when necessary. Reproduction and recruitment are apparently occurring within Clear Lake Reservoir, but population trends are unknown. This general lack of information concerning all management units in the Lost River recovery unit, but specifically Clear Lake Reservoir, preclude establishment of specific demographic criteria; however, sufficient monitoring plans to better quantify the status of Clear Lake Reservoir populations through time must be developed and implemented in order for downlisting to occur.

The following enumerates recovery criteria in the context of threats identified in the listing rule and the above objectives. Unless stated explicitly, criteria are applicable to both recovery units.

1. Factor A: The present destruction, modification, or curtailment of its habitat or range

In order to downlist shortnose sucker and Lost River sucker to threatened status, threats to the species due to degraded or limited habitat must be reduced. This will have been accomplished if the following have occurred:

A.1 Current spawning and rearing habitat is maintained and improved access ensures annual use.

A.2 A range-wide Spawning and Rearing Enhancement Plan has been developed and implemented. This plan shall identify and prioritize areas of potential spawning and rearing habitat for enhancement and/or restoration, including areas which are degraded or unavailable due to lack of connectivity or passage.

A.3 Connectivity and access is assured to habitats that provide refuge to suckers to avoid poor water quality (particularly Pelican Bay) during the months of July, August, and September – Upper Klamath Lake Recovery Unit.

A.4 Restore natural vegetated wetland areas in-stream and around the mouth of Willow Creek where it meets Clear Lake Reservoir – Clear Lake Reservoir Management Unit.

2. Factor C: Disease or predation

Little is known about effects of predation or disease on Lost River sucker or shortnose sucker populations. In order to safely enable downlisting of Lost River sucker and shortnose sucker to threatened status, the effects of predation, whether from disease, parasites, or other sources, must be determined and, if necessary, minimized. This will have been accomplished if the following has occurred:

C.1 Newly identified or clarified effects of predation and disease are minimized through implementation of recommendations from ongoing scientific research which clarifies the interaction of Lost River sucker and shortnose sucker with predators and pathogens.

3. Factor D: Inadequacy of existing regulatory mechanisms

Current regulatory mechanisms are sufficient as not to present a threat to Lost River sucker or shortnose sucker.

4. Factor E: Other natural or manmade factors affecting its continued existence

In order to safely downlist Lost River sucker and shortnose sucker to threatened status, the species must be protected from other natural or manmade factors known to affect their continued existence. This will have been accomplished if the following has occurred:

E.1 An Entrainment Reduction Plan has been developed and implemented. This plan shall identify and prioritize screening of diversions throughout upper Klamath Basin, including the Klamath Project, and propose strategies for efficient reduction of entrainment.

E.2 All diversions greater than 5 cubic feet per second in the Sprague River and the Lower Williamson, below the confluence with the Sprague River, are screened.

E.3 Entrainment minimizing strategies, as developed in the Entrainment Reduction Plan, are implemented for the Link River dam.

E.4 Establishment of two additional recurring and successful spring-spawning populations in the Upper Klamath Lake-Spring Management Unit.

E.5 Development and implementation of a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography, including threats and negative impact reduction. This plan shall also designate specific demographic or vital rate targets, and strategies for achieving these targets, important for downlisting and delisting.

E.6 The effects of algal toxins and bloom-crash cycles have been minimized through implementation of recommendations from ongoing scientific research which clarifies the relationship of these factors with sucker mortality – Upper Klamath Lake Recovery Unit.

F. DELISTING CRITERIA—LOST RIVER SUCKER AND SHORTNOSE SUCKER

In order to safely delist Lost River and shortnose sucker the following additional criteria must be met:

1. Factor B: Overutilization for commercial, recreation, scientific, or educational purposes

Overutilization was a factor affecting Lost River sucker and shortnose sucker abundance until 1987 when recreational fishing was no longer permitted. While this contributed to declining population levels prior to listing, it has ceased and is not currently known to be a threat. However, given the potential recreational use once these species are delisted the following criteria are made for delisting:

B.1 The States of Oregon and California and the Klamath Tribes, collaboratively or separately, should prepare and finalize population management plan(s) for the species.

2. Factor E: Other natural or manmade factors affecting its continued existence

E.7 After 25 years, the average annual rate of population change is greater than one and the number of spawning individuals is greater than what was present in the baseline years for the Upper Klamath Lake River and Upper Klamath Lake Spring Management Units. See Appendix II for descriptions and estimation procedures of these measures. Twenty-five years equates to approximately two average adult life spans for Lost River sucker and three for shortnose sucker, and will enable assessment of the populations' response to cyclical threats, such as periodic die-offs and drought. 2002 and 2001 will serve as the baseline years for Lost River sucker and shortnose sucker, respectively, since these are the first years in which estimates of this type are statistically valid for each species.

E.8 Spawning populations in Upper Klamath Lake recovery unit exhibit evidence of recurrent recruitment that is indicative of a stable, self-sustaining population. This will be evident as spawning populations become comprised of individuals from multiple, well-represented age-classes suggestive of regular recruitment.

G. RECOVERY ACTIONS

The actions identified below are those that, in our opinion, are necessary to bring about the recovery of Lost River sucker and shortnose sucker and ensure their long-term conservation. However, these actions are subject to modification as dictated by new findings, changes in species status, and the completion of other recovery actions. Each action has been assigned a priority according to our determination of what is most important for the recovery of these species based on the life history, ecology, and threats (see the Background section of this document) and the following definitions of the priorities:

Priority 1: An action that is taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: An action that is 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.

There are several factors that are pertinent to consider when assigning priority numbers to these actions. In our view, populations within Upper Klamath Lake are generally a higher priority than other populations, because of the importance and status of the populations to the overall stability of the species. Also, we believe that the lack of survival of juveniles is currently a significant limiting factor for these species. Given these perspectives, we generally assign higher priorities to actions that will clarify and improve the ecology of suckers within Upper Klamath Lake, especially for juveniles. Likewise, many significant actions have occurred since publication of the original recovery plan for these species (USFWS 1993; see also the Past Conservation Section within this document). For this reason, many of the highest priority actions include research and the subsequent implementation of appropriate actions in accord with the new findings, while other, perhaps more tangible, actions have been assigned lower priorities.

The following Recovery Action Outline provides a summary of recovery actions, whereas the Recovery Action Narrative provides greater detail of the actions necessary to achieve full Lost River sucker and shortnose sucker recovery. Throughout the Recovery Action Outline and the Recovery Action Narrative the priorities of each action are specified within parentheses at the end of the description.

