RECLAMATION

Managing Water in the West

Biological Assessment

The Effects of the Proposed Action to Operate the Klamath Project from April 1, 2008 to March 31, 2018 On Federally-Listed Threatened and Endangered Species

Mid-Pacific Region

.

U.S. Department of the Interior
Bureau of Reclamation

October 2007

Cover photo: A Canal Fish Screen/Headworks:
primary water delivery system to Klamath Project Irrigators

Biological Assessment

The Effects of the Proposed Action to Operate the Klamath Project from April 1, 2008 to March 31, 2018 On Federally-Listed Threatened and Endangered Species

Klamath Basin Area Office
Mid Pacific Region

ACRONYMS AND ABBREVIATIONS

AF	acre feet
AFA	*Aphanizomenon flos-aquae*
AFWO	Arcata Fish and Wildlife Office
ALR	Agency Lake Ranch
BA	Biological Assessment
BLM	Bureau of Land Management
BO	Biological Opinion
BOD	Biochemical Oxygen Demand
°C	degrees Celsuis
CDFG	California Department of Fish Game
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
cm	centimeter
CM	Conservation Measure
CR	Conservation Recommendation
CWA	Clean Water Act Federal
DO	dissolved oxygen
EFH	essential fish habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
ft^3	cubic feet
IGD	Iron Gate Dam
in	inch
KBAO	Klamath Basin Area Office
KDD	Klamath Drainage District
KID.	Klamath Irrigation District
KWUA	Klamath Water Users Association
LRDC	Lost River Diversion Channel
mg/L	milligrams per liter
mm	millimeter
MPID	Modoc Point Irrigation District
NAS	National Academy of Science
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	Natural Resources Conservation Service
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
O&M	operation and maintenance
ORNHIC	Oregon Natural Heritage Information Center

PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council
Plan	Water User Mitigation Plan
PP	particulate phosphorus
Reclamation	Bureau of Reclamation
RM	River Mile
RPA	Reasonable and Prudent Alternatives
RPM	Reasonable and Prudent Measures
Services	Both NMFS and USFW
SSHAG	Salmon and Steelhead Hatchery Assessment Group
SOD	Sediment Oxygen Demand
SOD	Safety of DamS
SONCC	Southern Oregon/Northern California Coast
SRP	soluble reactive phosphorus
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
T&C	Terms and Conditions
TID	Tulelake Irrigation District
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRFE	Trinity River Flow Evaluation Final Report
UKL	Upper Klamath Lake
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	Viable Salmonid Populations
WRIMS	Water Resources Integrated Modeling System
WCW	Willow Creek weir

CONTENTS

Appendices

1-A - USFWS Listed Species and Critical Habitat Concurrence Letter

1-B - NMFS Listed Species and Critical Habitat Concurrence Letter

1-C - Klamath Project Historic Operation November 2000. Prepared by the Bureau of Reclamation

3-A - Coho Salmon (Oncorhynchus kisutch) Life History Patterns in the Pacific Northwest and California, March 2007). Biostream Environmental. Poulsbo, WA. Prepared for the Bureau of Reclamation, Klamath Bain Area Office.

3-B - Klamath Coho Integrated Modeling Framework, Draft Version 1.1 Model Report Prepared by: Cramer Fish Sciences and submitted to the Bureau of Reclamation, Klamath Basin Area Office, September 10, 2007.

3-C - Memorandum dated September 10, 2007 - Klamath River Flow and Water Temperature Applications – Flow: Temperature Tables; as well as Preliminary results of the temperature modeling conducted for the coho life-cycle model to assess the effects of Klamath River flows on temperature downstream of Iron Gate Dam.

3-D - Appendix Tables.

4-A - Glossary

Figures

Tables

EXECUTIVE SUMMARY

This biological assessment (BA) has been prepared pursuant to section 7(a)(2) of the Endangered Species Act (ESA)of 1973, as amended, (16 U.S.C. 1531 et seq., to evaluate the potential effects of the proposed operation of the Bureau of Reclamation's (Reclamation) Klamath Project (Project) on listed species. The Project is located in south central Oregon and northern California and contains approximately 240,000 acres of irrigable land. The Project provides irrigation water to approximately 200,000 to 220,000 acres annually. Waters of the Klamath and Lost Rivers are stored and delivered to meet Project purposes in compliance with State and Federal laws. Species included in this consultation are the threatened coho salmon (*Oncorhynchus kisutch*), the threatened Lost River sucker (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes brevirostris*), endangered Applegate's milk vetch (*Astragalus applegatei*), and the candidate species Oregon spotted frog (*Rana pretiosa*). Reclamation received the species concurrence lists provided by the U.S. Fish and Wildlife Service (USFWS) July 26, 2007 and the National Marine Fisheries Service August 20, 2007. Since receiving the species concurrence list from the USFWS, the Lost River sucker was recommended to be down-listed to threatened (USFWS 2007 SNS). This proposed change in status does not change consultation requirements for the Lost River sucker.

The bald eagle (*Haliaeetus Lucocephalus*) is not formally evaluated because it was removed from the endangered species list on August 8, 2007. Nonetheless, a discussion of this species is included in this document.

This Biological Assessment (BA) describes Reclamation's proposed operation of the Project from April 1, 2008, through March 31, 2018. Reclamation proposes to continue operating the Project for authorized Project purposes and to meet contractual obligations in compliance with State and Federal law. The proposed action consists of four major elements: (1) the storage and diversion of Klamath River and Lost River water and the management of return flows; (2) maintaining lake elevations and river flows that meet or exceed proposed minimum levels; (3) implementation of an Interactive Management Program; and (4) establishment of a Water User Mitigation Plan.

Reclamation has considered the best scientific and commercial information available and determined the potential effects of the proposed action on the listed species. This analysis shows that the proposed action may affect coho salmon, Lost River and shortnose suckers and will have no effect on the Applegate's milk vetch and Oregon spotted frog. This analysis also indicates critical habitat for the coho and proposed critical habitat for the suckers may be adversely modified. Based on these conclusions Reclamation is requesting formal consultation under section 7(a)(2) of the ESA with the USFWS on the Lost River and shortnose suckers and their proposed critical habitat, and with National Marine Fishery Service (NMFS) on the coho salmon and their designated critical habitat.

Part 1 INTRODUCTION, ACTION AREA, AND PROPOSED ACTION

Introduction

This BA describes the Bureau of Reclamation's (Reclamation) proposed operation of the Klamath Project (Project) from April 1, 2008, through March 31, 2018 and provides an analysis of the potential effect to ESA listed species.

> "*Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency (hereinafter in this section referred to as an ''agency action'') is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical..." 16 U.S.C. § 1536 (a)(2)*

Reclamation has determined that initiation of consultation is warranted pursuant to Section 7(a)(2) of the ESA primarily because of proposed changes to Project operations and new scientific information about the effect of operations on listed species. This consultation is being conducted consistent with a March 2006 injunction by the District Court for the Northern District of California, which directed Reclamation "to undertake a comprehensive analysis of new information that has come to light since May 31, 2002." Reclamation is consulting with both the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) but is submitting a single BA to both agencies to facilitate coordination between them and to reduce the potential for conflicting recommendations for multiple listed species in the resulting Biological Opinions (BOs). In early informal consultation, NMFS and USFWS indicated they will respond with separate BOs.

Appendices 1-A and 1-B contain the correspondence from USFWS and NMFS in which they identified ESA-listed species and critical habitat which may be present in the action area. They are the threatened coho salmon (*Oncorhynchus kisutch*) and its designated critical habitat; the endangered Lost River (*Deltistes luxatus*) and shortnose suckers (*Chasmistes brevirostris*) and their proposed critical habitat; and the endangered Applegate's milk vetch (*Astragalus applegatei*). The Oregon spotted frog (*Rana pretiosa*) is a candidate species. The regulations implementing Section 4 of the ESA (5 U.S.C. § 1533) define ''candidate'' as ''any species being considered by the Secretary [of Commerce or Interior] for listing as an endangered or a threatened species, but not yet the subject of a proposed rule'' (50 CFR 424.02). Such a designation does not confer any procedural or substantive requirements on action agencies. However, a brief discussion of the potential effects on the Oregon spotted frog is included. At the request of the USFWS, this BA also contains a discussion of the potential effects on the bald eagle (*Haliatis leucocephalus*), which was removed from the list of threatened and endangered species by the USFWS on June 29, 2007.

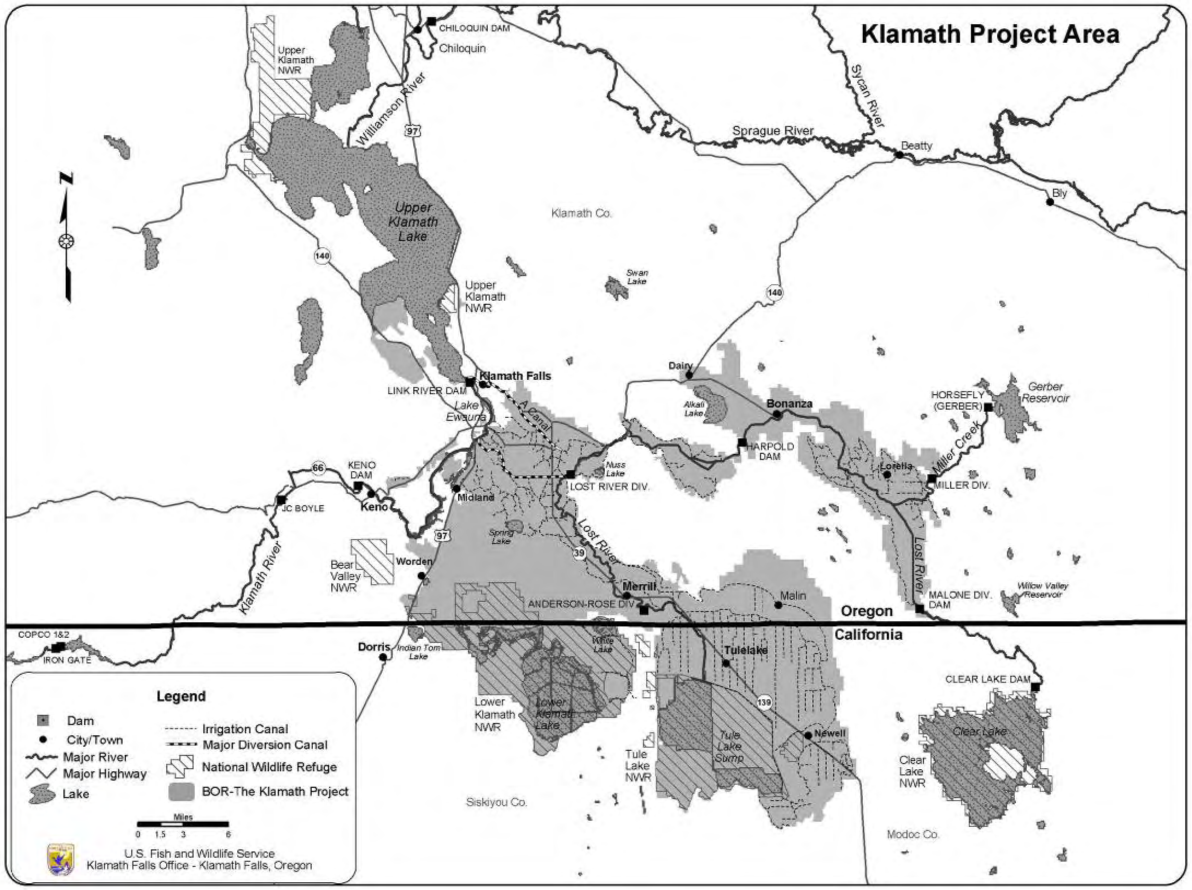
Reclamation will address Essential Fish Habitat as directed by the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265), as amended through October 11, 1996, in a separate document.

Klamath Project Description

The Project is located in south central Oregon and northern California. It covers lands in Klamath County, Oregon, and Siskiyou and Modoc Counties in northern California. Communities in the vicinity of the Project include Tulelake in California, and Klamath Falls, Merrill, Bonanza, and Malin in Oregon. Clear Lake Dam and Reservoir, Tule Lake, and Lower Klamath Lake lie south of the Oregon-California border. Gerber Dam and Reservoir; Upper Klamath Lake (UKL); Link River Dam; and the Lost River, Miller, Malone, and Anderson-Rose Diversion Dams are located in Oregon. Clear Lake Dam and Reservoir are Project facilities located in California. (See Figure 1-1)

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.), authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of water for the reclamation of arid and semi arid lands in the Western States. Congress authorized the Klamath Project by specific statute on February 9, 1905 (Act of February 9, 1905, ch. 567, 33 Stat. 714). The Oregon and California legislatures passed legislation to for certain aspects of the Klamath Project, and the Secretary of the Interior authorized construction May 15, 1905, in accordance with the Reclamation Act of 1902. The Project was authorized to drain and reclaim lake bed lands in Lower Klamath and Tule Lakes, to store water of the Klamath and Lost Rivers, including storage of water in the Lower Klamath and Tule Lakes, to divert and deliver supplies for Project purposes, and to control flooding of the reclaimed lands.

Figure 1-1. Upper Klamath Basin of Oregon and California. Klamath Project lands are shown as shaded area on the map.



Source: USFWS 2002.

The west side of the Project (i.e., Main Project) consists of three large irrigation districts, several small irrigation districts, and two National Wildlife Refuges (NWRs) and are all served by water that is stored in UKL. The three larger districts are Klamath Irrigation District (KID), Tulelake Irrigation District (TID) and Klamath Drainage District (KDD). The KDD also receives water from the Klamath River through two privately owned and operated canals, the Ady canal and the North canal. For more detailed descriptions, Appendix 1-C contains a Reclamation document titled Klamath Project Historic Operation, November 2000. It includes a description of each of the major Project features and a brief history of the Klamath Project. Some minor changes have been made to some Project features since 2000 (i.e., pump replacements, replacement of Clear Lake Dam) but none meaningfully affect the 2000 descriptions or operations.

The east side of the Project consists of two irrigation districts, Langell Valley and Horsefly Irrigation Districts. Langell Valley Irrigation District operates Clear Lake and Gerber Reservoirs to provide irrigation water to their customers. Releases from Clear Lake and Gerber Reservoirs are made directly for Langell Valley customers, and Horsefly customers receive water from return flows, accretions and additions from Bonanza Big Spring. Irrigation on the East Side is managed to minimize any return flows passing Harpold Dam, a Horsefly Irrigation District facility. No releases are made from East Side Dams to provide water for the Main Project and water used for irrigation in the Main Project from UKL is not used in the East Side of the Project due to facility limitations. The earth fill Clear Lake Dam completed in 1910 operated under a Safety of Dams restriction of 350,000 acre-feet (AF) from 1999 until it was replaced by a Roller Compacted Concrete Dam in 2003. Since replacement it has returned to a full capacity of 513,000 AF. These facilities also serve to prevent flooding in and around Tulelake, CA. Excess water is shunted to the Klamath River via Straights Drain, enhancing Klamath River flows in winter months when UKL is being filled. The waters of the Lost River basin have been adjudicated including those of Langell Valley and Horsefly Irrigation Districts. Langell Valley Irrigation District operates and maintains the two reservoirs to meet irrigation needs and required reservoir levels for listed suckers under the USF&W 2002 BO.

Overview of Proposed Action

Project Area

Project Area: The Project Area is defined by the map at Figure 1-1 and is located in south central Oregon and northern California. It consists of two watersheds (Lost River and Klamath River) that provide independent sources of stored water to meet Project purposes.

Action Area

Action Area – all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. 50 CFR § 402.02.

The Action Area begins at the confluence of the Wood River with Agency Lake, Klamath County, in south central Oregon, and extends approximately 240 miles downstream to the outfall of the Klamath River at the Pacific Ocean, near the city of Requa, in Del Norte County, CA (Figure 1-2). There is the potential for direct effects on listed suckers throughout the Project Area, although mitigating measures such as fish screens and ladders have been installed to minimize direct effects. The direct effect of Project operations below the Project ends at Keno Dam, Oregon, the last place where Reclamation regulates Project outfall (through an agreement with PacifiCorp) (see Figure 1-1).

Indirect effects on suckers and coho salmon continue beyond the Project Area through a series of hydroelectric dams and reservoirs (Keno, J.C. Boyle, Copco 1, Copco II, and Iron Gate dams) owned and operated by PacifiCorp, and continue to the mouth of the river. The indirect effects on coho salmon continually diminish with increasing distance downstream as the volume of water contributed to the Klamath River by the Project combines with water from the Scott, Shasta, Salmon and Trinity Rivers, as well as numerous creeks and other tributaries. Figure 1-3 below shows the flow volumes contributed to the mainstem Klamath River by these tributaries seasonally, illustrating this diminishing indirect effect.

Figure 1-2. Klamath River Basin.

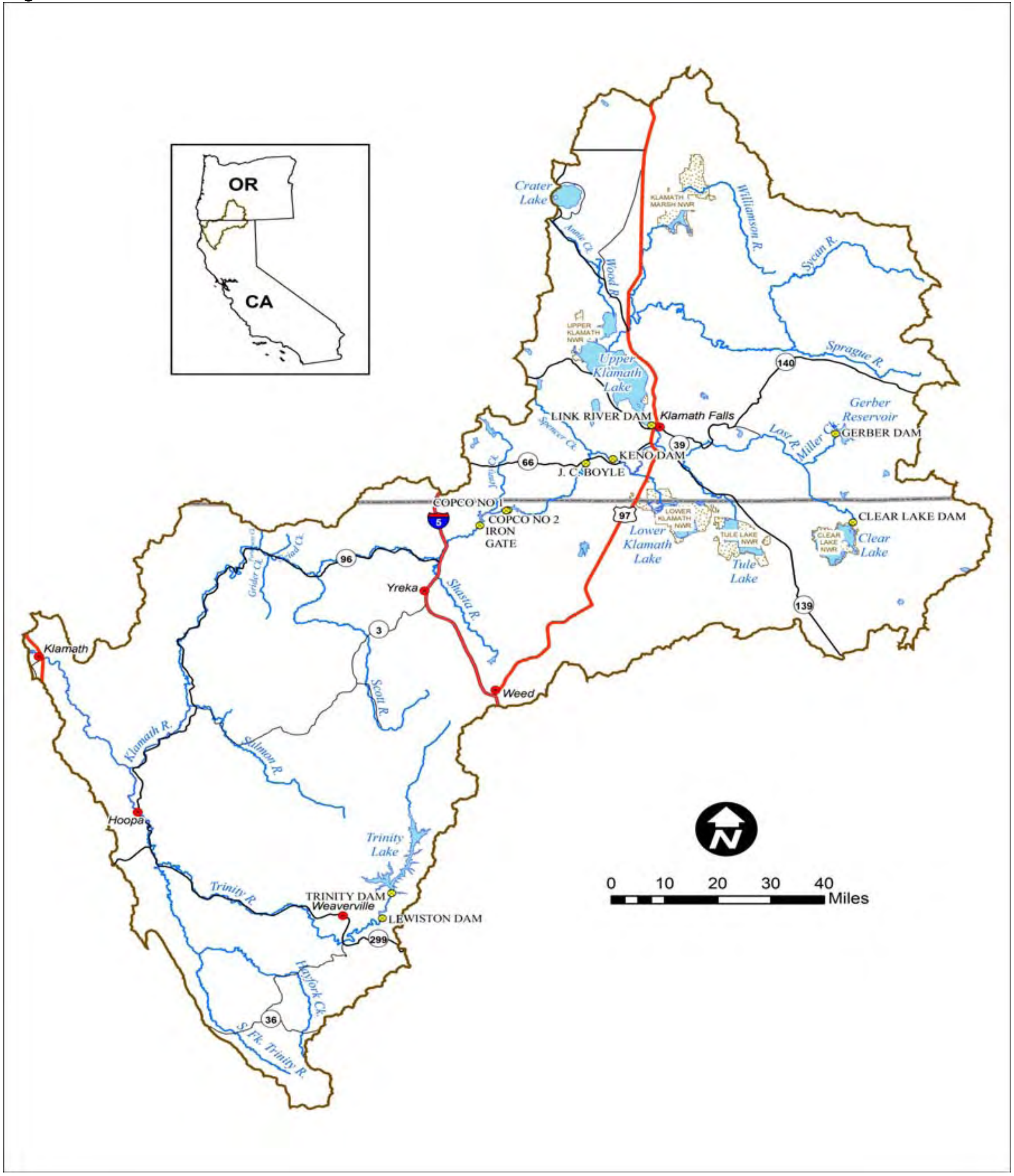
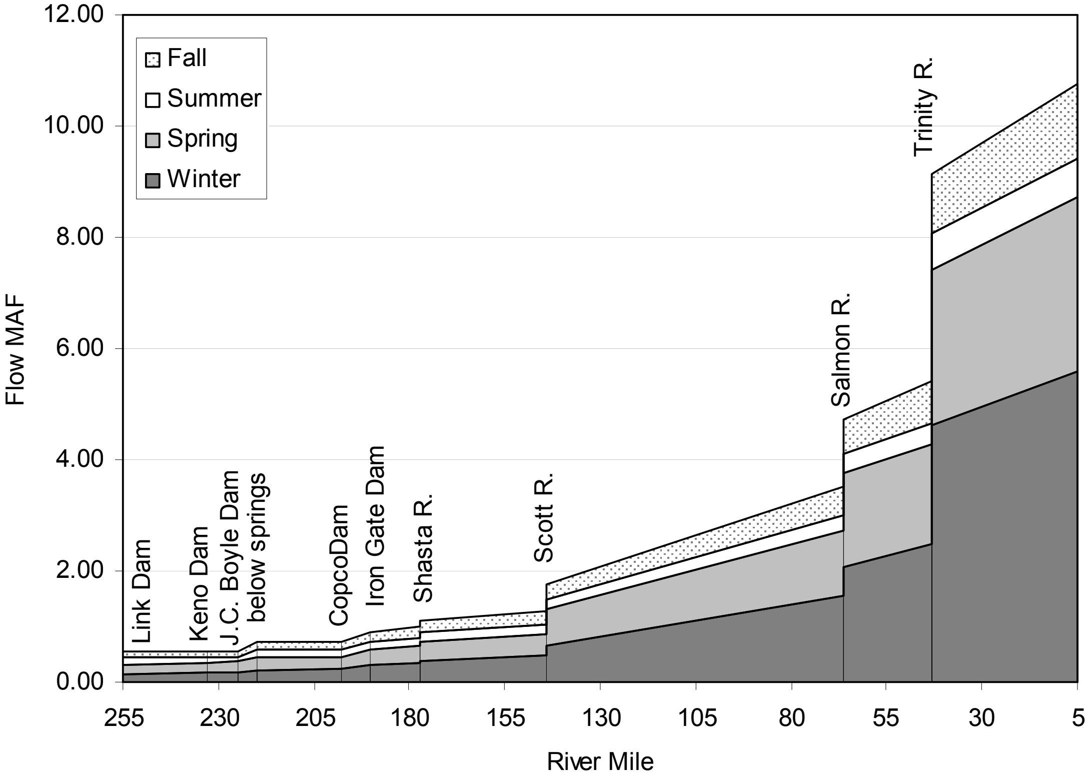


Figure 1-3. Simulated seasonal flows in the Klamath River from Link River to Turwar in 2000.



Source: Figure 14, after "Temperature and flow dynamics of the Klamath River," April 20, 2007. By Cramer Fish Sciences.

Proposed Action

The proposed action consists of four major elements:

1. To store and divert waters of the Klamath and Lost Rivers and to manage return flows for authorized Klamath Project purposes and to meet contractual agreements between Reclamation and water users.

2. To operate the Project to maintain UKL elevations and Klamath River flows that meet or exceed the proposed minimum levels as specified below. Reclamation believes that the proposed minimum Klamath River flows and UKL elevations should avoid the likelihood of jeopardy and will not preclude recovery of the species listed under the ESA. During most years, river flows and lake elevations will exceed the minimum levels. Reclamation proposes to continue to operate the east side of the Project, Clear Lake and Gerber Reservoirs, as defined in the 2002 USFWS Biological Opinion (BO).

3. To implement an Interactive Management (IM) process by which Tribal and State governments and other Federal agencies will work collaboratively with Reclamation to manage and distribute water available in the system after meeting proposed minimum Iron Gate Dam (IGD) flows and UKL elevations and addressing Project obligations. The IM water will enhance minimum levels to bring river flows and lake elevations closer to desired targets beyond the jeopardy standard, to contribute toward tribal trust obligations, and to help conserve and enhance fish and wildlife habitat.

4. Work with the Klamath Water Users Association (KWUA) to establish a Water User Mitigation Plan (Plan) which could be implemented to lessen the impact to water users when the Project experiences a water shortage after meeting the proposed minimum river flows and lake elevations. The Plan will initially be managed by Reclamation during a four-year transition period, after which it will be the sole responsibility of the KWUA under a Joint Powers Agreement.

Each of the elements of the proposed action is described in greater detail in the following section setting out the detailed proposed action. A glossary of specific terms used in this BA can be found in Appendix 4-A.

Detailed Proposed Action

Background

The Klamath Project is not operated according to a static set of planned operations but is instead operated in response to the particular environmental conditions at hand, including weather patterns, soil moisture, crop type and requirements, number of acres in production, hydrology, timing, duration and magnitude of inflows, etc. Given UKL's lack of carryover storage, inaccurate inflow forecasts for both quantity and timing of inflows, and varying irrigation and NWR demand, Reclamation has a limited ability to carryover water from one year to the next or control excess spills and has no control over inflows. For purposes of this consultation, Reclamation analyzed historic hydrology and Project operations between 1961 through 2004 to model future Project demand. In its 2002 BA, Reclamation used only a ten-year period (1990s) of record to estimate potential future conditions. Reclamation believes that a ten-year period does not adequately represent the range of expected water supply conditions which has been problematic because water quantity and timing in one year differs from any other year. Subsequently, Reclamation has found it very difficult to manage operations based upon two separate and often competing BOs that were developed independently without coordination between the USFWS and NMFS. The USFWS did work with Reclamation to improve the original BO lake elevation requirements to help improve Reclamation's ability to meet required minimum lake elevations. Therefore, Reclamation has expanded the ten-year period to the forty-three year period from 1961 to 2004. The observed values from this forty-three year period were selected as the best data to represent the range of potential future demand and conditions because there is a complete set of data available, and because all of the Reclamation and PacifiCorp facilities were in place during this period.

Elimination of Specific Water Year Types

The 2002 BOs issued by the USFWS and NMFS identified different water year types, each defining a range of inflows into UKL. The water year type for any given year would then be determined based upon hydrology, calculating projected inflows to UKL using the Natural Resource Conservation Services (NRCS) forecasts for the months of April through September. As inflow predictions were refined throughout the season, the water year type would be reviewed and changed if inflows changed to a different range. Each water year type had corresponding monthly river flow requirements and lake elevations.

The USFWS BO included four water year types, as proposed in Reclamation’s BA, while the NMFS BO included five water year types. The water year types from NMFS did not match any of the water year types from USFWS. Water year types also changed between April and July in most years as a result of the difficulty of making accurate predictions as a result of changes in the NRCS April through September predicted and actual seasonal inflow. The inherent uncertainty in NRCS inflow predictions, changing water year types, conflicting year-type structuring, and the large variation in the monthly flow and lake level requirements between water year types, made it extremely difficult for Reclamation to predict or manage water distribution (see section below on water supply predictions). In addition, because water year types were defined by large ranges of inflows between the lower limit of one water year type and the higher limit of the same water year type, (i.e., up to 218,000 AF, or 604 cfs) for every day between April 1 and September 30, a very small change in predicted inflow could result in a change in water year type. The change in water year type could require large changes in river flows and lake elevations. While USFWS accepted Reclamations proposed four water year types, they provided a Reasonable and Prudent Alternative (RPA) that changed the proposed 70% exceedence to 50% inflow exceedence which reduced Reclamation’s ability to manage for all demands.

This method of setting river flows and lake elevations, without coordination between NMFS and USFWS’s BOs, and based upon two different sets of water year types, had several results. First, the predictability of water supply for the Project was greatly decreased. Second, in months when the Project was not delivering water, the two BOs often came into conflict with one another, as neither requirement could simultaneously be met. Third, a nearly un-measurable change in estimated UKL level could be viewed as a “violation” of the BO because of its precise and rigid, and thus unrealistic, lake measurements. In light of these uncertainties and strict prescriptive BO requirements, Reclamation operated the Protect extremely conservatively.

As a result of the multiple difficulties listed above and the wide variation in actual monthly inflows (demonstrated in Table 1-1 below), Reclamation is proposing the use of an IM process that can better accommodate all of the uncertainties and limitations experienced when operating according to separate and different water year types in two BOs. Instead of four or five water year types, operations will respond to actual conditions such as current lake elevation and inflows, Keno to IGD accretions, net irrigation and NWR diversions, etc. In response to these actual and current conditions, IM will be better able to partially restore the natural range of variation formerly present in the system.

Water Supply Predictions

Accurate predictions for seasonal inflow into UKL have proven to be very elusive. Monthly inflows into UKL can vary significantly depending on current temperature, precipitation, and depletions above the lake, making it difficult to manage lake elevation to precise levels on a monthly basis. Monthly inflows into UKL during the April through September period can vary by as much as three times the seasonal variance in inflows for the entire period of April through September, as illustrated the Table 1-1. Although the seasonal inflow for each of the six years displayed varies by only 31,000 AF, the difference in inflow during the same month of different years ranges widely. The table also includes the NRCS 50% April 1st forecast of runoff, based upon snowpack. This information is considered the best available for estimating water available for Project purposes and demonstrates the elusive nature of forecasting in the Klamath Basin.

Table 1-1. Seasonal variance in inflows for the entire period of April through September. (variation in UKL inflow for six years with similar total inflow).

	Monthly data is in Thousands of Acre Feet (TAF)						**UKL Inflow**	**NRCS 50%**
Water Yr							**TAF**	**April 1st**
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Apr-Sept**	**Forecast**
2005	78	174	46	3	7	24	332	215
1979	94	111	30	19	28	50	331	295
2003	124	107	27	12	15	43	328	290
1990	99	76	37	18	45	44	318	240
2002	124	90	33	14	16	32	309	385
1977	68	79	49	17	28	60	301	225
Highest Inflow	124	174	49	19	45	60	332	
Lowest Inflow	68	76	27	3	7	24	301	
Difference	**56**	**99**	**22**	**15**	**38**	**36**	**31**	
Variability Range	181%	319%	71%	48%	123%	116%		

Discontinuation of Certain Elements of the Former Pilot Water Bank

In response to the NMFS 2002 BO, Reclamation conducted a Pilot Water Bank program to augment Klamath River flows. NMFS typically requested the majority of the Pilot Water Bank water be released in the spring to bring flows somewhat closer to the long term flows in Table 9 from NMFS 2002 BO. With no unused storage space available in which to bank water, the Pilot Water Bank consisted of compensating land owners to forego the use of Project water through land idling or the pumping of groundwater. These methods have proven to be both cost prohibitive (Reclamation expended over $22 million on the Pilot Water Bank between Fiscal Years 2002-2005) and unsustainable (ground water pumping, for example).

As a part of the former Pilot Water Bank, Reclamation requested bids each year for land idling but received relatively small numbers of applicants. In addition, irrigation demand is relatively low during spring months (April and May) so land idling does not provide a sufficient quantity of water during that period when it is most needed to meet the needs of out-migrating coho salmon. On average, net reductions of consumptive use from idling land produces a total of approximately 1.9 AF per acre during the months of April through September. Reductions in consumptive use from land idling are approximately 3% in April, 13% in May, 23% in June, 28% in July, 20% in August and 13% in September. This consumptive use is for irrigation use only which represents approximately 67% to 72% of total net deliveries. The remaining 28% to 33% of non-agricultural consumptive use occurs in the two NWRs served by Project water supplies. Reclamation's efforts to include significant land idling in the Pilot Water Bank have fallen short of expectations. Many individuals were unwilling to consider land idling because the economic value from being able to farm a parcel of land exceeded the compensation they could receive through land idling in a competitive bid process.