1. Recovery Action Outline

1. Restore or enhance spawning and nursery habitat in the Upper Klamath Lake and Clear Lake Reservoir Systems

- 1.1. Develop and implement a range-wide Spawning and Rearing Enhancement Plan (2)
- 1.2. Conduct and apply research on how to best manage lake levels to protect spawning habitat (2)
  - 1.2.1. Assess the effects of Upper Klamath Lake elevations on shoreline-spring spawning and production (2)
  - 1.2.2. Assess the effects of Clear Lake Reservoir elevations on spawning access and production (2)
  - 1.2.3. Improve our ability to assess and forecast hydrologic conditions in the upper Klamath Basin (2)
- 1.3. Re-establish stream and river connectivity (2)
  - 1.3.1. Improve access to Willow Creek from Clear Lake Reservoir (2)
  - 1.3.2. Improve passage for upstream migrants through Link River (3)
- 1.4. Conserve and restore wetland and riparian areas (2)
  - 1.4.1. Determine the importance of in-stream rearing habitats for larvae and juveniles in the Sprague River (2)
  - 1.4.2. Improve in-stream and wetland habitat in Willow Creek (3)
- 1.5. Improve habitat quantity and quality of eastern shoreline springs in Upper Klamath Lake (2)
- 1.6. Identify and assess the feasibility of potential habitat improvements for suckers in Lake Ewauna / Keno Impoundment (3)

2. Reduce negative impacts of poor water quality

- 2.1. Assure continued connectivity and access to Pelican Bay (2)
- 2.2. Conduct and apply research on the dynamics of algal cycles within Upper Klamath Lake and their effects on sucker populations (1)
  - 2.2.1. Conduct comparisons of algal community composition and ecology among sites where these species currently occur (2)
  - 2.2.2. Clarify ecology of *Aphanizomenon flos-aquae* (2)

- 2.2.3. Determine the effects of the algal toxin microcystin on suckers in Upper Klamath Lake and implement appropriate management actions (1)

2.3. Conserve and restore riparian and wetland areas along the Wood, Williamson, and Sprague Rivers to improve water quality (1)

3. Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations (2)

4. Reduce the loss of individuals to entrainment

4.1. Develop and implement an Entrainment Reduction Plan (1)

4.2. Assure the efficacy of A-canal bypass (1)

4.3. Improve the efficacy of the Link River Dam fish ladder (3)

5. Establish a redundancy and resiliency enhancement program

5.1. Develop and implement a Genetics Assessment and Management Plan (1)

5.2. Prepare emergency response protocols for Upper Klamath Lake, Clear Lake Reservoir, and Tule Lake populations (2)

5.3. Establish at least two auxiliary populations (1)

5.4. Develop a controlled propagation program (1)

6. Increase juvenile survival and recruitment to spawning populations

6.1. Develop and implement a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography (1)

6.2. Improve understanding of juvenile life history and ecology through study of Clear Lake Reservoir populations (2)

7. Maintain or increase the number of recurring, successful spawning populations

7.1. Increase the number of spawning sub-populations in Upper Klamath Lake (3)

7.1.1. Establish a spawning population in the Harriman Springs area (3)

7.1.2. Establish a spawning population in the Barkley Springs area (3)

7.1.3. Establish an additional river-spawning population in the Upper Klamath Lake system (3)

7.2. Facilitate successful spawning for the Tule Lake population (3)

7.3. Continue monitoring of adult populations (1)

8. Establish a Klamath Basin Sucker Recovery Implementation Program

8.1. Conduct outreach with public / stakeholder groups (3)

8.2. Facilitate information exchange and synthesis through establishment or utilization of an information sharing process (1)

8.3. Periodically assess the effectiveness of and adjust recovery actions and priorities (1)

8.3.1. Implementation (compliance) monitoring (1)

8.3.2. Cause and effect monitoring (1)

2. Recovery Action Narrative

The following step-down narrative further clarifies the actions needed to achieve recovery, with recovery priorities within the parentheses:

1. Restore or enhance spawning and nursery habitat in the Upper Klamath Lake and Clear Lake Reservoir Systems

The relationship between spawning and nursery habitat with healthy population demography is critical. Given the extensive losses of habitat in general, including loss of connectivity, it is vital that such habitats be restored to functionality.

1.1. Develop and implement a range wide Spawning and Rearing Enhancement Plan (2)

A plan should be developed to enhance spawning and rearing range wide, including, but not limited to, the most efficient and effective means for restoring spawning and rearing habitat, and evaluation and prioritization of restoration efforts of spawning and rearing habitat throughout the range of these species. This plan should also address potential improvements to currently used spawning areas as well as potential sites for spawning expansion. Likewise, measures for assessing the effectiveness of efforts should be developed.

1.2. Conduct and apply research on how to best manage lake levels to protect spawning habitat (2)

The primary populations of these species occur in bodies of water that are managed to provide water for irrigation. Additional information is needed to better understand relationships between lake level and the functionality of spawning habitat. If it is determined that management of lake levels can reduce the risk of extinction or improve the recovery of these species, actions should be taken through collaboration with agencies and other interested parties to develop and implement appropriate activities to achieve desired outcomes.

1.2.1. Assess the effects of Upper Klamath Lake elevations on shoreline-spring spawning and production (2)

Much of the seasonal and annual fluctuations in Upper Klamath Lake are driven by the complex interaction among irrigation demand, climate, and downstream flows to provide habitat for threatened Coho (*Oncorhynchus kisutch*). Lake levels within Upper Klamath Lake are likely very important to spawning at the springs located on the east shoreline of the lake, as well as to the inundated wetlands utilized as rearing habitats. Water levels can affect the development of these wetland habitats and subsequent connectivity. Likewise, areas may become separated from the lake if levels are too low. These issues should be researched and strategies to reduce the impacts of lake level management should be developed and implemented.

1.2.2. Assess the effects of Clear Lake Reservoir elevations on spawning access and production (2)

Water elevations within Clear Lake Reservoir currently may affect the access to the only known spawning site given the location of the mouth of Willow Creek. These issues should be researched and strategies to reduce the impacts of lake level management should be developed and implemented. Likewise, the sensitivity of rearing habitat to water elevations within this system should be clarified.

1.2.3. Improve our ability to assess and forecast hydrologic conditions in the upper Klamath Basin (2)

In large degree our ability to manage and reduce negative impacts on sucker populations by low lake elevations is dependent on the accuracy of forecasts of hydrologic conditions (for example, seasonal inflow estimates). We need to improve the tools necessary for making such assessments and forecasts, including refinement of statistical methods, and better regional coverage and collection of important data (for example, groundwater and snow pack assessments).

1.3. Re-establish stream and river connectivity (2)

Lost River sucker and shortnose sucker spawn in rivers and streams and grow to adulthood in lakes; this requires connectivity between habitats for spawning adults ascending the rivers and drifting larvae moving to wetland habitats surrounding the lakes. Likewise, barriers often preclude entire populations from being able to access suitable spawning habitat, as in the case of populations in Keno Reservoir and Tule Lake. Efforts to restore connectivity to promote spawning and rearing should occur based on recommendations from the Spawning and Rearing Enhancement Plan.

1.3.1. Improve access to Willow Creek from Clear Lake Reservoir (2)

Currently the arrangement of the mouth of Willow Creek with the forebay of Clear Lake Dam may limit access of adults to spawning sites during dry years or increase entrainment rates of out-migrating larvae. The threats posed by this arrangement should be determined and ameliorated, if necessary, by rearrangement of the channel to a configuration more representative of historical conditions, if feasible.

1.3.2. Improve passage for upstream migrants through Link River (3)

To promote use of the Link River Dam fish ladder, the suitability of the Link River for upstream sucker passage should be assessed and improved accordingly, if necessary.

1.4. Conserve and restore wetland and riparian areas (2)

Programs should be implemented to restore historical wetlands associated with known or potential spawning areas to provide suitable rearing habitat for larvae and juveniles, through such programs as our Partners for Fish and Wildlife Program, the National Resource Conservation Service's Wetlands Reserve Program, or organizations such as National Fish and Wildlife Foundation or the Oregon Watershed Enhancement Board, as well as any others that may be appropriate.

1.4.1. Determine the importance of in-stream rearing habitats for larvae and juveniles in the Sprague River (3)

It is unclear if historic nursery and rearing areas included areas within the rivers, such as side channel or backwater. Studies should be conducted to better assess this possibility and the potential benefits to populations.

1.4.2. Improve in-stream and wetland habitat in Willow Creek (3)
Efforts to improve spawning and rearing habitat associated with Willow Creek and tributaries should be carried out.

1.5. Improve habitat quantity and quality of eastern shoreline springs in Upper Klamath Lake (2)
Many eastern shoreline springs have been degraded by alterations to the surrounding area. Efforts to improve both the quality and quantity of these sites should be undertaken, such as substrate improvements or reasonable expansion of the sites. Given that these areas are indispensible and sensitive to perturbations extreme care should be used when planning and completing these actions.

1.6. Identify and assess the feasibility of potential habitat improvements for suckers in Lake Ewauna / Keno Impoundment (3)
Plans to improve water quality within Lake Ewauna / Keno Impoundment are being addressed cooperatively through the Total Maximum Daily Load analysis by the States of Oregon and California; additionally, improvements to habitat may further promote sucker recovery. These habitat improvements should be undertaken based on recommendations in the Spawning and Rearing Enhancement Plan.

2. Reduce negative impacts of poor water quality
Most water bodies currently occupied by Lost River sucker and shortnose sucker do not meet water quality standards for nutrients, dissolved oxygen, temperature, and pH. This is mostly attributed to nutrient loading. Upper Klamath Lake has become hypereutrophic, and summer time conditions are characterized by an overabundance of the blue-green alga, *Aphanizomenon flos-aque*. Poor water quality may affect fish by creating lethal conditions or by weakening fish thereby increasing their susceptibility to disease and parasites. Lost River sucker and shortnose sucker are able to tolerate relatively harsh conditions, but periodic die-offs show that they are susceptible to poor water quality that occurs primarily during summer. Actions to reduce these effects by providing sufficient habitat that provides refuge and minimizing the occurrence of poor water quality events should occur.

2.1. Assure continued connectivity and access to Pelican Bay (2)
Pelican Bay, located in the northwestern quadrant of Upper Klamath Lake, has been identified as an area utilized by sucker to avoid extreme poor water quality within Upper Klamath Lake. Steps should be taken to assure connectivity to this area for the suckers during the critical period between July and September. Likewise,

identification of other areas that provide refuge to any life stages of suckers from poor water quality events should occur. Connectivity and access to these areas should be assured during the periods when poor water quality events are probable.

2.2. Conduct and apply research on the dynamics of algal cycles within Upper Klamath Lake and their effects on sucker populations (1)

Additional information is needed to quantitatively determine relationships between water quality (especially as a result of algal population cycles) and sucker mortality or susceptibility to disease and parasites. Once such relationships are better understood, the next step will be to develop and implement actions, which may include management, restoration, and manipulation, to reduce the negative effects to suckers. However, it is problematic to specifically identify such actions until more information becomes available.

2.2.1. Conduct comparisons of algal community composition and ecology among sites where these species currently occur (2)

Comparisons of algal community composition and ecology among sites where these species currently occur may provide insight into the how algal community dynamics are affecting suckers within Upper Klamath Lake.

2.2.2. Clarify ecology of *Aphanizomenon flos-aquae* (2)

The mechanism(s) by which *Aphanizomenon flos-aquae* maintains dominance in the Upper Klamath Lake ecosystem is essentially unknown. Studies to better understand the ecology of this alga, with a focus to reduce its abundance, should be undertaken. However, implementation of actions must also attempt to maintain a healthy algal community, and not simply eliminate *Aphanizomenon flos-aquae*, which may then be replaced with another equally detrimental or worse species.

2.2.3. Determine the effects of the algal toxin microcystin on suckers in Upper Klamath Lake and implement appropriate management actions, if necessary (1)

Additional research on the interactions of suckers with microcystin, including the effects on individuals, the pathways for ingestion, and how these may ultimately affect the health of populations within Upper Klamath Lake, should occur. Efforts should also include ways to minimize these negative effects, if warranted.

2.3. Conserve and restore riparian and wetland areas along the Wood, Williamson, and Sprague Rivers to improve water quality (1)

Although, conservation and restoration of these areas has already been proposed for nursery and rearing habitats, it is also important that these actions occur to promote healthier water quality. As areas for each of these purposes may be slightly different in structure and/or location, this action is included here as well.

3. Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations (2)

Approximately 85 percent of the fish biomass in Upper Klamath Lake when the suckers were listed was comprised of non-native species. The fathead minnow and yellow perch are most likely to affect Lost River sucker and shortnose sucker through predation on and competition for food and space with young suckers. Nevertheless, there is little quantitative information to indicate their actual influence on sucker abundance, distribution, and status. Additional work is needed to clarify these relationships and their effects on the trends, distribution and demography of suckers. Observational and controlled experiments should be conducted to determine the negative effects of non-native species on suckers, and strategies to efficiently reduce or minimize such effects should be developed and implemented

4. Reduce loss of individuals to entrainment

Entrainment of individuals, especially larvae and juveniles, can remove significant numbers of individuals from populations. It is critical that a reduction in the number of individuals lost to entrainment occur.

4.1. Develop and implement an Entrainment Reduction Plan (1)

To facilitate efficient and effective entrainment reduction, an Entrainment Reduction Plan should be prepared. It is anticipated that entrainment resulting from action of Federal Agencies will be addressed through consultation (Section 7 of the ESA); therefore, this plan will evaluate and prioritize entrainment reductions measures throughout the range of these species, with emphasis on diversions outside of the Klamath Irrigation Project.