Furthermore, continued extensive groundwater pumping is not a sustainable hydrological approach to supplementing water supplies because of its unknown effects on the water table depth and other limitations. Continued groundwater pumping year after year has not allowed for recharge of the natural system and has exacerbated naturally declining water levels. (See U.S. Geological Survey [USGS] "Ground-Water Hydrology of the Upper Klamath Basin, Oregon-California" for more information).

Efforts to Increase Project Storage

Although Reclamation is discontinuing certain elements of the Pilot Water Bank, storage of water on Agency Lake /Barnes Ranches (approximately 63,800 AF) (soon to become part of the Upper Klamath NWR) as well as The Nature Conservancy's (TNC) Williamson River Delta (Delta) Restoration (approximately 28,800 AF) will continue and increase. Reclamation also plans to continue the partnership with Lower Klamath NWR which allows for the storage of 12,000 to 15,000 AF on the NWR. All of this additional storage comprises 85% of the additional storage anticipated in discussions regarding a proposed Klamath Settlement agreement.

Reclamation has been actively working to restore UKL. In 1997, Reclamation purchased Agency Lake Ranch (ALR), located along the north shore of UKL, and began using it for off-stream storage to help supplement water deliveries later in the irrigation season when lake elevations would begin to fall. In 2006, Reclamation, in partnership with the USFWS, and TNC purchased the Barnes Ranch, adjacent to ALR, to use for water storage. In approximately 2009, when the raising of the dikes at the northern end of the Barnes property is complete, the gross storage capacity of UKL should be increased by approximately 63,800 AF. Reclamation has provided approximately $5 million to TNC's Delta Restoration. In fall 2007, TNC will breach dikes at the Delta, restoring wetlands on approximately 1,400 acres of land which were separated from UKL by dikes. TNC is planning to return another 1,880 acres of land to the lake within the next two years. Collectively, these efforts toward restoring UKL and improving storage capacity will also improve habitat conditions for listed suckers, and the resulting restored wetlands could improve water quality and conditions for the Oregon spotted frog.

Element One

> **Element One:** *To store and divert waters of the Klamath and Lost Rivers for authorized Klamath Project purposes and to manage return flows, to meet contractual agreements between Reclamation and water users.*

1. Annual Storage of Water

A typical Reclamation water project has the capacity to store large quantities of water during high inflow periods and make it available to meet delivery needs in low precipitation years. UKL (the Project's primary storage facility), however, averages only eight feet deep when at full pool and thus does not have the capacity to carry over significant amounts of stored water from one year to the next. It is also unable to store excess inflows during winter months, so the system is highly dependent on actual monthly inflows in any individual year, and is predominately dependent upon snowpack to sustain inflow throughout the season.

Reclamation proposes to store water in UKL year round with a significant portion of the water stored during October through March. In some years of high flows, storage can also be significant in April, May, and June. Reclamation proposes to store water in Clear Lake and Gerber Reservoir generally from October through April and deliver from storage from April through September.

The storage of water in UKL generally occurs between the months of October through March. On occasion, storage may also take place during the months of April, May, and June. The action of storing water in UKL creates rising lake elevations which usually peak between March and May. The action of storing water during the fall and winter months has a minor effect on river flows during that period of time due to the augmentation of Lost River water flowing from Reclamation's facilities into the Klamath River through the Lost River Diversion Channel (LRDC) and the Klamath Straits Drain (KSD). Between 1961 and 2004, from October through March, the average augmentation from Reclamation's LRDC and KSD facilities to the Klamath River totaled approximately 154,000 AF of water. This augmentation allows Reclamation to store the equivalent volume of water in UKL without any reduction in Klamath River flows below Keno.

2. Diversions for Agricultural and NWR Purposes

Delivery of water to the Project mainly occurs from early April through mid-October. However, some Project diversions from the Klamath River take place during the months of October through March to accomplish pre-irrigation on some land and provide additional water to the NWRs.

Deliveries to Project lands and NWRs are assumed to be similar to those occurring during the 43-year of 1961-2004. These deliveries were included in the model runs that define the expected river flows and lake levels discussed in Element 2 below. Model runs estimate that full annual deliveries to the Project lands and NWRs will be experienced in many years when the proposed minimums are maintained. A Water User Mitigation Plan will be put into effect in years when Project deliveries must be reduced to provide for minimum river flows and lake elevations.

3. Return Flows and Lost River Additions

The Proposed Action includes the continuation of diversions to the Klamath River from the Lost River through Reclamation's LRDC and return flows from the KSD. Reclamation's LRDC and KSD contribute significant quantities of water to the Klamath River system during both the April through September period and on an annual basis. Exceedence Table 1-2 below, display the significant quantities of water contributed to the Klamath River system from these two Reclamation facilities. The annual quantities are not the sum of the monthly exceedence quantities since monthly exceedence flows will not always occur sequentially.

Table 1-2. LRDC and KSD contributions to the Klamath River (in thousands of acre feet).

Lost River Diversion Channel contribution to the Klamath River.													
Exceedence	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Annual**
90%	7.31	3.82	5.15	5.49	6.89	6.37	3.56	5.02	2.60	1.77	2.09	6.25	73.56
80%	7.98	4.76	6.27	7.81	7.95	8.80	5.55	7.03	5.39	4.18	5.60	8.10	96.38
70%	8.86	5.99	6.81	8.53	9.56	11.16	6.67	9.30	6.42	5.20	7.87	10.23	113.22
60%	9.53	6.97	8.32	10.00	11.84	12.82	7.43	10.61	7.38	6.71	8.90	11.54	131.09
50%	9.94	7.86	8.97	10.83	13.05	14.67	11.07	11.34	9.27	8.17	11.12	13.23	143.16
40%	11.85	8.20	11.38	14.23	15.15	19.67	12.52	12.45	10.45	9.23	12.11	13.51	168.00
30%	12.69	8.41	12.38	19.78	20.29	27.01	15.24	14.18	12.33	10.29	14.71	14.89	185.84
20%	14.47	9.86	17.07	23.14	23.41	35.53	18.65	15.58	13.91	12.79	15.49	16.84	228.79
10%	15.37	11.41	20.56	29.59	38.37	46.52	39.03	17.68	16.54	13.34	18.21	19.64	285.56

Klamath Straits Drain contributions to the Klamath River													
Exceedence	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Annual**
90%	0.96	1.40	1.64	2.03	6.15	10.30	3.39	3.90	3.59	3.20	3.09	1.44	69.03
80%	1.55	1.69	3.74	3.71	8.05	12.26	5.54	5.52	4.42	4.12	3.63	3.18	80.52
70%	2.08	3.29	5.25	4.73	10.12	13.64	6.76	6.19	5.96	4.91	4.44	3.53	93.64
60%	3.15	5.44	6.43	7.45	11.70	17.07	7.28	8.15	6.73	5.30	4.83	4.15	100.82
50%	3.99	8.15	7.88	9.02	12.60	17.99	7.91	8.97	7.19	5.52	5.58	5.63	112.35
40%	4.48	9.29	11.14	10.44	13.99	18.63	9.00	10.42	7.56	5.92	7.61	7.44	119.99
30%	5.46	11.37	12.52	12.27	16.55	19.12	10.40	11.68	8.29	6.15	7.98	8.21	124.46
20%	6.66	14.01	15.00	15.22	17.17	22.65	12.10	13.56	8.84	6.83	9.87	9.50	129.13
10%	9.27	15.82	16.63	18.69	21.21	25.32	15.84	16.45	10.59	8.58	11.42	10.48	140.39

4. Operation of the East Side of the Klamath Project

Reclamation proposes that minimum lake elevations and water storage operations at Clear Lake and Gerber reservoirs remain unchanged from those provided in the USFWS 2002 BO and amendment (USFWS 2003 Amendment).

Reservoir	Minimum Lake Elevation
Clear Lake Reservoir	4520.6 feet
Gerber Reservoir	4798.1 feet

Element Two

> **Element Two:** *To operate the Project to maintain lake elevations and river flows that meet or exceed the proposed minimum levels as specified below. Reclamation believes that the proposed flows and lake levels avoid the likelihood of jeopardy and will not preclude recovery of the listed species under the ESA. Under the proposed action, Klamath River flows and lake elevations will likely exceed the minimum levels during most years.*

Rather than using water year types, as was the case in the 2002 Section 7 consultation, this consultation uses estimated river flows and lake levels based upon exceedence criteria as well as specified minimum flows. Reclamation modeled estimated river flows and lake levels using the 43-year period of record, 1961-2004, to determine how frequently the proposed minimum flows and lake levels would likely be exceeded.

1. Klamath River Minimums

Flows

Under the proposed action, river flows for each year will be no lower than the minimum flows identified in Table 9 of the NMFS 2002 BO for the months of July through February. For the months of March through June, the minimum river flows in the proposed action will be no lower than 1450 cfs, 1500 cfs, 1500 cfs and 1400 cfs respectively. The historical monthly average river flows, as measured at IGD, are shown in Appendix 3-D. In certain months, primarily June and July, the historical average monthly flows as measured at IGD were lower than the minimum flows described in the proposed action. In the proposed actions for those months the minimum flow will be 1400 and 1000 cfs respectively. Table 1-3 describes the proposed minimum flows as measured at the USGS gage below IGD.

Using the exceedence criteria, the actual anticipated river flows in each month are as shown in Appendix 3-D. The 43-year (1961-2004 average monthly) historical flows can be useful when attempting to understand the frequency that the proposed action flows are greater than those of the 43-year period.

As discussed in the Effects of The Action section, certain portions of these anticipated flows are greater than needed to offset any adverse effects to coho salmon. These flows are considered IM water to be managed as discussed in Element 3 below.

Many of the Klamath River minimums have been adopted directly from Table 9 in the NMFS's 2002 BO. The river minimums are identical to the Phase III flows for all former water year types during the months of July through February and the former Dry Water Year for the months of March through June from NMFS's BO. The flows will be measured at the USGS gage below IGD. After review of the 43-year period of record, Reclamation anticipates that the Klamath River minimums described here will only be utilized in years when no spills or IM water is available. Annual IGD releases to the river will be higher in most other years, with striving toward target flows being the goal. Because of the limited amount of storage in UKL, springtime spills should continue to occur, significantly increasing the opportunities for releases well above the minimum flows.

Table 1-3. Minimum flows for the Klamath River.

Month	Proposed Minimum Flows for the Klamath River Below IGD
October to February	1,300cfs
March	1,450cfs
April	1,500cfs
May	1,500cfs
June	1,400cfs
July to September	1,000cfs

Flow Measurement Location

Outflow from Project operations in the Klamath River can most accurately be measured at the USGS gage located below the Keno Dam. As the Klamath River flows from Keno towards the Pacific Ocean, the contribution of river flows from Keno become continually less significant relative to total cumulative river flows as previously described and depicted in Figure 1-3. Flows from Keno may comprise a higher percentage of total Klamath River flows during the summer months and during drier hydrologic years due to extensive irrigation diversions from the Klamath River's main tributaries, the Shasta, Scott, and Trinity Rivers. Although Keno Dam is the furthest downstream location where Project flows can be controlled, Reclamation agrees to continue to measure flows at the USGS gage below IGD in an effort to accommodate the desires of numerous downstream interests, provided that a written agreement between Reclamation and PacifiCorp can be established. PacifiCorp is an applicant in the Federal Energy Regulatory Commission's (FERC) ESA consultation on relicensing their hydropower project. The outcome of that consultation may be helpful to Reclamation in continuing to measure flows below IGD as well.

2. UKL Minimums

In past consultations on the operations of the Klamath Project, the FWS has recommended minimum elevations for UKL (2001 BO) to ensure sufficient habitat and to contribute to the improvement of water quality conditions. Recent analysis of a 17-year dataset of water quality parameters and lake depth from UKL was unable to identify a discernable relationship between lake elevation and water quality conditions (Morace 2007). This relationship is discussed in more detail in Part 2 regarding the endangered suckers. However, habitat use at each life history stage of the ESA listed suckers may be related to lake elevation (Terwilliger 2006).

In 2005, FWS found that lower lake levels in some years would be offset by the additional habitat being created by wetlands restoration at TNC's Delta (FWS BO 1-10-05-F-046). This is a very important finding because as the size of UKL is increased by the action of TNC (breaching dikes at the Delta) and by the USFWS's proposed action of breaching of the dikes at ALR and Barnes properties in the near future, it will be more difficult for Reclamation to maintain historic lake levels in some years.

Recent modeling, using Reclamation's Water Resources Integrated Modeling System (WRIMS) Model, indicates when UKL's elevation at the end of September is at 4138 ft, the probability of refilling the lake to 4143 ft is 84% when the storage in TNC's Delta project and the ALR-Barnes properties are included. The probability of refilling to 4142.6 is 93% under the same expanded lake conditions. Under existing storage conditions, the probability of refilling the lake to 4143 ft is 91%.

Reservoirs with sufficient storage capacity can carry-over excess water received in wet years, making it available in dryer years. Unlike most Reclamation Projects, the Klamath Project operates primarily on an annual supply of water because the capacity of UKL is not sufficient to store excess water. This lack of carry over storage means it is extremely important to fill the reservoir every year it is possible to do so. IGD releases between October and February that are higher than needed for sufficient coho habitat (1,300 cfs vs 1,000 cfs) reduce the likelihood of refilling UKL from 94% to 84%. To begin the spring coho outmigration and irrigation season with less than a full lake would result in only minimum flows at IGD, increased shortages to the Project, and further reduce the likelihood of re-filling UKL the following year, creating a situation in which less water would be available for any purpose the following year. In a period of consecutive very dry years, such as 1992 and 1994, meeting minimum flows and lake elevations may likely not be possible even if no Project diversions were to occur. The end-of-month lake elevations for the months of October through March were determined in part to maximize the likelihood of refilling UKL in most years.

Reclamation believes the proposed minimum lake levels from February through September avoid the likelihood of jeopardy and will not preclude recovery of the listed species under the ESA. During most years lake elevations will exceed the minimum levels (Table 1-4).

Table 1-4. Minimum elevations at UKL.

	Biological Minimum Elevation – USBR Datum	**Operational Refill Targets**
October		4139.1
November		4139.9
December		4140.8
January		4141.7
February	4141.5	4142.5
March	4142.2	4143.0
April	4142.2	
May	4141.6	
June	4140.5	
July	4139.3	
August	4138.1	
September	4137.5	

3. Ramp Down Rates at IGD

Reclamation proposes that ramp down rate releases, above 3,000 cfs, at IGD will follow the rate of decline of inflows into UKL combined with accretions between Keno and IGD. This ramp down rate should ensure that UKL elevations are not drawn down to accommodate non-natural declines in inflow. Ramp down rates, below 3,000 cfs at IGD will continue as were required in the NMFS 2002 BO.

Element Three

> **Interactive Management:** *Implement an IM process by which Tribal and State governments and other Federal agencies will work collaboratively with Reclamation to manage and distribute water available in the system after meeting proposed flows and lake levels and addressing Project obligations. The IM water will enhance minimum levels to bring river flows and lake elevations closer to desired targets, to contribute toward tribal trust obligations, and to help conserve and enhance fish and wildlife habitat.*

1. Target River Flows and Lake Elevations

Water remaining in the system after Reclamation meets the river flows and lake levels identified in Element Two above, and then Project demand, is referred to as "IM" water for the purposes of this BA. Reclamation believes the enhanced flows are not necessary to avoid the likelihood of jeopardy to listed species, but will promote conservation of other fish and wildlife species as well as listed species. Given Reclamation's UKL refill criteria and Klamath River and UKL minimums, modeling from 1961-2004 suggests that IM water will be available in many years. Flows sufficient for movement of gravels and scouring occur on a natural cycle and are experienced as uncontrolled spills from UKL and PacifiCorp's hydroelectric dams. Flows sufficient to accomplish movement of gravels and scouring can not be achieved in years when insufficient natural inflow is occurring.