4.2. Assure the efficacy of A-canal bypass (1)

Under present design, a screen prevents fish from entering the A-Canal and being removed from the population into irrigation facilities. These fish are delivered via pipeline to Upper Klamath Lake at a point that is near the Link River Dam. The screen appears to reduce fish movement into A-Canal but little is known about where fish go that are delivered into Upper Klamath Lake. Investigations are needed to determine if these fish remain in Upper Klamath Lake or pass downstream into Lake Ewauna.

4.3. Improve the efficacy of the Link River Dam fish ladder (3)

Limited use of the Link River fish ladder has been documented. Improvements must be made to assure utility of these structures. Functionality of the Link River Dam fish ladder should be improved by design and implementation of operational protocols.

5. Establish a redundancy and resiliency enhancement program

The purpose of this program will be to support and enhance efforts to improve ***in situ*** conditions through creation or maintenance of populations that provide redundancy and potentially produce individuals for augmentation to increase resiliency of the most important populations for the species, Upper Klamath Lake and Clear Lake Reservoir. This program will proactively prepare for contingencies that may arise if numbers become so low that action is required. This program may include two similar but distinct parts, auxiliary populations and controlled propagation, both of which may be utilized to maintain a stock of individuals to prevent extinction or loss of significant diversity, or to produce individuals to augment existing "wild" populations or to facilitate research. We recognize that augmentation simply treats the "symptoms", in other words, the declining populations, and does not ultimately fix the cause of those declines, but we assert that this can be a very useful tool, even though substantial time and planning will be required to develop this program, and construction of new facilities may be necessary.

5.1. Develop and implement a Genetics Assessment and Management Plan (1)

A Genetics Assessment and Management Plan should be developed to 1) determine genetic diversity within and among recovery units and management units and 2) prescribe objectives and protocols for preserving and protecting genetic diversity within natural populations, and propagation efforts. Because actions 5.3 and 5.4 depend on this plan, this action was also given a Recovery Priority of 1.

5.2. Prepare emergency response protocols for Upper Klamath Lake, Clear Lake Reservoir, and Tule Lake populations (2)

Given the vulnerability of these areas to potential catastrophe, such as widespread fish die-offs or severe drought, site specific protocols to detect and respond to an emergency in each of these locations should be developed and revised periodically.

5.3. Establish at least two auxiliary populations (1)

Species that are concentrated into a few populations are inherently at risk to demographic and environmental stochasticity and catastrophic events (such as disease outbreaks). One method to reduce this risk is to establish separate distinct populations that can serve as a source of individuals should abundance in other populations decline severely. At least two auxiliary sites for each species should be established and maintained. Potential sites for the establishment of auxiliary populations should be identified using quantifiable evaluations and **qualitative** assessment of feasibility. Criteria should include suitability (for example, water quality, food resources, and drought risk, to name a few) as well as the potential for reproduction and/or rearing. Given that Tule Lake is the only known auxiliary population where significant sucker populations currently occur that will be able to persist into the future outside of Upper Klamath Lake, Clear Lake Reservoir, and Gerber Reservoir, this system should be given preference for establishing and maintaining an auxiliary population. However, should equally suitable and/or successful areas be identified, the establishment of auxiliary populations in these areas should not be preempted by the current importance of Tule Lake. Small numbers of mostly adult Lost River sucker and shortnose sucker are also scattered elsewhere throughout the upper Klamath River basin. These populations are supported by fish moving downstream from Upper Klamath Lake and Clear Lake Reservoir. Although reproduction is low or does not occur in these populations, these fish currently serve as auxiliary populations that provide redundancy to Upper Klamath Lake and Clear Lake Reservoir populations, and may potentially provide stock for augmentation, should this be necessary. It is important to note, however, that many of the dams located along the Klamath River have been proposed for removal in the Klamath Basin Restoration Agreement (KBRA 2010). While the populations located in the reservoirs behind these dams are currently important as auxiliary populations, the inability of these Klamath River mainstem reservoir populations downstream of Keno Dam to contribute directly to long-term recovery means that protection of these populations should not preclude removal of the dams. Nevertheless, efforts to capitalize upon these populations prior to dam removal should occur.

Recommendations from the Genetics Assessment and Management Plan for preserving and protecting genetic diversity should be adhered to. Monitoring plans for each auxiliary population should be developed and implemented, including protocol for utilizing auxiliary populations as a source population to augment other areas (such as capture and transport methods, timing, target individuals, and number of individuals to be extracted, etc.).

5.4. Develop a controlled propagation program (1)

The declining demographic health of Lost River sucker and shortnose sucker populations documented in Upper Klamath Lake since 2001 suggests that a controlled propagation program may also be necessary to prevent extinction. This program may involve various methods, including but not limited to in situ rearing of larvae and/or juveniles in semi-natural environments, such cages or ponds, or more intensive (traditional) hatchery methods. For example, small diked ponds can be developed within Lower Klamath and Tule Lake National Wildlife Refuges, which can be utilized to provide suitable rearing habitat for larvae and juvenile suckers, which can then be used to augment natural populations. The selected option(s) should be implemented if populations in any Recovery Unit decline below 25 percent of the early 2000s (See Appendix II for discussion on how to estimate this realized population change). Demographic monitoring will provide information for tracking trends and informing managers about the urgency of creating a hatchery program and the effectiveness of augmentation efforts if initiated.

6. Increase juvenile survival and recruitment to spawning populations

Relatively little is known about the ecology and demography of these species as juveniles. Studies should be implemented to better understand the manner and magnitude to which individuals of this age class are affected by the various biotic and abiotic factors.

6.1. Develop and implement of a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography (1)

Understanding the ultimate and proximate causes of the apparent high rate of juvenile mortality is of critical importance. Research with an emphasis on decreasing juvenile mortality and increasing recruitment into spawning populations should be collaboratively planned and implemented range wide.

6.2. Improve understanding of juvenile life history and ecology through study of Clear Lake Reservoir populations (2)

A clearer understanding of the ecology and life history of populations within Clear Lake Reservoir is important to understand the overall status of the species and specifically the dynamics within this reservoir, but this information may also provide insight into ways to improve populations in Upper Klamath Lake through comparison of ecology and life history. Studies to clarify the ecology of populations within Clear Lake Reservoir should therefore be conducted.

7. **Maintain and increase the number of recurring, successful spawning populations**
When populations or sub-populations of species are temporally or spatially distinct, this can provide a measure of security against potential catastrophic loss for the overall group. This is known as redundancy and is relevant to spawning groups of the same species. The number of total spawning aggregations has decreased dramatically for both Lost River sucker and shortnose sucker. Successful establishment of additional spawning aggregations will likely increase the species' ability to overcome many threats.

7.1. Increase the number of spawning sub-populations in Upper Klamath Lake (3)
At least two additional spawning sub-populations should be established within Upper Klamath Lake. This should include at least one population which spawns at springs near the shoreline of the lake.

7.1.1. Establish a spawning population in the Harriman Springs area (3)
A distinct self-perpetuating spawning population should be established in the Harriman Springs area. This may include individuals that use the spring area or habitat within Fourmile Creek.