Reclamation's goal is to operate the Project to meet or exceed proposed minimums, which will be enhanced by the IM water. Reclamation will determine the quantity of IM water available. Reclamation proposes to manage this water collaboratively with Tribal and State governments and other Federal agencies, through the IM process described below. These parties will form an IM Technical (Tech) Team that will recommend how the IM water should be distributed based on the status of the fish and their habitat, not strictly upon inflow. Reclamation will review the IM Tech Team's recommendations and determine how to best implement them consistent with the guidance below. Recommendations for distribution of IM water will be re-evaluated on a bi-weekly basis should the volume of IM water change. Reclamation would provide guidance on historical inflows and system effects to the IM Tech Team to help in making informed recommendations. Reclamation reserves the authority to alter recommended distribution of IM water if deemed necessary to meet future minimums.

Potential Benefits of Proposed Guidelines for UKL and Klamath River Releases

Less restrictive lake elevations and river flows provide NMFS, USFWS, Tribes, Project irrigators and NWRs, as well as other interested parties the maximum amount of flexibility to work cooperatively to meet the real time needs of listed and other species within the limitations of actual UKL inflows in any particular year. Target elevations for UKL and target flows for Klamath River are the desired outcomes of IM. Higher required lake elevations or Klamath River flows at IGD may reduce flexibility in the future months, therefore, risk analyses is a key component of IM.

For example, in order to meet higher minimum river flows and lake levels, Reclamation may need to reduce desired spring time releases to ensure sufficient water supply is available throughout the entire season.

As discussed previously, Reclamation is not using water year types for this BA. The IM process can more readily adjust operations to distribute IM water while taking into consideration factors such as fish movement, year-class or cohort strength, disease conditions, air and water temperatures, water quality, etc. This type of information could be collected through existing monitoring programs, with continued financial and other support of Reclamation. The specific elements monitored would be modified based on needs of the IM Tech Team, availability of funds, and other factors. Under IM, species' needs and habitat conditions, as well as water use and supply, will be reviewed every two weeks to determine the volume of IM water available, increasing flexibility to manage the water for all purposes and all species. Small changes in estimated inflow will translate to similar changes in management, more closely mimicking a natural hydrograph for the river and for UKL. Interactive Management promotes communication between involved parties on a timely basis to make recommendations based on current water and habitat conditions and species needs.

In an attempt to simulate potential lake levels and river flows that may be realized from an IM process, Reclamation employed its WRIMS. The model uses 1961-2004 historical data for UKL inflows and Keno to IGD accretions, minimum lake levels and river flows, and estimated Project needs to estimate future UKL elevations and Klamath River flows at IGD, under different potential water management scenarios. It must be noted that the modeling results for Klamath River flows and UKL elevations are interdependent. For example, any change in minimum river flows will alter the results for lake elevations, refill and spill potential as well as IM water availability.

Modeling Assumptions:

(1) Minimum IGD flows are as indicated in the Proposed Project.

(2) Minimum UKL elevations are as indicated in the Proposed Project.

(3) Priorities are river, lake, Project from April through September.

(4) Lake level refill targets are as indicated in the Proposed Project.

(5) Distribution of a portion of storable inflow to the river, October through February, after monthly UKL refill targets are achieved.

(6) Distribution of a portion of the April-September surplus to the river in May – September, varying the percentage of the surplus depending on the seasonal supply, i.e., 35% in wetter years, 25% in median years, and 10% in drier years. The actual percentage varied linearly with the water supply. The distribution was: May 1-15 15%, May 16-31 15%, June 1-15 20%, June 16-30 20%, July 1-15 7.5%, July 16-31 7.5% and September 10%. This distribution was used in the modeling in an attempt simulate how the IM process might be used to distribute available water.

It should be noted that WRIMS has the luxury of going back in time and using actual historical UKL, LRDC and KSD inflows to adjust monthly distributions for river flows and lake levels. Specific replication of these scenarios today would be somewhat limited by the unpredictable future of the inflows listed above as well as a number of other factors including; precipitation, snow pack and soil moisture content, temperature, etc. Operations in the future would attempt to achieve similar results using the IM process described in the BA.

The following exceedence tables reflect the estimated frequency that different lake levels and river flows might be realized under the Proposed Action using historical inflow data (Tables 1-5 and 1-6). For comparison purposes only, Appendix 3-D contains similar tables illustrating modeled exceedence flows using the NRCS April 1st forecast rather than the known historical inflows.
Note: Monthly exceedence flows will not always occur sequentially.

Table 1-5. Modeled IGD flow exceedence in cubic feet per second.

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
90%	1,300	1,300	1,300	1,300	1,300	1,450	1,500	1,504	1,405	1,000	1,000	1,000
80%	1,300	1,300	1,300	1,300	1,300	1,766	1,500	1,524	1,432	1,009	1,004	1,007
70%	1,300	1,300	1,300	1,300	1,300	2,365	1,500	1,569	1,496	1,035	1,012	1,024
60%	1,300	1,300	1,300	1,309	1,880	2,565	1,892	1,602	1,554	1,060	1,020	1,041
50%	1,300	1,300	1,695	1,855	2,577	2,813	2,669	1,719	1,658	1,091	1,030	1,062
40%	1,300	1,300	1,986	2,251	3,097	2,974	2,982	2,067	1,719	1,118	1,038	1,082
30%	1,300	1,629	2,471	2,581	3,632	3,720	3,713	2,775	1,754	1,143	1,049	1,089
20%	1,300	1,966	3,018	2,908	3,960	4,920	4,521	3,111	1,942	1,193	1,066	1,145
10%	1,300	2,911	3,337	3,948	5,663	5,952	5,544	3,885	2,563	1,380	1,120	1,239

Table 1-6. Modeled lake elevation exceedence.

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
90%	4141.20	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.78	4141.81	4141.03	4140.82
80%	4141.02	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.58	4141.59	4140.92	4140.68
70%	4140.78	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.50	4141.41	4140.72	4140.37
60%	4140.45	4141.22	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.33	4141.34	4140.41	4140.27
50%	4140.12	4140.75	4141.70	4142.30	4142.70	4143.15	4143.30	4143.18	4142.24	4141.08	4140.13	4139.88
40%	4139.76	4140.53	4141.47	4142.16	4142.70	4143.15	4143.30	4143.08	4142.02	4140.83	4139.82	4139.42
30%	4139.20	4139.82	4140.97	4141.92	4142.61	4143.15	4143.22	4142.74	4141.66	4140.32	4139.57	4139.14
20%	4138.31	4139.25	4140.28	4141.26	4142.05	4142.94	4142.99	4142.52	4141.26	4139.86	4138.66	4138.18
10%	4137.88	4138.52	4139.23	4140.08	4141.13	4142.09	4142.61	4142.01	4140.69	4139.51	4138.49	4138.00

Source: Reclamation data

The WRIMS model, and other similar models, uses programming rules that do not easily adapt to managing varying monthly inflows on a month by month basis. As a result, the modeled-estimated flows may have sharp peaks and declines that would not likely occur under the proposed operations and IM process. This observation appears to be particularly true for the month of April. However, WRIMS is able to provide valuable estimates regarding how much water may be available, on average, above the minimum lake levels, river flows and Project needs. Under an IM process the available water could be better shaped to smooth out the peaks and declines, and help reach target lake elevations and river flows.

Figures 1-4 and 1-5 illustrate the WRIMS- exceedence river flows and lake levels, which were then adjusted by likely management actions through IM, and compares these to the minimums. This type of adjustment could be achieved through IM. Only in the drier years or months would minimum flows and lake elevations likely occur.

Figure 1-4. WRIMS projected river flows.

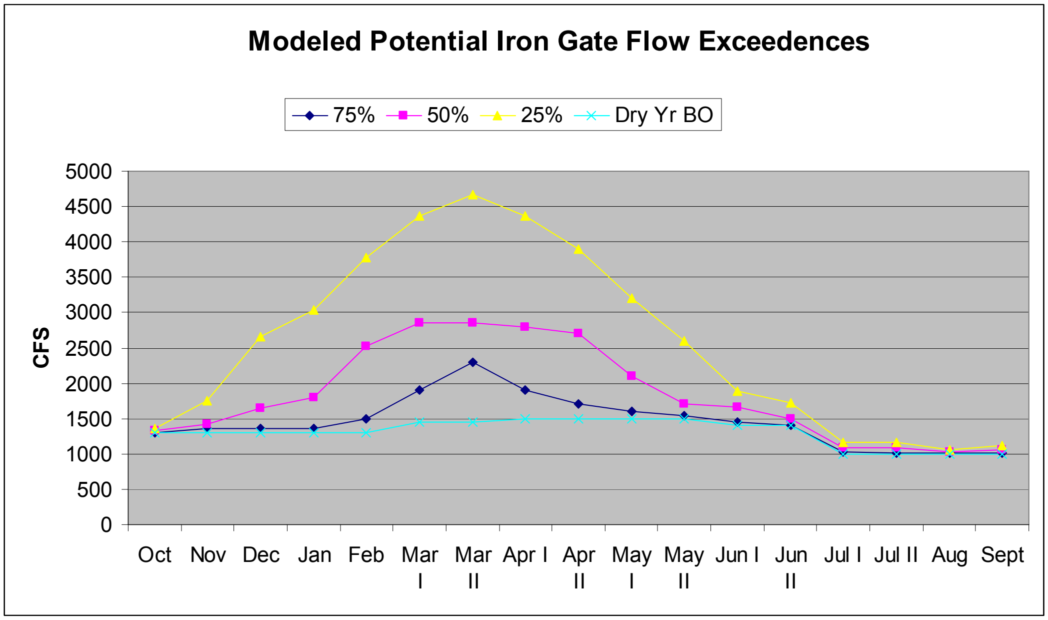
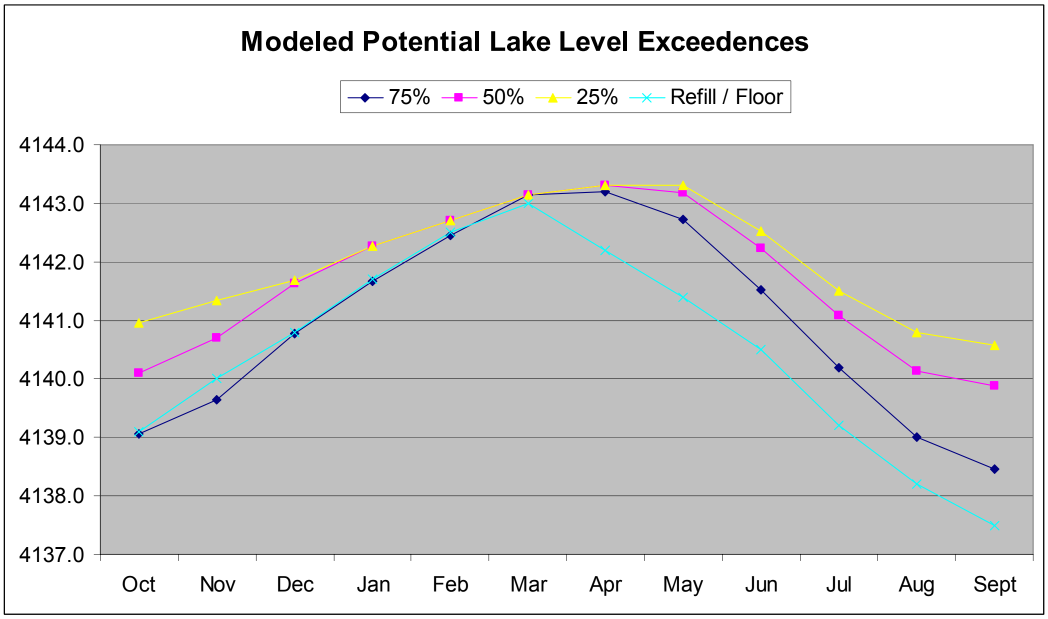


Figure 1-5. WRIMS projected lake levels. .



2. *Determination of IM Water Availability*

April through September

The following summarizes how Reclamation will determine the quantity of IM water available.

(1) Assess current (bi-weekly) UKL inflow and elevation.

(2) Assess other basin-wide hydrological and climatological information, including National Oceanic and Atmospheric Administration (NOAA) short-term weather forecasts.

For each two week period:

(3) Estimate UKL inflow based upon previous two week inflow trend, i.e., Increasing or decreasing.

(4) In coordination with the KWUA and NWRs, Reclamation will estimate Project irrigation and NWR use based upon previous two week trend and projected future two week use.

(5) Estimate Keno to IGD accretions based upon previous two week inflow trend, i.e., Increasing or decreasing.

(6) Estimate available water, potential IGD releases and its effect on UKL elevations and storage as well as potential April through September effects.

(7) Receive IM Team recommendation on additional releases at IGD or hold as storage in UKL.

October through March

To increase the potential of refilling UKL during the following winter, UKL elevation at the end of September should approach 4138 feet or higher but should not go below 4137.5 ft. Reclamation's WRIMS modeling has shown end of September UKL elevations below 4138 ft decrease the potential for refilling UKL which extends the effects of prolonged drought cycles and limits available water in following years.

To maximize the potential for maximum lake spawning areas and higher spring flows, a schedule to target the refilling of UKL will be observed. IGD releases may increase incrementally as inflows into UKL increase to meet the UKL end of month operational target refill elevations listed below;

a. October = 4139.1 ft
b. November = 4139.9 ft (53.9 thousand acre feet [TAF])
c. December = 4140.8 ft (62.4 TAF)
d. January = 4141.7 ft (66.0 TAF)
e. February = 4142.5 ft (61.8 TAF)
f. March = 4143.0 ft (38.7 TAF)

The operational target refill elevations listed above are historically and model driven and designed to maximize the probability of refilling UKL. Recent modeling, using Reclamation's WRIMS Model, indicates when UKL's elevation at the end of September is at 4138 ft, the probability of refilling the lake to 4143 ft is 84% when the increased storage in the Delta and the ALR and Barnes properties are included. The probability of refilling to 4142.6 ft is 93% under the same expanded lake conditions.

3. Interactive Management Technical Team Role

April through September

The following summarizes how the IM Tech Team will determine its recommendation of how to use the IM water.

(1) Estimate key tributary releases below IGD (e.g., Shasta, Scott, Salmon and Trinity rivers) based upon previous two week trend.

(2) Assess, to the greatest extent practicable, real-time biological data (e.g., out migrant trap information, radio-tracking data), and water quality data.

(3) An IM team consisting of USFWS, NMFS, the States, and the Tribes, in consultation with Reclamation, may assess current and anticipated future species needs:
   a. Shortnose and Lost River suckers (ESA-endangered and threatened)
   b. Coho (ESA-threatened)
   c. Chinook (Magnuson/Stevens Act)
   d. Other Tribal Trust species and ecosystem needs
   e. Assess the potential effects of UKL elevation and Klamath River flow on species of concern.

(4) IM Tech Team forwards bi-weekly requests to Reclamation for potential adjustment to IGD releases, up or down, to balance current bi-weekly species needs and available water.

October through March

(5) Minimum IGD flows will be maintained or exceeded through the period of egg incubation to reduce the likelihood of de-watering redds: Reclamation believes that these minimum flows, for each of the following months, are not likely to jeopardize the listed coho salmon.

   a. October = 1,300 cfs
   b. November = 1,300 cfs
   c. December= 1,300 cfs
   d. January = 1,300 cfs
   e. February= 1,300 cfs

The NMFS, USFWS and Reclamation will use the guidelines in Tables 1-6 and 1-7 to help determine the distribution of IM water to UKL and the Klamath River.