7.1.2. Establish a spawning population in the Barkley Springs (3)
A distinct self-perpetuating spawning population should be established in Barkley Springs.

7.1.3. Establish an additional river-spawning population in the Upper Klamath Lake system (3)
A distinct self-perpetuating spawning population should be established within the Upper Klamath Lake. This population should be in addition to improvement made in the Williamson and Sprague Rivers. Feasibility assessments of potential sites should be part of the Spawning and Rearing Enhancement Plan.

7.2. Facilitate successful spawning for the Tule Lake population (3)
Habitat within Tule Lake is able to sustain populations of both Lost River and shortnose sucker; however, spawning habitat is limiting. Attempts to perform spawning migrations by adult suckers in this system have been observed. With the addition of successful spawning from this population the threat of extinction of these species from stochastic events would be significantly reduced. Details to accomplish

this should be included in the Spawning and Rearing Enhancement Plan, and implementation should occur, including collaboration with the Tule Lake National Wildlife Refuge.

7.3. Continue monitoring of adult populations (1)

Continued monitoring of population status and trends is imperative as we continue to assess the threats to each population and the species overall. Such monitoring trends will enable us to determine if threats are being appropriately addressed, or if further actions are necessary to protect the species. Monitoring of adult populations, especially in Upper Klamath Lake and Clear Lake Reservoir, should continue. Such monitoring may include demographic characteristics (for example, age composition of spawning populations), spawning occurrence and success, and responses to poor water quality events, but at a minimum should include the data necessary to assess trends within the population.

8. Establish a Klamath Basin Sucker Recovery Implementation Program

A program comprised of interested parties and entities to implement recovery actions should be initiated. This recovery implementation program will consist of several focused "teams" and coordinate public outreach, scientific collaboration, and assessment of current program direction. Because the efficiency and effectiveness of many other recovery actions depends on portions of this action, many of the sub-actions named here have been assigned a Recovery Priority of 1.

8.1. Conduct outreach with public / stakeholder groups (3)

Those responsible for implementing recovery should inform interested parties of proposed and completed actions regularly through various means. A stakeholder group, including participants during the process to revise this recovery plan, should be maintained and consulted.

8.2. Facilitate information exchange and synthesis through establishment or utilization of an information sharing process (1)

A team should be created to regularly review and assess activities to ascertain the effectiveness of research and management. This team should facilitate the sharing of information among organizations implementing recovery actions and research, as well as other interested parties.

8.3. Periodically assess the effectiveness of and adjust recovery actions and priorities (1)

Monitoring is an essential part of any recovery program. We plan to monitor actions regularly through the efforts of the recovery implementation program.

8.3.1. Implementation (compliance) monitoring (1)

We will periodically solicit internal and external expert review of the recovery implementation program to promote the highest quality of work and provide suggestions for future recovery actions. The goal of this monitoring will be to determine if the recovery actions are being implemented as laid out in the recovery plan.

8.3.2. Cause and effect monitoring (1)

Given the level of uncertainty pertaining to some threats, many of the actions described in this plan call for development and implementation of scientific research to further clarify the situation. As the impacts of threats are reduced or eliminated the expectation is that beneficial responses will be seen in the status and trends of populations. It is vital that monitoring be established to sufficiently assess the successfulness of actions. This includes assessment of the effectiveness of restoration efforts, reduction of entrainment, and research to reduce impacts from poor water quality and non-native species.

H. IMPLEMENTATION SCHEDULE

Implementing recovery actions will require multiple partners and a diversity of approaches. The Implementation Schedule (Table 4) shown below is a guide for meeting the recovery goals identified in this revised plan for Lost River sucker and shortnose sucker. It indicates action priorities, action numbers, action descriptions, duration of actions, and proposed parties responsible for actions (either funding or implementing), as well as estimated costs. It is important to note that most actions contribute toward recovery of both species. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in this schedule. However, the listing of party in the Implementation Schedule does not require the identified party to implement the action(s) or secure funding for implementing the action(s). When one or more party has been identified, the proposed lead party is indicated by an asterisk (*). For the sake of brevity in the Implementation Schedule, annual costs are estimated for the first five years, and an estimated total cost to achieve full recovery is provided.

We estimate that Lost River sucker and shortnose sucker recovery can occur in five to seven generations. In ecological terms, a generation is the average time it takes for females to become reproductive; this is approximately seven years for Lost River sucker and five years for shortnose sucker (Perkins et al. 2000b). Therefore, we may expect recovery of these species to occur in between 30 – 50 years, depending on our ability to reverse current trends and eliminate threats. This time frame also includes the estimated time required to reverse current trends, and the time required to establish and document increased abundances and stable population dynamics.

1. Definition of Action Durations

Continual (C): An action that will be implemented on a routine basis once begun.

Ongoing (O): An action that is currently being implemented and will continue until no longer necessary.

Periodic (P): An action that recurs periodically, for example every five years, so long as the species are listed.

To Be Determined (TBD): The action duration is not known at this time or implementation of the action is dependent on the outcome of other recovery actions.

2. Explanation of Acronyms in Implementation Table

BOR	Bureau of Reclamation
CDFG	California Department of Fish and Game
FWS	U.S. Fish and Wildlife Service
KBNWR	Klamath Basin National Wildlife Refuge Complex, U.S. Fish and Wildlife Service
KT	Klamath Tribes
NRCS	Natural Resources Conservation Service
ODFW	Oregon Department of Fish and Wildlife
RI	Research Institutions
Team	Klamath Basin Recovery Implementation Team

Table 4 The Implementation schedule for the Lost River and shortnose Recovery Plan. Dollar estimates of costs to achieve recovery (in thousands of dollars) are given for the first five fiscal years (FY) and the total estimated costs. Totals include estimates for the first five fiscal years and estimates for an additional 30 years, assuming the time to recovery would be 35 years. If no funds are required during the first five fiscal years this is indicated with a dash (–). Implementation of lower priority actions may not occur within the first five fiscal years; only the total estimated cost is presented in these cases. Unless specifically noted, actions are intended to benefit both species. Actions or headings that have been broken down into sub-actions do not have costs estimated when it is assumed that estimates of the sub-actions will comprise estimates for the entire action or heading and have therefore been excluded from this table.