Table 1-7. Possible Distribution of IM Water Guidelines.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep
Monthly % of Average Net Ag and NWR Use							9%	13%	22%	24%	19%	11%
Monthly % of Average UKL Apr-Sep Inflows <500 TAF							32%	26%	13%	7%	8%	14%
Coho Salmon												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep
Species of concern by life stage and life history requirements (priority in bold)	Adult Chinook Spawning Habitat, coho parr rearing	Adult Chinook Spawning Habitat, coho parr rearing	In-gravel egg incubation	In-gravel egg incubation	Chinook fry rearing habitat	Chinook fry and coho juvenile rearing habitat	Chinook fry, Chinook juvenile, coho young-of-year, coho juvenile rearing habitat	Chinook juvenile, coho young-of-year, coho juvenile rearing habitat	Coho young-of-year, and juvenile habitat, Salmon River Chinook juvenile out migrants	Coho parr rearing	Coho parr rearing, Adult Chinook up-migration and lower River holding	Adult Chinook up-migration and lower River holding
Priority Reach	Mainstem from Estuary to IGD[1]	Mainstem from Estuary to IGD[1]	IGD to Shasta River	IGD to Shasta River	IGD to Scott River[1]	IGD to Scott River[1]	IGD to Scott River[1]	IGD to Scott River[1]	IGD to estuary	IGD to Trinity	IGD to estuary	IGD to estuary
Geo-fluvial concerns	Passage Impediments	Passage Impediments	Maintain minimum flows to ensure protection of mainstem redds[4]	Maintain minimum flows to ensure protection of mainstem redds[4]	Flow variability below IGD to reduce disease risks	Flow variability below IGD to reduce disease risks	Flow variability below IGD to reduce disease risks	Flow variability below IGD to reduce disease risks	Flow variability below IGD to reduce disease risks	Maintain connectivity with tributaries for juvenile non-natal rearing	Maintain connectivity with tributaries for juvenile non-natal rearing. Passage impediments	Maintain connectivity with tributaries for juvenile non-natal rearing. Passage impediments
	e.g., Ishi-Pishi Falls[2], Pecwan Riffle[3]	e.g., Ishi-Pishi Falls[2], Pecwan Riffle[3]									e.g., Ishi-Pishi Falls[2], Pecwan Riffle[3] for adults.	e.g., Ishi-Pishi Falls[2], Pecwan Riffle[3] for adults
	Connectivity with key tributaries for parr and adults	Connectivity with key tributaries for parr and adults	Flow variability below IGD to reduce disease risks	Flow variability below IGD to reduce disease risks	Channel maintenance flows	Channel maintenance flows						
			Channel maintenance flows	Channel maintenance flows								

[1] Reference- Hardy Phase II Final Report, Appendix I.
[2] Reference- Karuk Tribal information.
[3] Reference- USFWS-AFWO Modeling
[4] Reference- AFWO annual redd survey data

Suckers												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep
Species of concern by lifestage and life history requirements	Lost River and shortnose suckers: adults	Lost River and shortnose suckers	Lost River and shortnose suckers	Lost River and shortnose suckers	Lost River and shortnose suckers: lakeshore spawning	Lost River and shortnose suckers: lakeshore spawning	Lost River and shortnose suckers: lakeshore spawning	Lost River and shortnose suckers: larvae	Lost River and shortnose suckers: larvae	Lost River and shortnose suckers: larvae & age 0	Lost River and shortnose suckers: adult refuge & age 0 habitats	Lost River and shortnose suckers: adult refuge habitat
UKL elevation concerns (also see comments below)	Adverse water quality can extend into October, so concern is providing water quality refuge habitat in Pelican Bay area. Desired elevation >4138 ft on Oct 30th	Priority would be to provide sucker spawning habitat in March and fill lake by March 30th. Desire 4142.0 ft by March 1.	Priority would be to provide sucker spawning habitat in March and fill lake by April 30th. Desire 4141.5 ft by March 1.	Priority would be to provide sucker spawning habitat in March and fill lake by March 30th. Desire 4142.0 ft by March 1.	Priority would be to provide sucker spawning habitat in March and fill lake by March 30th. Desire 4142.0 ft by March 1.	Priority would be to provide sucker spawning habitat in March and fill lake by March 30th. Desire 4142.0 ft by March 1.	Priority would be to provide sucker spawning habitat in March and fill lake by March 30.	From May 1 to July 15 sucker larvae are present in UKL and adequate emergent vegetation needs to be present to provide cover. Desired elevation is >4142.5 ft on May 30.	Focus here is for larval emergent vegetation habitat with desired elevation >4141.5 ft on June 30.	Focus here is for larval/juvenile habitat with desired elevation >4140 ft on July 30.	Adequate adult sucker water-quality refuge habitat needs to be present in Pelican Bay and for near shore juvenile suckers. Desired elevation >4139.5 ft on August 30.	Focus here is to ensure adult sucker water-quality refuge habitat in Pelican Bay with desired elevation >4138.5 ft on September 30.
Note: The desired lake levels shown above should provide adequate habitat for suckers during most years and should allow for adult survival and recruitment to occur. During rare critically dry years (~2 of 10 years), lower lake levels would be acceptable, but a drought plan needs to be implemented to minimize risk to the suckers in case drought continues and UKL does not refill.												

Element Four

> **Water User Mitigation Plan:** *Work with the KWUA to establish a Water User Drought Mitigation Plan which could be implemented to lessen the impact to water users when the Project experiences a water shortage. The Plan initially will be managed by Reclamation for a four-year transition period, after which it will be the sole responsibility of the KWUA under a Joint Powers Agreement.*

Reclamation will work with the KWUA to establish a Water User Mitigation Plan which could be implemented to lessen the impact to water users when the Project experiences water shortages. The Water User Mitigation Plan will not be a tool for providing water for endangered species purposes because Reclamation proposes to first meet flows and lake levels which Reclamation believes are sufficient to avoid the likelihood of jeopardy. Certain activities being considered for inclusion in the Water User Mitigation Plan are not within Reclamation's authority and would have to be undertaken by non-Reclamation parties.

Part 2 ENDANGERED SUCKERS

Sucker Description, Life History, Habitat, Distribution, and Abundance

Description

Shortnose (*Chasmistes brevirostris*) and Lost River (*Deltistes luxatus*) suckers are endemic to the Upper Klamath Basin of southern Oregon and northern California (Figure 2-1; Moyle 2002). Both shortnose and Lost River suckers belong to a group of suckers commonly referred to as lake suckers. Member species of the lake sucker group can be generalized as large-bodied, long-lived, late-maturing suckers that reside in lake habitats and primarily spawn in tributaries (National Research Council [NRC] 2004). Lake suckers populated much of the Snake River, Great Basin, and Lahonton Basin region (Miller and Smith 1981, Scoppettone and Vinyard 1991). Lake suckers differ from other suckers in having a terminal or subterminal mouths that open more forward than down, an apparent adaptation for feeding on zooplankton rather than suctioning food from substrate (Scoppettone and Vinyard 1991). Lake suckers belong to the family Catostomidae. As a member of the genus *Chasmistes*, the shortnose sucker is closely related to the cui-ui (C. c*ujus*) of Nevada, the June sucker (C. *liorus*) of Utah, and the recently extinct Snake River sucker (C. *muriei*) of Wyoming (NRC 2004). The Lost River sucker is currently the only species representative of the genus *Deltistes*.

Reclamation recognizes that hybridization is common among Upper Klamath Basin suckers (Dowling 2005, Tranah and May 2006, USFWS 2007 LRS, 2007 SNS). The degree of hybridization does make field identification of suckers in the Upper Klamath Basin difficult, particularly in certain bodies of water in the Lost River drainage, such as Clear Lake and Gerber reservoirs (Barry et al. 2007 UKL, Leeseberg et al. 2007). For the purposes of life history and population descriptions at certain bodies of water throughout this document, Reclamation has attempted to compile information on only the two endangered species. For bodies of water where identification of species has proven difficult, such as the Lost River drainage including Clear Lake and Gerber reservoirs, this was not always possible. Thus, the reader should be aware that shortnose sucker identifications in the Lost River drainage are suspect and likely include an unknown number of misidentifications and hybrid suckers with morphological characteristics that are shared by shortnose, Lost River, and Klamath largescale suckers (*Catostomus snyderi)*.

Life History

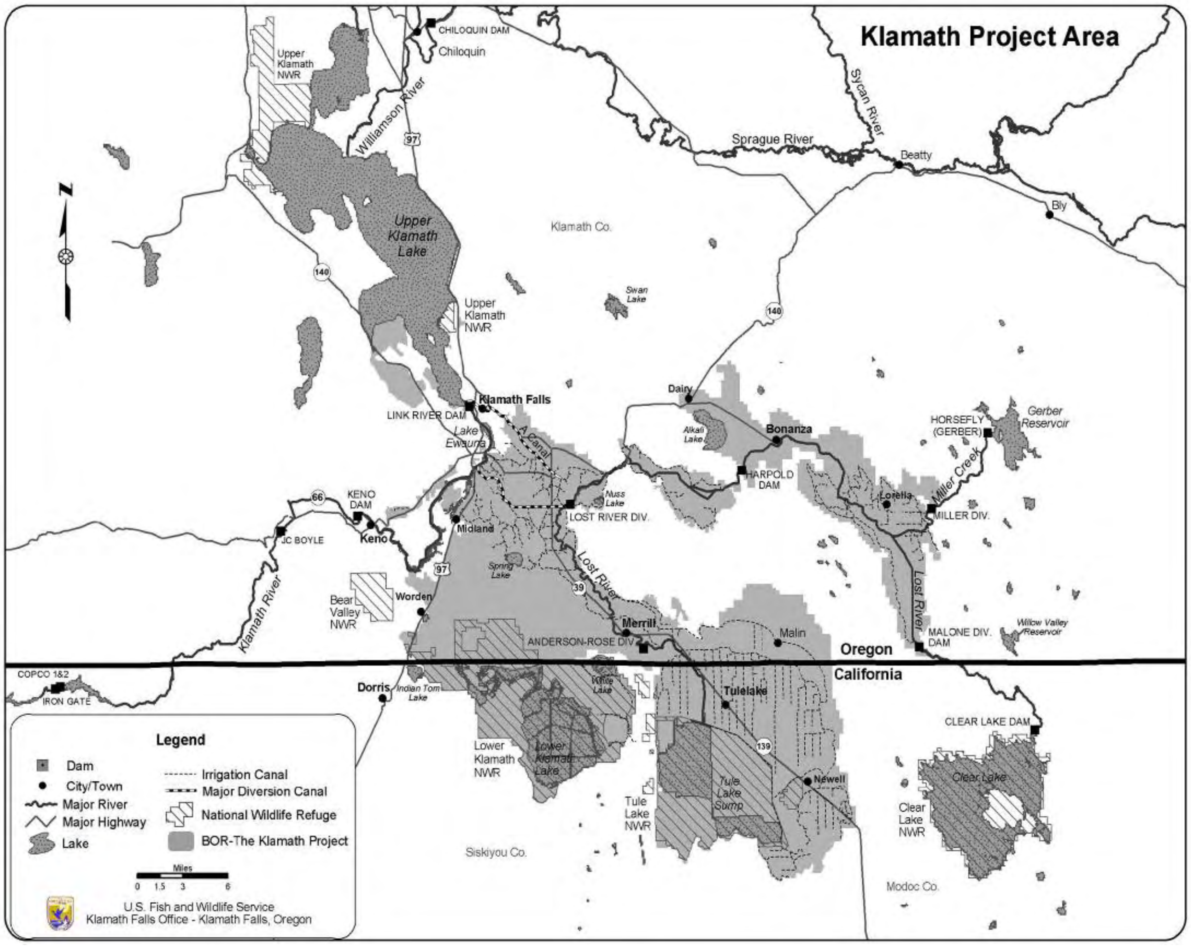
Lost River suckers may survive up to 43 years of age while shortnose suckers may live as long as 25 years (Buettner and Scoppettone 1990). Reproductive maturity for female shortnose suckers may be attained as early as 4 years of age while Lost River suckers reach reproductive maturity at 6 to 9 years of age (Perkins et al. 2000 Biology). Fecundity in both Lost River and shortnose suckers is variable and likely associated with the size of the individual female (Perkins et al. 2000 Biology). Lost River suckers typically produce 44,000 to 236,000 eggs per spawning season, while female shortnose suckers produce 18,000 to 72,000 (Perkins et al. 2000 Biology).

Larvae

Embryo development is likely related to temperature, but, generally the relatively small sucker eggs hatch in approximately 10-14 days after fertilization (Buettner and Scoppettone 1990). Developing larvae remain in the natal substrates for approximately an additional 7 days before emergence. Much of the yolk sac is absorbed by the developing larvae before emergence (Buettner and Scoppettone 1990). Larval sucker emergence from natal gravels typically occurs at night and much of the larval sucker migration to the lake from the tributaries also occurs principally at night (Cooperman and Markle 2003). Larval suckers exit the river current and move to nearshore shallow areas of the riverine environment during daylight (Cooperman and Markle 2003). Seasonal and nightly timing of larval drift from the tributaries is variable between natal sites (Ellsworth et al. in review). Larval suckers hatched at shoreline spawning areas also emerge from the gravels in greater numbers at night (Larry Dunsmoor, Senior Aquatics Biologist,, Klamath Tribes, pers. comm.). Larvae hatched at shoreline spawning areas may disburse southward by prevailing currents in the lake environment (Markle et al. 2007 Juvenile).

Soon after hatching, sucker larvae swim up from natal gravels. Larvae are about a third of an inch long (7-9 mm) and mostly transparent with a small yolk sac (Buettner and Scoppettone 1990). Larval suckers need to begin feeding quickly before they exhaust their yolk or they starve (Klamath Tribes 1996, Cooperman and Markle 2003). Therefore, the availability of appropriate habitat, which provides sufficient food soon after hatching, may be critical to the survival of larvae. Larvae grow into juveniles during the summer, usually by July (Reclamation 2002).

Figure 2-1. Upper Klamath Basin of Oregon and California. Klamath Project lands are shown as shaded area on the map.



Source: USFWS 2002

Upper Klamath Lake

Larvae produced in UKL tributaries migrate to the lake shortly after emergence from natal gravels (Cooperman and Markle 2003). Seasonal timing of larval sucker migration from the natal areas in the tributaries is determined by the timing of adult spawning and variable between sites (Tyler et al. 2007, Ellsworth et al. 2007). Larval suckers entering the drift peaked earliest at sites in the upper Sprague River, typically late March through April. Peak migration of larvae at the lower reaches of the Williamson and Sprague rivers occurred during mid May, but larvae were present in the drift as early as March and as late as early July (Ellsworth et al. in review).

Early evidence suggested that larvae spend relatively little time upriver before drifting downstream to the lakes (Buettner and Scoppettone 1990, Perkins and Scoppettone 1996, Klamath Tribes 1996, Cooperman and Markle 2003). In the Williamson River, larval sucker out-migration from spawning sites begins as early as March and is generally completed by mid-July (Ellsworth et al. in review). Downstream movement takes place at night and near the water surface. During the day, larvae appear to move to the river margins and to seek cover in the emergent shoreline vegetation (Cooperman and Markle 2000). Recent evidence indicates that some larvae may rear to the juvenile stage in the riverine environment, as juvenile suckers have been captured in the Williamson and Sprague rivers through the summer months (Parrish 2007, Ellsworth et al. in review).

In UKL, larval suckers are first captured in early April during most years. Peak larval sucker catches occur during June with densities dropping to very low levels by late July (Cooperman and Markle 2000, Simon et al. 1996, 2000). Larval suckers are found throughout UKL, with highest concentrations generally near the mouth of the Williamson River, and just to the east and west of the mouth, apparently depending on flow patterns. At the Link River, the outlet from UKL, larval suckers have been collected as early as April 28 and as late as July 18 (Gutermuth et al. 1999). Larval habitat in UKL is generally along the shoreline, in water 4 - 20 inches deep and associated with emergent aquatic vegetation (Buettner and Scoppettone 1990, Dunsmoor 1993, Simon et al. 1995, 1996, Markle and Simon 1993, 1994, Cooperman and Markle 2000, Dunsmoor et al. 2000, Reiser et al. 2001, Cooperman 2002, Markle and Dunsmoor 2007). Emergent vegetation provides cover from predators, protection from currents and turbulence, and concentrated prey (including zooplankton, macroinvertebrates, and periphyton). Larvae do not appear to use submerged vegetation (e.g., pondweeds) as an alternative to emergent vegetation (Klamath Tribes 1995, Cooperman 2002). This is likely due to the absence of submerged vegetation when larvae are transforming into juveniles and possibly due to habitat preferences of the larvae (USFWS 2002). Submerged vegetation in in the Upper

Klamath Basin typically dies back in the winter and new growth does not reappear until mid summer (USFWS 2002).

Larval suckers produced at tributary and shoreline spawning areas may be present in UKL from late March through July (Gutermuth et al. 1999, USFWS 2002, Terwilliger 2006). Although efforts to monitor larval suckers at other bodies of water have been limited, larval sucker presence in other systems probably follows similar seasonal patterns based on comparisons of spawning migration between populations of both species in UKL and those in Gerber Reservoir and Clear Lake (Leeseberg et al. 2007, Barry and Scott 2007, Barry et al. 2007 Lost, 2007 UKL, 2007 Sprague). While in the lake environment larval suckers appear to depend on shallow, nearshore areas (Simon et al. 2000), particularly those areas vegetated with emergent wetland plants in UKL (Buettner and Scoppettone 1990, Dunsmoor 1993, Simon et al. 1995, 1996, Markle and Simon 1993, 1994, Cooperman and Markle 2000, Dunsmoor et al. 2000, Reiser et al. 2001, Cooperman 2002, Markle and Dunsmoor 2007).

Larval sucker ecology and habitat use within the Lost River watershed, particularly Tule Lake, Lost River, and both Clear Lake and Gerber reservoirs, have not been directly studied. Given the lack of direct observations, larval sucker ecology in the Lost River watershed is assumed similar as the observations from UKL, except for the use of emergent vegetation in lake environments. Permanent emergent vegetation is generally scarce or absent along the shorelines of Clear Lake and Gerber reservoirs (Reclamation 2002). However, some vegetative cover may be provided to larval suckers by flooded annual grasses and herbs remaining from the previous growth season on the lake bed prior to lake level rising in the spring (USFWS 2002). Also, the lower reaches of the primary spawning tributaries do provide some emergent and submerged shoreline vegetation during the spring and early summer when larvae would be present (USFWS 2002). Additional cover may be provided by high turbidity and through the use of shallow shoreline areas. Juvenile suckers, although older and larger than larval suckers, occupy shoreline habitats in these systems that lack shoreline emergent vegetation (Scoppettone et al. 1995, Reclamation 2001).

Juveniles

Larvae grow into young of the year (YOY) juveniles typically by mid summer. Transition from the larval to juvenile stage typically occurs at a total length of about 20 to 30 mm (0.78 to 1.18 in; Markle and Clauson 2006). Juveniles appear to continue to occupy shoreline habitats in UKL including both unvegetated areas and areas with emergent vegetation (Buettner and Scoppettone 1990, Simon et al. 2000, Hendrixson et al. 2007a, 2007b). Juvenile sucker habitat is generally in nearshore areas with depths < 1.2 m (4 ft; Markle and Simon 1993, Reiser et al. 2001, Simon et al. 2000, Simon and Markle 2001, VanderKooi and Beulow 2003). However, juvenile suckers appear to occupy a wide range of substrate types in comparison to larvae while in these nearshore areas of UKL. Three investigations of juvenile suckers in UKL have each indicated a different dominant substrate where juvenile suckers have been observed in unvegetated nearshore areas: mud and sand (Buettner and Scoppettone 1990), gravel and cobble (Simon et al. 2000, Terwilliger et al. 2004, Terwilliger 2006), and sand, fines, gravel, intermixed substrates and cobble (Hendrixson et al. 2007a, 2007b). In late summer and early fall, YOY juveniles continue to occupy shoreline areas of UKL with evidence of a habitat transition into offshore areas during autumn (Terwilliger 2006). There is also substantial evidence that suggests emergent vegetation may also provide important habitat for juvenile suckers (Reiser et al. 2001, VanderKooi and Beulow 2003, VanderKooi et al. 2006, Hendrixson et al. 2007a, 2007b).

In mid-summer, juveniles are concentrated in the northern and eastern sections of UKL, near the mouth of the Williamson River and along the eastern shoreline. In late summer and fall most juveniles are concentrated in the south end of UKL and along the eastern shoreline (Simon et al. 2000, Simon and Markle 2001, Terwilliger et al. 2004, Hendrixson et al. 2007a, 2007b). Rocky bottoms occur along the shoreline primarily in the southern portion of UKL while emergent shoreline vegetation occurs primarily in the northern half of the lake, and soft, mucky bottoms occupy the vast majority of the deeper offshore areas.

Juvenile sucker abundance drops dramatically from August to October in UKL (Simon and Markle 2001, Terwilliger et al. 2004, Terwilliger 2006). Catches of juveniles in emergent vegetation also declined significantly near the end of August in both 2000 and 2001 (VanderKooi and Beulow 2003, VanderKooi et al. 2006). However, the cause for declining juvenile sucker abundance in late summer and early autumn is undetermined. Possible hypotheses explaining the apparent reduced abundance of juvenile suckers include reduction of emergent vegetation habitat with reducing lake elevation (VanderKooi and Beulow 2003, Markle and Dunsmoor 2007), a shift to offshore habitat use (Terwilliger 2006), and emigration from UKL (Markle et al. 2007 Juvenile).

There is evidence that sucker emigration from UKL into the Link River, including the east and west power canals that parallel the Link River, increases during the period between July and October at the south end of the lake (Gutermuth et al. 1999, 2000, Foster and Bennetts 2006, Tyler 2007). The cause of emigration by juvenile suckers is not currently understood. Plausible hypotheses include natural emigration, avoidance of poor water quality events, and diminished habitat in the north end of UKL which concentrates suckers in the southern end of UKL near the outlet (USFWS 2002). The fate of emigrant suckers is not fully understood but it has been hypothesized that UKL is a better environment for suckers due to its food rich environment, the loss of connectivity between habitats below the Link River, and frequent poor water quality events in the Link to Keno reach of the Klamath River (Reithel 2006).

Subadults and Adults

Much of our knowledge regarding subadult and adult suckers is from observations of populations in UKL. Direct observations of subadult suckers are typically few and anecdotal in nature. In the absence of information, it is presumed that subadult suckers typically demonstrate behavior patterns similar to adult suckers while in the lake environment as subadult suckers are neither frequently encountered nor abundant when encountered during YOY juvenile studies.

Subadult and adult suckers are found in open water areas of the lake environment typically at depths of greater than 1 m in the northern half of UKL (Peck 2000, USFWS 2002). During summer, adult suckers generally demonstrate a depth preference for water depth greater than the mean depth available in the area (Reiser et al. 2001, Banish et al. 2007). Recent information on adult sucker behavior in UKL indicated that each species demonstrated different depth utilization in 2005 and 2006 (Banish et al. 2007). Adult suckers were observed using water depths generally > 3 m (9.84 ft) for Lost River suckers and > 2 m (6.56 ft) for shortnose suckers where adequate water quality was above the species' tolerance thresholds determined by Loftus (2001) and neither species were observed at water depths > 5 m (16.4 ft, Banish et al. 2007).

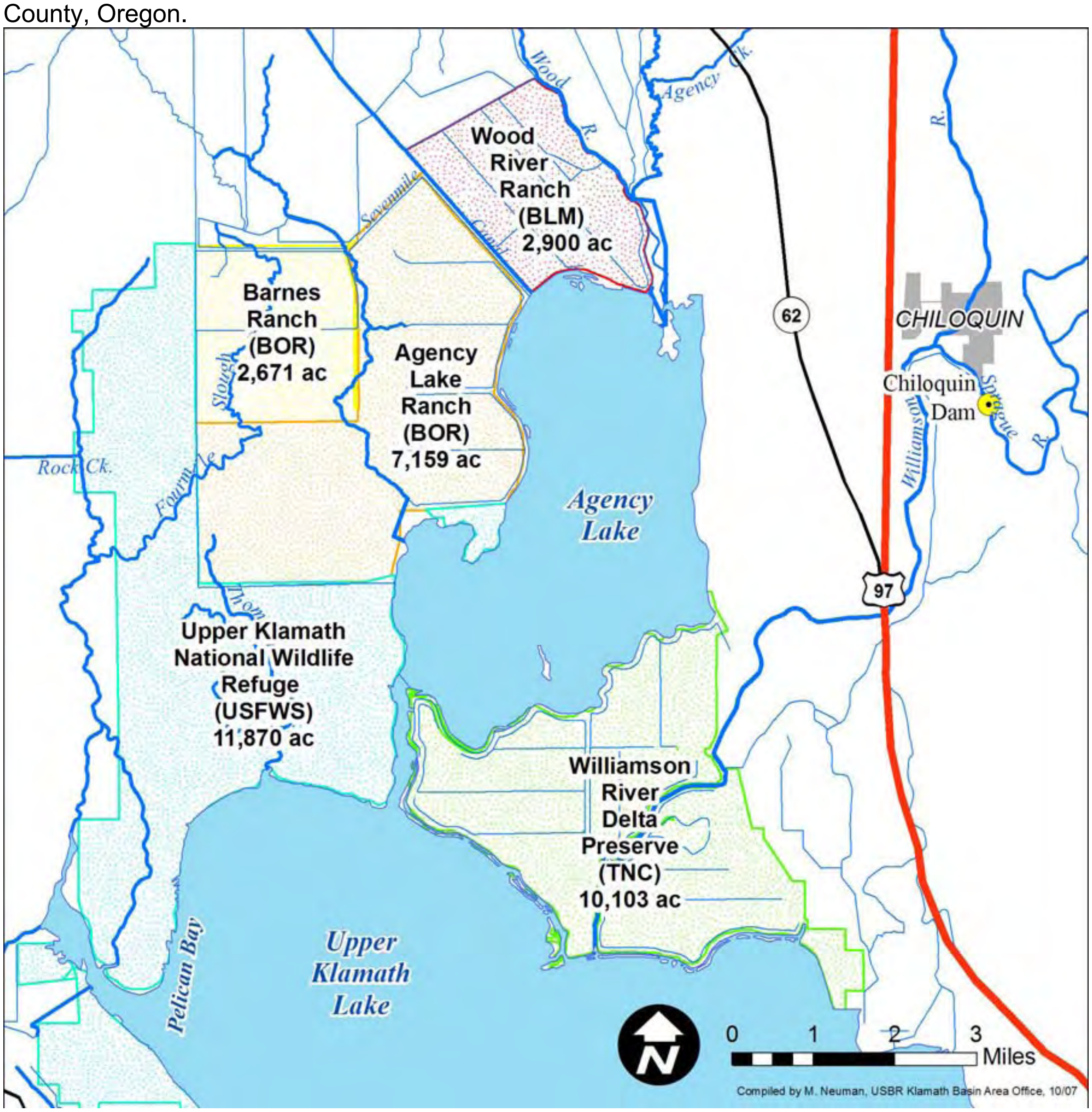
During times other than mid summer, adult suckers were seasonally observed in water depths other than the former generalizations. For several weeks during June, shortnose suckers were observed in the area between the Williamson River and Agency Straits that is typified by relatively shallow water, but were never observed in water depths between 0 and 1 m (between 0 and 3.28 ft) throughout the study (Banish et al. 2007). Both species tended to congregate in or near Pelican Bay during 2005 and 2006 at a variety of depths when water quality conditions, particularly dissolved oxygen (DO), in the north end of the lake became stressful (Figure 2-.2; Banish et al. 2007). Adult suckers selected depths < 2 m (6.56 ft) only when water quality conditions deteriorated in mid summer and during fall as they redistributed in the lake (Banish et al. 2007).

Adult Lost River and shortnose suckers primarily occupy lake habitats of the Upper Klamath Basin. Some adult suckers migrate into tributaries to spawn, while others spawn in suitable near-shore lake habitats, primarily spring influenced areas (NRC 2004). Apparently some shortnose suckers both live and spawn in streams, notably in the Clear Lake and Gerber Reservoir watersheds where lake-like environments exist as a result of manmade reservoirs (Reclamation 2002). Stream and lake spawning populations appear to rarely exchange individuals and may be reproductively isolated (Perkins et al. 2000 Biology, Shively et al. 2000 Shoreline, Hayes and Shively 2001, Hayes et al. 2002, 2004). Adult Lost River suckers are generally limited to lake habitats when not spawning, and no large populations are known to occupy stream habitats. Shortnose suckers have resident populations in both lake and some riverine habitats, including Lost River, Willow Creek, and other tributaries of Clear Lake and Gerber Reservoir. Species identification in the Lost River drainage, including

Clear Lake and Gerber reservoirs, may contain an unspecified number of hybrid suckers as field identification of suckers in this drainage have proven difficult (Barry et al. 2007 Lost).

Currently, most of the stream-spawning Lost River and shortnose suckers in UKL migrate into the Williamson and Sprague rivers to spawn during spring months. Small spawning populations of Lost River and shortnose suckers may also use the Wood River (Figure 2-2; Markle and Simon 1993, Simon and Markle 1997). Lost River suckers and a small number of shortnose suckers spawn at shoreline sites of UKL, especially along the eastern shore of UKL at areas with spring influence and gravel substrate (Buettner and Scopettone 1990, Hayes and Shively 2001, Hayes et al. 2002, 2004, Barry et al. 2007 UKL). Presently, known sucker spawning occurs along the shore of UKL at Sucker, Silver Building, Ouxy, and Boulder springs, and Cinder Flats (Shively et al. 2000 Subbasin, Hayes and Shively 2001, Hayes et al. 2002, 2004, Barry et al. 2007 UKL). Suckers in the Clear Lake and Gerber Reservoir drainages spawn primarily, if not entirely, in the tributary streams (Buettner and Scoppettone 1991, Koch and Contreras 1973, Perkins and Scoppettone 1996, BLM 2000).

Figure 2-2. Northern portion of UKL and Agency Lake showing major tributaries, Klamath County, Oregon.



Cover is a primary habitat feature required by fish. For fish like lake suckers that primarily occupy open water, depth and turbidity can provide needed cover. In streams, while deeper pools provide some cover, additional cover is provided by instream and overhanging structure (Buettner and Scoppettone 1991, Perkins and Scoppettone 1996). Adults, and probably subadults, of both species are bottom-oriented, consistently staying within 1 ft of the bottom (Buettner and Scoppettone 1991, Reiser et al. 2001). Adults rarely enter water shallower than 1 m (3.28 ft; Reiser et al. 2001, Banish et al. 2007), except possibly to spawn at night or to avoid deteriorating water quality conditions. In Tule Lake, where much of the lake is shallower than 1 m (3.28 ft), adult suckers are found only in the very limited areas with available habitat and depths > 1 m (3.28 ft, Hicks et al. 2000, Reclamation 2000 Sucker Salvage).

In late spring, summer, and autumn, adult suckers generally occupy the northern third of UKL (Bienz and Ziller 1987, Buettner and Scoppettone 1990, Golden 1969, Peck 2000, Perkins et al. 2000a, Reiser et al. 2001). However, suckers apparently avoid shallow, clear water in UKL except when showing ill effects of poor water quality (Bienz and Ziller 1987, Buettner and Scoppettone 1990, Reiser et al. 2001), although some shortnose suckers congregate in the shallow area between the Williamson River and Pelican Bay in early summer (Banish et al. 2007). Avoidance of shallow depths by adult suckers may be related to increased vulnerability to predators while in shallow water. During poor water quality events in UKL, adult suckers may avoid shallow water areas where water quality is more suitable but lacking in cover, such as near Pelican Bay and the Williamson River. There is evidence that adult suckers utilize Pelican Bay, an area considered relatively shallow, during poor water quality events (Banish et al. 2007).

Spawning

Both Lost River and shortnose suckers primarily reside in lakes but may enter tributaries to spawn (NRC 2004). Whether spawning occurs at shoreline areas in lakes or in lake tributaries, both species begin spawning as early as February and may continue through early June. The timing of spawning migration is somewhat variable from year to year and apparently depends on age, species, sex, and environmental conditions, most notably water temperature (Andreasen 1975, Ziller 1985, Buettner and Scoppettone 1990, Klamath Tribes 1996, Perkins and Scoppettone 1996, Markle et al. 2000 Sampling, 2000 Annual Report, Shively et al. 2000 Shoreline, BLM 2000, Barry and Scott 2007, Barry et al 2007 Sprague).

Tributary spawning generally occurs in riffle areas with moderate current and gravel to cobble sized substrates (Buettner and Scoppettone 1990). Spawning by Lost River suckers in the Sprague River above Chiloquin Dam appears to be concentrated at groundwater influenced areas (Tyler et al. 2007, Ellsworth et al. 2007).