Action number and description		Priority	Responsible Parties	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)						Comments
					FY1	FY2	FY3	FY4	FY5	Total	
1.1	Develop and implement a range-wide Spawning and Rearing Enhancement Plan	2	Team	15	–	–	50	–	–	125	$25K every 5th year for reassessment of the plan developed in FY3
1.2.1	Assess the effects of Upper Klamath Lake elevations on shoreline-spring spawning and production	2	BOR, FWS	5	–	–	200	200	150	800	Costs for assessment and implementation
1.2.2	Assess the effects of Clear Lake Reservoir elevations on spawning access and production	2	BOR, FWS, KBNWR	4	–	–	50	50	50	200	
1.2.3	Improve our ability to assess and forecast hydrologic conditions in the upper Klamath Basin	2	BOR, FWS, NRCS	15	–	40	100	100	100	660	
1.3.1	Improve access to Willow Creek from Clear Lake Reservoir	2	BOR, FWS, KBNWR	4	–	30	50	50	30	160	
1.3.2	Improve passage for upstream migrants through Link River	3	BOR, FWS, KT	9	–	–	–	–	–	2,075	

Action number and description		Priority	Responsible Parties	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)						Comments
					FY1	FY2	FY3	FY4	FY5	Total	
1.4	Conserve and restore wetland and riparian areas[3]	2		30	–	–	–	–	950	36,415	
1.4.1	Assess the importance of in-stream rearing habitats for larvae and juveniles in the Sprague River	2	FWS, KT	6	–	–	–	–	–	625	
1.4.2	Improve in-stream and wetland habitat in Willow Creek	3	FWS	4	–	–	–	–	–	400	
1.5	Improve habitat quantity and quality of eastern shoreline springs in Upper Klamath Lake	2	BOR, FWS, KT	13	–	80	50	50	50	310	
1.6	Identify and assess the feasibility of potential habitat improvements for suckers in Lake Ewauna / Keno Impoundment	3	BOR, FWS	2	–	–	–	–	–	75	
2.1	Assure continued connectivity and access to Pelican Bay	2	BOR, FWS	P	–	–	75	–	–	225	
2.2	Conduct and apply research on the dynamics of algal cycles within Upper Klamath Lake and their effects on sucker populations to minimize these effects	1	BOR, FWS, KT, RI	10	–	–	–	50	150	1,400	

[3] Some riparian or wetland restoration actions may receive funding under other programs, such as the Klamath Basin Restoration Agreement or Clean Water Act compliance, but given that funding is not guaranteed, cost estimates presented here assume that other programs do not contribute funding to this action. Estimates for these actions were adapted from Klamath Basin Restoration Agreement estimates.

Action number and description		Priority	Responsible Parties	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)						Comments
					FY1	FY2	FY3	FY4	FY5	Total	
2.2.1	Conduct comparisons of algal community composition and ecology among sites where these species currently occur	2	BOR, FWS, RI	6	–	–	20	100	100	495	
2.2.2	Clarify the ecology of *Aphanizomenon flos-aquae*	2	FWS, KT, RI	9	–	–	20	100	100	995	
2.2.3	Determine the effects of the algal toxin microcystin on suckers in Upper Klamath Lake and implement appropriate management actions, if necessary	1	FWS, KT, RI	10	–	100	100	100	100	1,000	
2.3	Conserve and restore riparian and wetland areas along the Wood, Williamson, and Sprague Rivers to improve water quality	1		30	–	–	–	950	950	33,888	
3.1	Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations	2	FWS, KT, RI	15	–	–	–	100	100	2,550	
4.1	Develop and implement an Entrainment Reduction Plan	1	Team	12	50	60	400	400	400	3,060	
4.2	Assure the efficacy of A-canal bypass	1	BOR	5	–	–	100	100	400	800	
4.3	Improve the efficacy of the Link River Dam fish ladder	3	BOR	4	–	–	–	–	–	40	
5.1	Develop and implement a Genetics Assessment and Management Plan	1	Team, RI	10	–	75	75	75	75	700	

Action number and description		Priority	Responsible Parties	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)						Comments
					FY1	FY2	FY3	FY4	FY5	Total	
5.2	Prepare emergency response protocols for Upper Klamath Lake, Clear Lake Reservoir, and Tule Lake populations	2	Team	2	60	30	–	–	–	90	
5.3	Establish at least two auxiliary populations	1	FWS	C	100	100	80	35	35	1,850	
5.4	Develop a controlled propagation program	1	FWS	C	–	–	–	–	–	16,750	Implementation of this action will only occur, if necessary; therefore, start time is unknown.
6.1	Develop and implement a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography	1	Team, RI	15	50	75	200	200	200	3,075	
6.2	Improve understanding of juvenile life history and ecology through study of Clear Lake Reservoir populations	2	BOR, RI	10	60	60	60	60	80	660	
7.1.1	Establish a spawning population in the Harriman Springs Area	3	FWS, KT	15	–	–	–	–	–	600	
7.1.2	Establish a spawning population in the Barkley Springs Area	3	FWS, KT	15	–	–	–	–	–	1,600	
7.1.3	Establish an additional river-spawning population in the Upper Klamath Lake system	3	FWS, KT	15	–	–	–	–	–	600	
7.2	Facilitate successful spawning for the Tule Lake population	3	BOR, FWS	11	–	–	–	40	200	2,690	

Action number and description		Priority	Responsible Parties	Duration (years)	Fiscal Year Cost Estimates (thousands of dollars)						Comments
					FY1	FY2	FY3	FY4	FY5	Total	
7.3	Continue monitoring of adult populations	1	BOR, FWS, RI	O	500	500	500	500	500	17,500	
8.1	Conduct outreach with public / stakeholder groups	3	Team	C	–	50	50	10	10	420	
8.2	Facilitate information exchange and synthesis through establishment or utilization of an information sharing process	1	Team	C	60	60	25	25	25	945	
8.3.1	Implementation (compliance) monitoring	1	Team	P	–	–	–	50	–	550	Includes costs every fourth year once initiated
8.3.2	Cause and effect monitoring	1	Team	P	–	–	50	–	–	550	Includes costs every fourth year once initiated

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XI. Appendix I: Glossary

Acre-feet – a unit of volume of water in irrigation: the amount covering one acre to a depth of one foot, equal to 43,560 cubic feet.

Age cohort – in this instance, all the individuals of a given species in a specific area that are approximately the same age.

Age-0 – this term refers to individuals that have lived less than one year, but is most often used in reference to juveniles.

Algal Bloom – the sudden development of conspicuous masses of organisms, such as algae, on the surface of a body of water.

Anthropogenic – caused or influenced by humans.

Bathymetry – the measurement of the depth of bodies of water, such as a lake.

Biomass – the amount of living matter in a given habitat, expressed either as the weight of organisms per unit area or as the volume of organisms per unit volume of habitat.

Copepod – any of numerous tiny marine or freshwater crustaceans of the order (or subclass) Copepoda, some abundant in plankton and others parasitic on fish.

Cyanobacteria – also known as blue-green algae, a widely distributed group of predominantly photosynthetic, single celled organisms, occurring singly or in colonies in diverse habitats: some species can fix atmospheric nitrogen.

Demographic Stochasticity – chance events affecting survival and reproduction of individuals in small populations, skewed sex ratios for example.

Demography – the science of vital statistics of populations, including births, deaths, and distribution of age classes, etc.

Ecology – the branch of biology dealing with the relations and interactions between organisms and their environment, including other organisms.