In UKL, shoreline spawning occurs at several areas characterized by a mix of gravel and coarse substrates, relatively shallow depths, and groundwater influence from nearby springs (Buettner and Scoppettone 1990, Hayes et al. 2002, Barry et al. 2007 UKL). Shoreline spawning areas in UKL are presently dominated by Lost River suckers, although few shortnose suckers do appear to also spawn at these areas (Hayes et al. 2002, Barry et al. 2007 UKL). Historically, shortnose suckers probably spawned in greater numbers at shoreline spawning areas in UKL (NRC 2004).

Lost River suckers and shortnose suckers typically spawn at night in shallow areas with gravel substrate where eggs are broadcast or slightly buried (Bienz and Ziller 1987, Buettner and Scoppettone 1990, 1991, Klamath Tribes 1995, Perkins and Scoppettone 1996, Perkins et al. 2000 Biology). Water depth at spawning sites has been reported as 0.1 to 0.7 m (0.33 to 2.3 ft) for shortnose suckers and 0.2 to 0.8 m (0.65 to 2.6 ft) for Lost River suckers, with most spawning occurring at a depth close to 0.5 m (1.6 ft) for both species (Buettner and Scoppettone 1990).

In a single spawning season, each Lost River and shortnose female can produce 44,000-236,000 and 18,000-72,000, respectively (Perkins et al. 2000 Biology). Larger, older females produce substantially more eggs and therefore can contribute relatively more to recruitment than a recently matured female (USFWS 2002). However, only a small percentage of the eggs survive to become larvae. There is evidence that individuals may not spawn each year, particularly for females (Perkins et al. 2000 Biology, Hayes et al. 2002, Barry et al. 2007 UKL).

Sucker Distribution and Habitat

Historically, both Lost River and shortnose suckers occurred throughout the Upper Klamath Basin, with the exception of the higher elevation, cooler temperature tributaries, which are dominated by resident trout, and the upper Williamson River, which is isolated by the Williamson Canyon (Figure 2-1, USFWS 2002). The general range of Lost River suckers and shortnose suckers had been reduced from its historic extent by the loss of major populations in Tule Lake and Lower Klamath Lake, including Sheepy Lake (USFWS 1988).

At the time of listing, Lost River and shortnose suckers were reported from UKL and its tributaries, Lost River, Clear Lake reservoir, the Klamath River, and the three larger Klamath River reservoirs (Copco, Iron Gate, and J.C. Boyle). The current geographic ranges of Lost River and shortnose suckers have not changed substantially since they were listed (Table 2-1).

Table 2-1. Lost River sucker (LRS) and shortnose sucker (SNS) population location and status. ^{A} denotes field identification of species has proven difficult due to hybridization with other basin suckers. * denotes populations identified since time of listing in 1988.

Location	Species	Status
Clear Lake Reservoir	LRS, SNS^A	Present, reproducing
Gerber Reservoir	SNS^A	Present, reproducing*
Williamson River	LRS, SNS	Present, reproducing
Sprague River	LRS, SNS	Present, reproducing
Upper Klamath Lake	LRS, SNS	Present, reproducing
Tule Lake	LRS, SNS	Present, reproducing*
Link River to Keno	LRS, SNS	Present, suspected reproduction
Lost River	LRS, SNS^A	Present, suspected reproduction
Wood River	Unknown	Present, suspected reproduction
J.C. Boyle Reservoir	LRS, SNS	Present, unknown reproduction
Copco Reservoir	LRS, SNS	Present, unknown reproduction
Iron Gate Reservoir	LRS, SNS	Present, unknown reproduction
L. Klamath Lake	Unknown	Unknown, extirpated
Sheepy Lake	Unknown	Unknown, extirpated
Lake of the Woods	SNS	Extirpated

Source: from NRC 2004

Only two additional populations of shortnose suckers and one additional population of Lost River suckers have been recognized since 1988 (Table 2-1). Each additional population occurs in isolated sections of the Lost River drainage, within the historical ranges of the species, and include an isolated population of shortnose suckers in Gerber Reservoir and a small population (limited to several hundred adults) of each species in Tule Lake (USFWS 2002). Presently, the Klamath River reservoir populations receive individuals carried downstream from upper reaches of the river, but they are isolated from the Upper Klamath Basin by dams and show no evidence of self-sustaining reproduction (Desjardins and Markle 2000).

Population estimates for both species of sucker remain elusive. At the time of listing, there appeared to be little recruitment into the sucker populations of UKL for nearly two decades (Markle and Cooperman 2002). Data on relative population size from before ESA listing are available from creel surveys conducted by Oregon Department of Fish and Wildlife (ODFW) at popular fishing spots on the Sprague and Williamson rivers and the shoreline spawning areas of UKL (Bienz and Ziller 1987). The popular sucker sport fishery was ended by the state of Oregon several years prior to the ESA listing of suckers. The sport fishery likely contributed to the suppressed sucker populations in the upper basin at the time of listing (Markle and Cooperman 2002). Data from ODFW creel surveys, available as catch per unit effort data, demonstrated a decline in abundance for both species during the decades preceding the suckers ESA listing in 1988 (Bienz and Ziller 1987).

Current Population and Status

Upper Klamath Lake and Tributaries

Lost River suckers are endemic to the lake habitats of the Upper Klamath Basin in northern California and southern Oregon, including those in the Lost River sub-basin (Figures 2-1 and 2-2). Primary habitat is in UKL. Adult Lost River suckers using UKL distribute widely throughout the lake in the fall, winter and spring (NRC 2004). In the spring months, Lost River suckers appear to stage in the north end of the lake near Goose Bay and Modoc Point prior to spawning in either the tributaries or the shoreline spawning areas (Hendrixson et al. 2004). Lost River suckers appear to be associated with the northern portion of the lake during summer months. Reasons for the summer distribution of suckers in UKL are not clear but may be related to proximity of better water quality near spring-fed Pelican Bay and the Williamson River (Figure 2-2; Reiser et al. 2001, USFWS 2002, Banish et al. 2007). During the summer and early fall, UKL water quality conditions periodically deteriorate to levels stressful and even lethal to suckers and other fish (Loftus 2001). Multiple years of a radio telemetry study have documented Lost River and shortnose suckers concentrate in or near Pelican Bay during periods of deteriorating water quality in UKL, presumably to seek refuge at areas of better water quality (Banish et al. 2007).

Adult Lost River suckers in UKL appear to consist of two distinct stocks, those fish that spawn along the eastern shoreline of UKL, and fish that spawn in the Williamson and Sprague rivers (NRC 2004). Mark-recapture data has indicated that the two stocks maintain a high degree of fidelity to spawning areas and probably seldom interbreed (Hayes et al. 2002, Barry et al. 2007 UKL). The river spawning segment of the UKL population makes a springtime spawning migration through the lower Williamson River, with most fish entering the lower Sprague River. The Chiloquin Dam has been identified as a partial barrier to upstream passage that may prevent a portion of the sucker spawning run from migrating further upstream into the Sprague River or may delay the timing of the migration to upstream areas (Scoppettone and Vinyard 1991, USFWS 1993 Sucker, NRC 2004), particularly during periods of low discharge. With removal of Chiloquin Dam during summer 2008, adult sucker migrations in the Sprague River will be unimpeded by 2009.

Known areas of concentrated Lost River sucker spawning in the Williamson and Sprague rivers include the lower Sprague River below Chiloquin Dam, areas of the lower Williamson River from the confluence with the Sprague River to immediately downstream of the US Highway 97 bridge, and in the Beatty Gap area of the upper Sprague River (Buettner and Scoppettone 1990, Tyler et al. 2007, Ellsworth et al. 2007). Other areas in the Sprague River watershed where Lost River sucker spawning is suspected include the lower Sycan River and the Sprague River near Kamkaun Spring (Ellsworth et al. 2007).

Presently, shortnose suckers from UKL spawn in the lower Williamson and Sprague rivers (Buettner and Scoppettone 1990), principally below Chiloquin Dam (Tyler et al. 2007, Ellsworth et al. 2007). The few adult shortnose suckers captured at the shoreline spawning areas in UKL indicate that some shortnose sucker spawning is likely to still occur at the shoreline spawning areas (Hayes et al. 2002, 2004, Barry et al. 2007 UKL). Although species identification is not apparent, sucker spawning is also suspected in the Wood River. Whereas it is possible that sucker spawning may occur in other small tributaries to UKL and its main tributaries, fisheries investigations have not identified sucker populations in tributaries other than the Williamson, Sprague, and Wood rivers.

Since listing, information on relative abundance of adult sucker populations has been obtained from the number of captured suckers migrating up the Williamson River each spring to spawn (USFWS 2002). The Williamson River spawning abundance index, based on actual and interpolated catch per unit effort (CPUE) data, shows a decline in abundance for both species during the three fish die-offs in the mid-1990s and a hiatus in recruitment of new individuals from 1998 to 1999 before the population began to increase in 2000 (Figure 2-3; Cunningham et al. 2002, Tyler et al. 2004). The increase in the spawning abundance index that began in 2000 could represent the recruitment of a single dominant year class over a period of two years or the recruitment of two distinct year classes. If a single year class recruited in over two years during 2000 and 2001 it would likely be the 1991 year class for Lost River suckers and the 1993 year class for shortnose suckers (USFWS 2002).

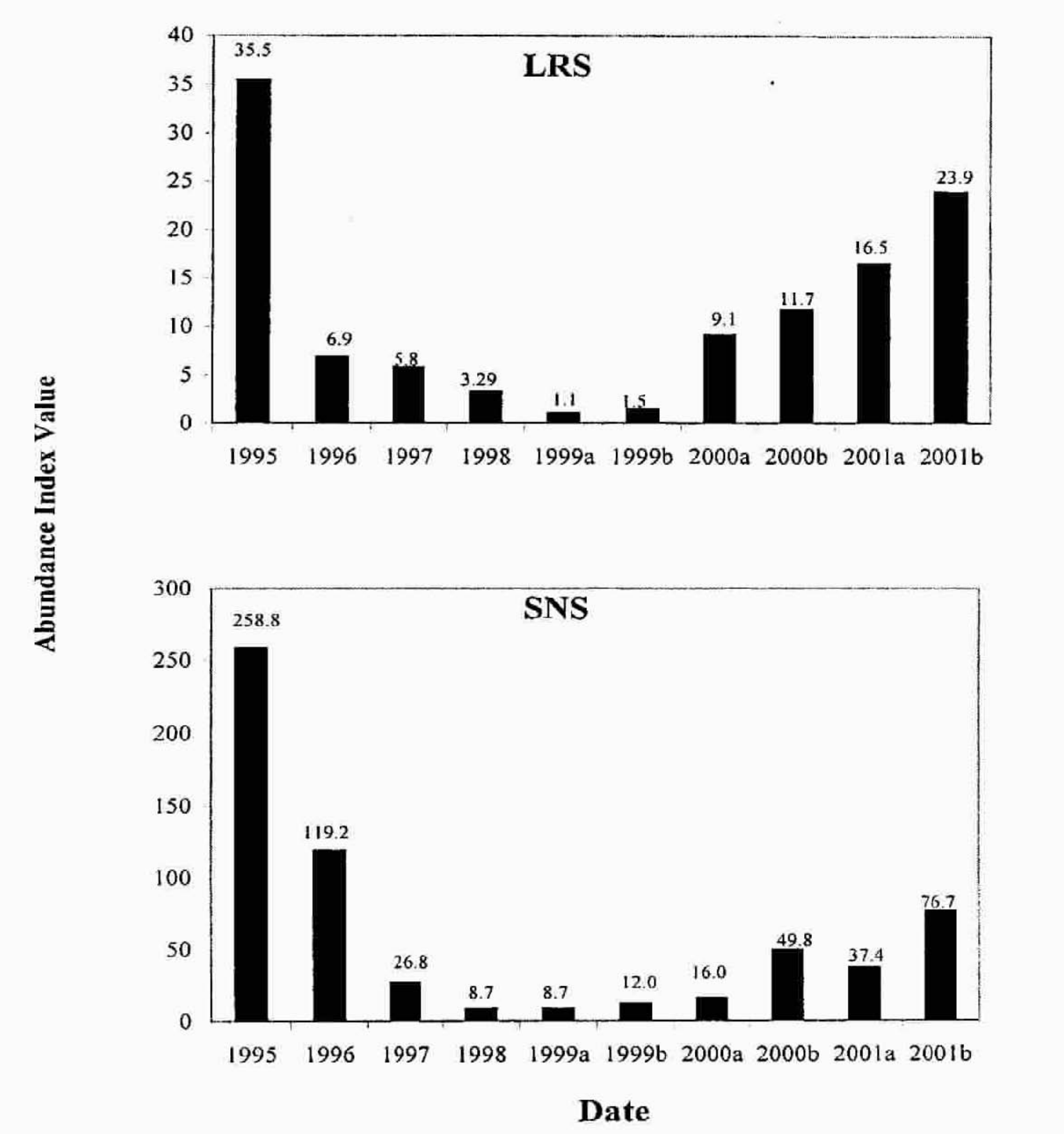
Since 2001, data from adult population monitoring in UKL has become robust enough to perform a capture-recapture analysis for shoreline spawning Lost River suckers that estimates the annual survivorship (Janney and Shively 2007, Janney et al. 2007). Furthermore, population assessment for UKL suckers can be understood by considering length frequency histograms and population change estimates as provided in Janney and Shively (2007) and Janney et al. (2007).

Length Frequency

Recent analysis of sucker population data corroborates the assessment in Scoppottone and Vinyard (1991) at the time of listing that the population of Lost River suckers in UKL was dominated by older individuals and showed no evidence of substantial recruitment during the 1980s and early 1990s (Janney and

Shively 2007). Although limited age data on shortnose suckers existed at the time of listing, length frequency data from the 1980s suggests that this population was also comprised of older individuals with little evidence of recruitment events (Janney and Shively 2007, Janney et al. 2007).

Figure 2-3. Abundance index values for adult Lost River suckers and shortnose suckers captured in trammel nets in the Williamson River, 1995-2000.



Source: Adapted from Cunningham et al. 2002, Fig. 7, p. 29. Data from 1995-1998 are revised from Perkins et al. (2000 Biology) based on data points that were previously omitted. Data from 2000 and 2001 are a) from the second set of trammel nets retrieved, and b) from all trammel nets retrieved. .

Length frequency data, although not entirely appropriate for estimating populations for long-lived fishes like the two endangered sucker species in Klamath Basin, indicated a size shift to smaller male Lost River suckers starting in 1992 and smaller female Lost River suckers in 1995 among Lost River suckers captured in UKL tributaries (Figure 2-4, Janney and Shively 2007). The frequency of large male Lost River suckers began decreasing in 1994 for both the tributary and shoreline spawning groups, with very few large male Lost River suckers present in survey efforts between 1996 and 1999 (Figures 2-4 and 2-5, Janney and Shively 2007).

Length frequency data on shortnose suckers from monitoring efforts on UKL tributaries indicates a shift to smaller male and female adults occurred in 1995. (Figure 2-6, Janney and Shively 2007). A shift to smaller individuals indicates a recruitment event of smaller individuals, a mortality event of larger individuals, or a combination of the two events. The shortnose sucker population shows an increasing trend in length frequency beginning in 1996 with the possibility of some recruitment occurring in 1999 (Janney and Shively 2007). Shortnose sucker populations in 2001 and 2002 were largely comprised of individuals between 6 and 15 years of age with very few older fish (Figure 2-6, Janney and Shively 2007).

Annual Rate of Population Change

Annual rates of population change were estimated for sucker populations in UKL from 1995 through 2004. To develop rate of change population estimates, calculated recruitment and adult survivorship are needed (Janney and Shively 2007). Data collected prior to and since this ten year period do not lend themselves to this analysis due to an unmeasured change in detection probability for marked suckers which was compounded by increased effort to monitor the sucker populations in UKL since the mid 1990s.

Interpretation of population change rates are summarized in Janney and Shively (2007) as:

- Values < 1 indicate a decreasing population where recruitment into the adult population is less than mortality.