Emergent Vegetation – erect, rooted herbaceous plants that may be temporarily to permanently flooded at the base but do not tolerate prolonged inundation of the entire plant.

Endemic – native to or confined to a certain region or locale.

Entrainment – in this case, when organisms, especially larval or juvenile suckers, are pulled along with the force of moving water into irrigation canals or other structures.

Environmental Stochasticity – random variation in physical environments, including temperature or precipitation.

Eutrophic – characterized by an abundant accumulation of nutrients that support a dense growth of algae and other organisms.

Exotic – of foreign origin or character; not native; introduced from abroad.

Extant – still in existence; not destroyed, lost, or extinct.

Fork Length – a length measurement in fish stretching from the tip of the snout to the fork between the two lobes of the tail fin.

Geometric Mean – the mean of n positive numbers obtained by taking the n^{th} root of the product of the numbers. For example, the geometric mean of 3 and 12 is 6. This calculation is more appropriate for values which may be exponential in nature such as population growth.

Gill rakers – projections off of the gill arch of fish into the throat, which are often used to filter food particles from passing water.

Hypereutrophic – characterized by an over-abundant accumulation of nutrients that support a dense growth of algae and other organisms.

Hypoxia – a condition where water, as in a lake or pond, exhibit low levels of dissolved oxygen.

In situ – situated in the original or natural place or position.

Juvenile – individuals which have developed the full complement of fin rays and no longer receive sustenance from a yolk but that have not reached sexual maturity.

Life-History – those traits and characteristics relating to the reproductive cycle of a species, including size and age at maturity, number of offspring per reproductive event, and number of reproductive bouts.

Macroinvertebrates – organisms lacking a backbone that are large enough to be seen with the naked eye, for example, aquatic insect larvae and snails.

Mark-Recapture – also known as capture-recapture, a sampling technique whereby organisms are captured, marked, released, and subsequently recaptured to provide information on such things as growth, dispersal, and survival rates.

Monotypic – having only one representative, as is a genus with a single species.

Moribund – approaching death; about to die.

Morphologically – referring to the form and structure of an organism.

Non-Point Sources– In this case, refers to pollution affecting a water body from diffuse sources, such as agricultural runoff.

Oblique– in this case, referring to a mouth that is slightly slanting or sloping relative to the axis of the body.

Opercle – the hard, bony flaps covering and protecting the gills of fish (singular – operculum).

Otolith – small, calcareous structures or stones that are found in the inner ear.

Papillose – In this instance small, nipple-like bumps or projections on the lips.

Passive integrated transponder (PIT) tags – PIT tags are used during mark-recapture studies to mark individuals so as to enable identification with subsequent recapture. Slightly bigger than a grain of rice and injected internally under the skin, each tag has a unique alphanumeric code that can be detected using an electronic scanner.

Periphyton – tiny organisms, such as algae or protozoans, which live on submerged objects, including vegetation and rocks.

Polytypic – having more than one representative, as is a genus with a more than one species.

Proximate factor – in a series of events the cause or factor that is very near or immediately preceding the end result.

Quantitative – of or pertaining to the describing or measuring of a specific quantity.

Qualitative – pertaining to or concerning certain qualities or characteristics of an object.

Ultimate factor – in a series of events the factor that is the fundamental cause of the end result.

Realized population change – the actual change of abundance population between successive samples or time steps.

Recruitment – the act or process when a juvenile becomes part of the adult population.

Redundancy – in conservation biology, the condition of having multiple populations that provide security from the risk of extinction of the species given the low probability that all populations will be negatively affected by a single catastrophic event.

Resiliency – in conservation biology, the ability of a population to recover from reduced abundance due to a disturbance.

River mile – a measure of distance in mile along a river from its mouth. River mile numbers begin at zero and increase moving upstream.

Sink population – a population in a low-quality habitat in which the birth rate is generally lower than the death rate and population density is maintained by immigrants from "source populations," which are generally more robust.

Sub-Adult – an individual that has survived to at least one year of age, but has yet to become sexually mature and recruit into the spawning population.

Sub-Basin – a distinct watershed that is part of a larger watershed or basin.

Sub-Terminal Mouth – a mouth that is intermediate of the terminal mouth (positioned pointing forward on fish) and inferior (positioned pointing downward).

Swim-Up – a period when larvae abandon the gravel in which they have sheltered since hatching and enter the flow of the river. In western lake suckers this typically occurs around 7 – 14 days after hatching.

Taxonomy – The classification of organisms in an ordered system that indicates natural relationships.

Total length – a measurement of individual length from the tip of the snout to the tip of the tail fin.

Terminal mouth – in fish, a mouth positioned to be directed forward.

Zooplankton – the aggregate of animal and animal-like organisms in the plankton.

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XII. Appendix II: Lost River Sucker and Shortnose Sucker Demography

An on-going demographic sampling program for Upper Klamath Lake Lost River sucker and shortnose sucker was initiated in 1995 by USGS using mark-recapture methods based on passive integrated transponder (PIT) tags in all suckers captured in nets or fish ladders. PIT tags are small, permanent chips with a unique code to identify each individual, which are read using electronic, external readers, either hand-held units or arrays of antennae installed at strategic locations. A tagged fish is detected when near a reader (typically within a few inches), and over time individual data translate into population trends of such parameters as probability of surviving from year to year or being recaptured (detected) during a particular sample event. In addition to the use of PIT tags, yearly data on weight and length are collected on a sub-sample of individuals. For Lost River sucker and shortnose sucker, PIT-readers are deployed during the spring time near spawning sites. Between 1999 and 2008 3,780 female Lost River sucker and 5,728 male Lost River sucker were captured, tagged, and released at Upper Klamath Lake shoreline spring spawning areas (Janney et al. 2009). In the Williamson and Sprague Rivers, between 2000 and 2008, 8,901 female and 6,157 male Lost River sucker were tagged and released, and between 1995 and 2008, 8,743 female and 5,553 male shortnose suckers were captured, tagged and released.

One method of analyzing mark-recapture data uses a model developed by Pradel (1996) and implemented in program MARK (White and Burnham 1999). For example, if an individual fish was captured only during the third and fourth events of a four-event sampling effort, the individual capture history would be 0011, with “1” representing captured and “0” representing not captured. This approach permits estimation of survival probabilities. The reverse-time analog of this example capture history would be 1100 and enables estimation of the probability that an individual present in a population in year *t* was also present in the previous year (year *t*-1). This parameter is known as seniority (γ), and is the inverse of recruitment. Using estimates of annual survival (Φ) and annual seniority (γ), an annual rate of change in a population (λ) can be estimated: $\lambda_t = \frac{\Phi_t}{\gamma_{t+1}}$ (see also Janney *et al.* 2009).

Table 5 Mean and one standard error (SE) of estimates of the probability of survival, seniority, and annual rate of population change (λ) for Upper Klamath Lake shoreline spring habitat spawning male and female Lost River sucker. Subsequent estimates of Δ_t for males = 0.56 and for females = 0.75. Data provided by E. Janney and D. Hewitt, U.S. Geological Survey, Klamath Falls, Oregon. All estimates are provisional and are subject to change with the collection of more data or refinements to the analysis methods.

Males

Year	Survival	SE	Seniority	SE	λ	SE	Δ_t
2002	0.795	0.021	0.97	0.006	0.820	0.022	NA
2003	0.857	0.020	0.97	0.006	0.883	0.021	0.724
2004	0.923	0.016	0.97	0.006	0.952	0.018	0.689
2005	0.905	0.010	0.97	0.006	0.933	0.012	0.643
2006	0.899	0.006	0.97	0.006	0.927	0.009	0.596
2007	0.917	0.005	0.97	0.006	0.945	0.008	0.563

Females

Year	Survival	SE	Seniority	SE	λ	SE	Δ_t
2002	0.863	0.016	0.968	0.011	0.892	0.019	NA
2003	0.907	0.014	0.968	0.011	0.937	0.018	0.836
2004	0.951	0.011	0.968	0.011	0.983	0.016	0.822
2005	0.939	0.007	0.968	0.011	0.97	0.013	0.797
2006	0.935	0.004	0.968	0.011	0.966	0.012	0.770
2007	0.947	0.004	0.968	0.011	0.978	0.012	0.753

Annual estimates of λ provide insight into the rate of growth and the stability of adult spawning populations by indicating whether a population decreased ($\lambda < 1$), remained stable ($\lambda = 1$), or increased ($\lambda > 1$). The long-term dynamics of a population can be summarized using a quantity known as Δ_t, which is simply the cumulative product of the λ estimates over a time period of interest (Anthony et al. 2006). This quantity represents the percent change in population size from the beginning of the period to the end. Values of Δ_t greater than 1.0 indicate increases in population size relative to the baseline. For example, a Δ_t of 7 indicates that populations are seven times greater than the reference year.

For Upper Klamath Lake sucker populations, seniority and, therefore, λ is currently only estimable for shoreline-spawning Lost River sucker and river-spawning shortnose sucker populations. Data are insufficient to provide reliable estimates for river-spawning Lost River sucker in Upper Klamath Lake or populations in Clear Lake Reservoir. Over the time period beginning in 2002 and ending in 2007, the adult spawning population of male Lost River sucker at the springs is estimated to have decreased to 56 percent of the starting population size (an estimated 44 percent reduction; Table 5). As shown in Table 5 and Table 6, estimated values of Δ_t for the populations of Lost River sucker and shortnose sucker in Upper Klamath Lake range from 0.42 to 0.75, indicating significant reductions in population size for both sexes of both species.

Table 6 Mean and one standard error (SE) of estimates of the probability of survival, seniority, and annual rate of population change (λ) for Williamson/Sprague spawning male and female shortnose sucker. Subsequent estimates of Δ_t for males = 0.42 and for females = 0.49. Data provided by E. Janney and D. Hewitt, U.S. Geological Survey, Klamath Falls, Oregon. All estimates are provisional and are subject to change with the collection of more data or refinements to the analysis strategy.

Males

Year	Survival	SE	Seniority	SE	λ	SE	Δ_t
2001	0.691	0.069	0.902	0.019	0.766	0.078	NA
2002	0.771	0.079	0.902	0.019	0.855	0.090	0.655
2003	0.902	0.081	0.902	0.019	1.000	0.092	0.655
2004	0.679	0.043	0.902	0.019	0.753	0.050	0.493
2005	0.870	0.030	0.902	0.019	0.965	0.039	0.476
2006	0.795	0.022	0.902	0.019	0.882	0.030	0.420
2007	0.905	0.014	0.902	0.019	1.004	0.026	0.421

Females

Year	Survival	SE	Seniority	SE	λ	SE	Δ_t
2001	0.675	0.052	0.918	0.014	0.735	0.058	NA
2002	0.894	0.063	0.918	0.014	0.974	0.071	0.716
2003	0.871	0.056	0.918	0.014	0.949	0.062	0.679
2004	0.675	0.028	0.918	0.014	0.735	0.032	0.499
2005	0.862	0.019	0.918	0.014	0.939	0.025	0.469
2006	0.923	0.012	0.918	0.014	1.005	0.02	0.471
2007	0.944	0.008	0.918	0.014	1.028	0.018	0.484

Three important caveats pertain to the seniority and λ estimates provided by the capture-recapture models. First, estimates of λ apply only to the populations or segments of populations being sampled, in this case adult spawning populations, and are not necessarily representative of the entire population. This means that changes in juvenile and sub-adult abundance are not reflected in our estimates of λ until those individuals join the spawning aggregations.

Second, estimates of seniority are based on a data set that includes only physical captures of fish during spring sampling with trammel nets. Detections of PIT-tagged fish on remote antennas are critical to estimating survival probabilities, but they cannot be used to estimate seniority because they induce bias in seniority, and thus λ. The model for estimating seniority requires that both tagged and untagged fish have the same probability of being encountered, but untagged individuals have a zero probability of being captured with antenna detections, and therefore physical captures of both tagged and untagged fish are required. The exclusion of remote detections from models for estimating seniority means that the amount of data available to estimate seniority is far less than that available to models for estimating survival. As a result, estimation problems and model selection indicate that the most appropriate models are ones in which seniority is constant through time. Thus, estimates of seniority are an average across years. For shoreline-spawning Lost River sucker, estimates of seniority from all models varied little through time, so this has little effect on inferences about Lost River sucker population dynamics. However, estimates of seniority for shortnose sucker are more variable and in some years appear to be indistinguishable from 1.0 based on the available data. Models with estimates so near 1.0 (termed “boundary” estimates) are eliminated in generating the model-averaged estimates presented here, as they may indicate other estimation problems. If in reality no recruitment occurred in years with boundary estimates, the seniority estimate presented here may be too low, thus indicating more recruitment than actually occurred. The overall effect is that the Δ_t presented for shortnose sucker may be as much as 10-15 percent higher than the actual value, providing a picture of shortnose sucker population dynamics that is overly optimistic. Data collection in future years may help to resolve this, but for now the γ, λ, and Δ_t values for shortnose sucker should be considered best case estimates in terms of population status.

The third caveat relates to the calculation of the standard errors for the annual λ estimates. Ideally, estimates of survival and seniority would be generated from a single model or several models from the same dataset as the standard error for the resulting λ estimates would be corrected for the covariance between these two parameters. Because the remote detections must be excluded from estimation of seniority, separate models are used to estimate seniority and survival and the two estimates are combined post-hoc to generate an estimate of λ. The delta method is then used to calculate standard errors for the λ estimates, but the covariance between survival and seniority is ignored. The effect of this approach on the standard errors is expected to be small, but the standard errors for λ may be too small.

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