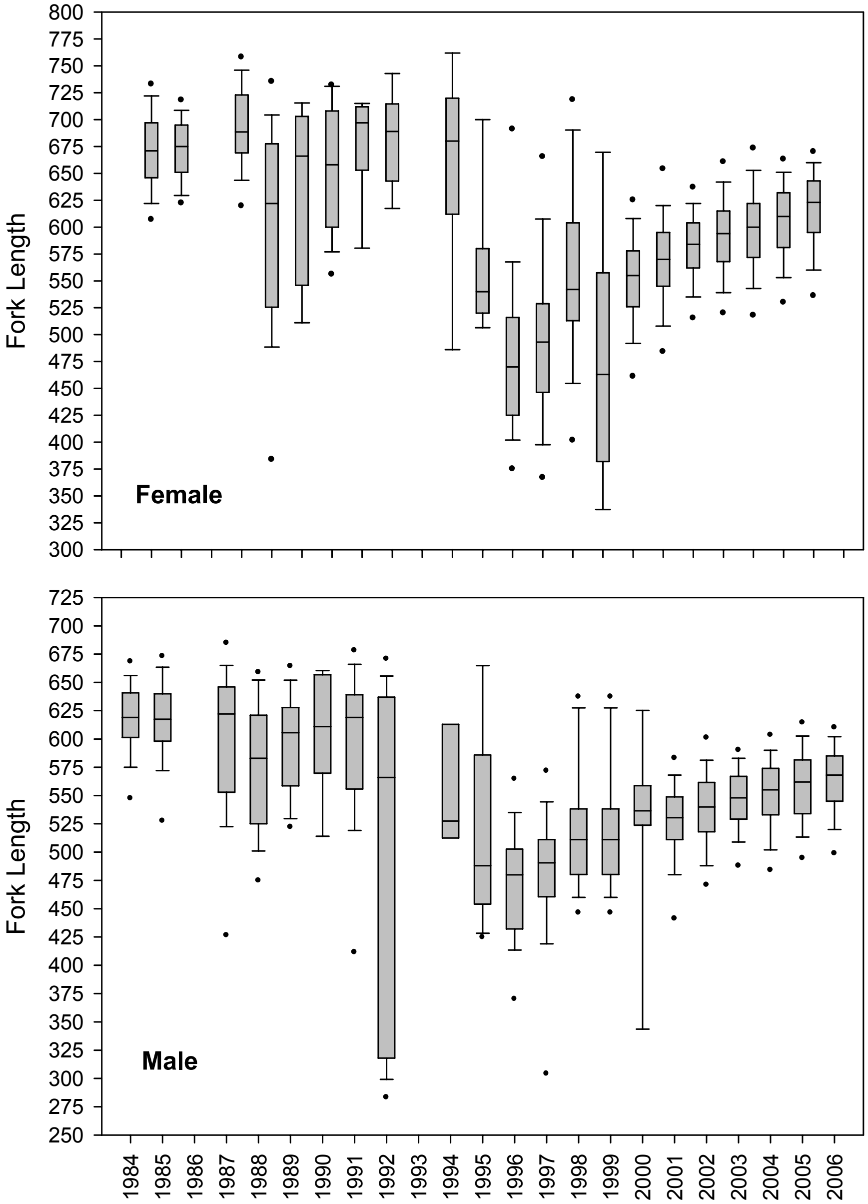
- Values > 1 indicate an increasing population where recruitment is greater than mortality.

- Values = 1 indicate a stable population where recruitment and adult mortality are equal.

Estimates for rate of population change for Lost River suckers at the shoreline spawning areas indicate both male and female populations demonstrated interannual increases from 1997 to 2001 (Figure 2-7, Janney and Shively 2007).

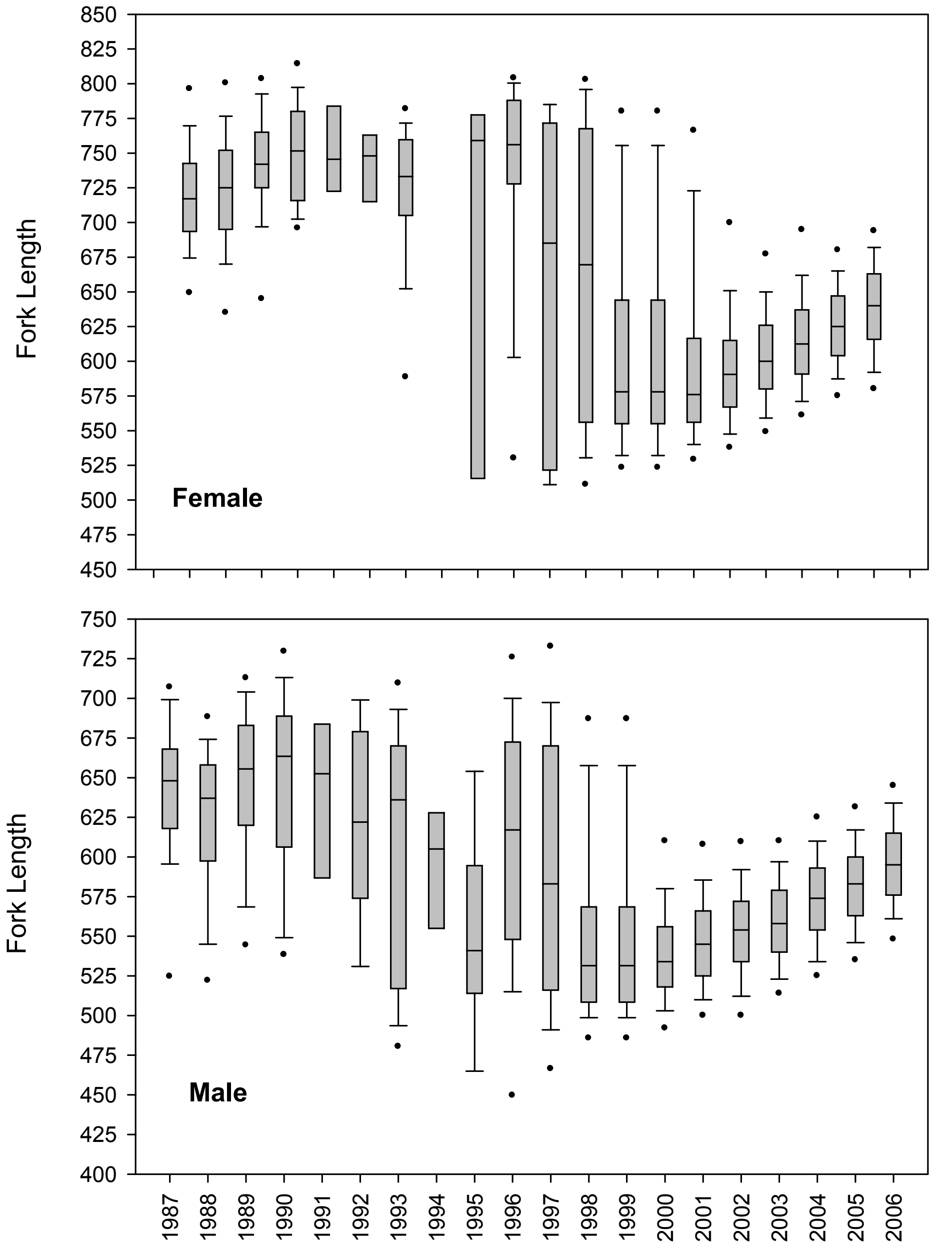
Confidence intervals for estimates during these periods were relatively wide, indicating some uncertainty in the precision of the estimates. Male and female Lost River suckers at the shoreline spawning areas demonstrated either stable or slight decreases between interannual population change estimates since 2001 (Figure 2-7, Janney and Shively 2007). Confidence intervals for estimates during these periods were relatively narrow, indicating more precise estimates than for the preceding periods of interannual comparisons.

Figure 2-4. Size distribution comparison of Lost River suckers collected in the Sprague and Williamson Rivers between 1984 and 2006. Lower and upper boundaries of a box correspond to the 25th and 75th percentile of the size distribution. The horizontal line dividing a box corresponds to the median size, the lower and upper whiskers represent the 10th and 90th percentiles, and the diamonds show the 5th and 95th percentile.



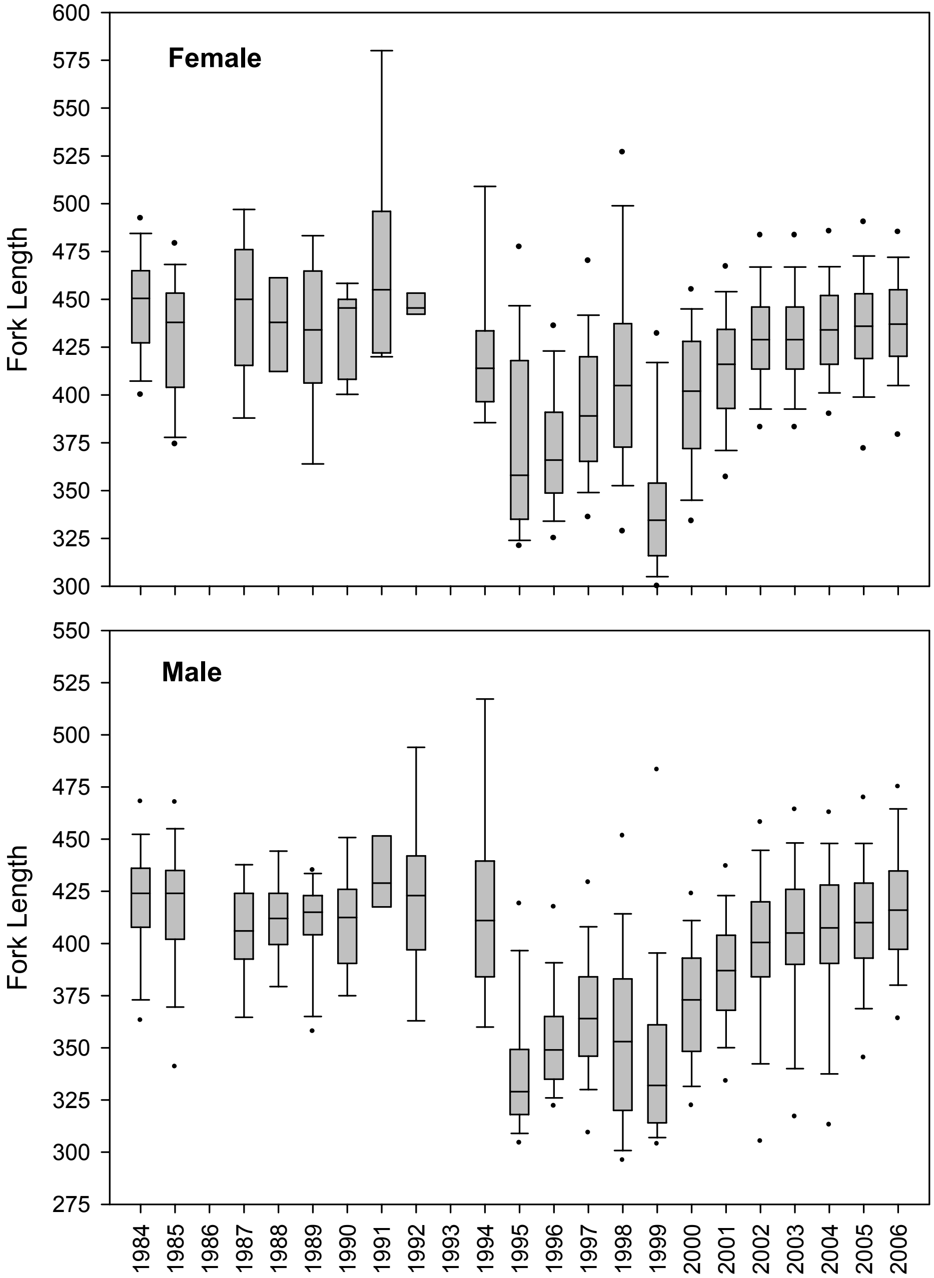
Source: Figure is reproduced with permission from page 11 in Janney and Shively 2007

Figure 2-5. Size distribution comparison of Lost River suckers collected at UKL shoreline spawning sites between 1987 and 2005. Lower and upper boundaries of a box correspond to the 25th and 75th percentile of the size distribution. The horizontal line dividing a box corresponds to the median size, the lower and upper whiskers represent the 10th and 90th percentiles, and the diamonds show the 5th and 95th percentiles.



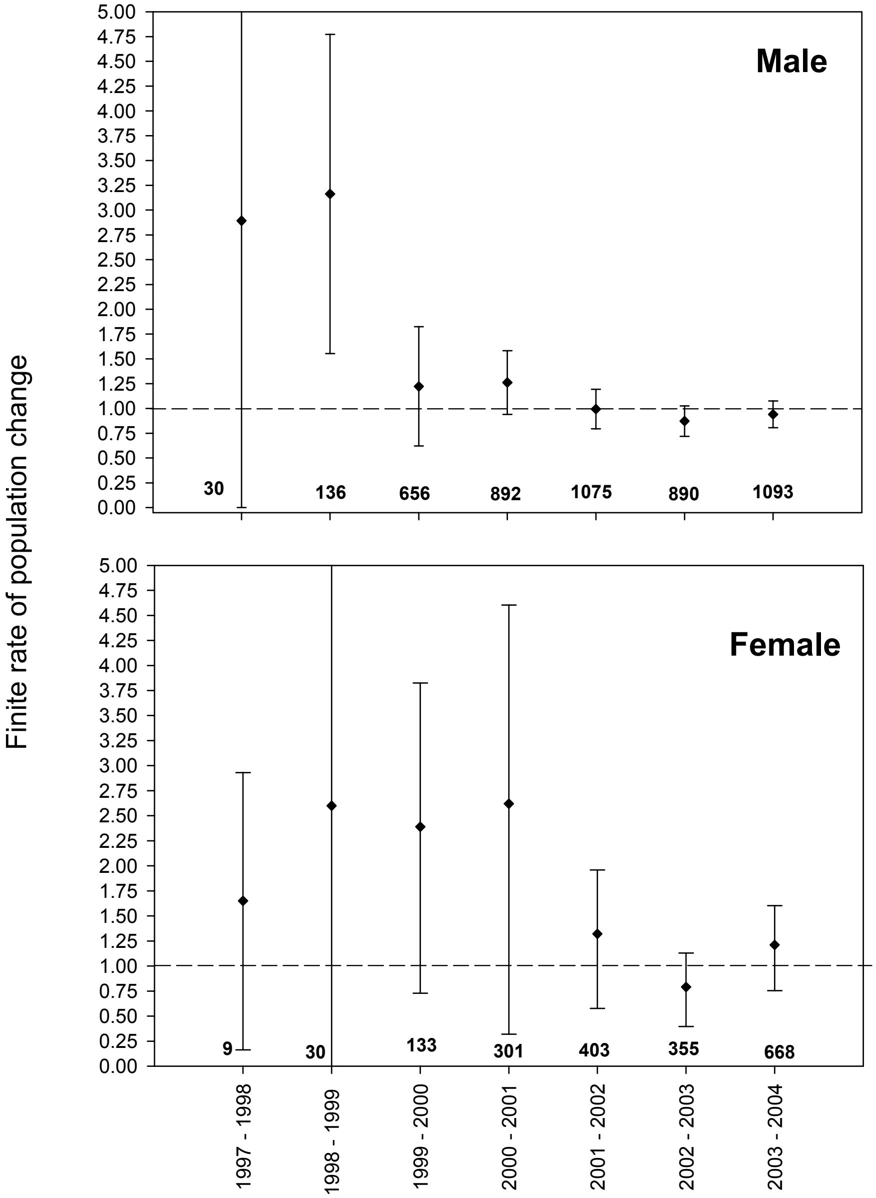
Source: Figure is reproduced with permission from page 12 of Janney and Shively 2007.

Figure 2-6. Size distribution comparison of shortnose suckers collected in the Sprague and Williamson rivers between 1984 and 2006. Lower and upper boundaries of a box correspond to the 25th and 75th percentile of the size distribution. The horizontal line dividing a box corresponds to the median size, the lower and upper whiskers represent the 10th and 90th percentiles, and the diamonds show the 5th and 95th percentiles..



Source: Figure is reproduced with permission from page 13 of Janney and Shively 2007

Figure 2-7. Adult Lost River sucker population growth rates between 1997 and 2004 for the UKL shoreline spawning population. Estimate values greater than one indicate annual population growth and values less than one indicate annual decline. The numbers presented along the x-axis indicate the sample size of fish captured and released at the beginning of the time interval.

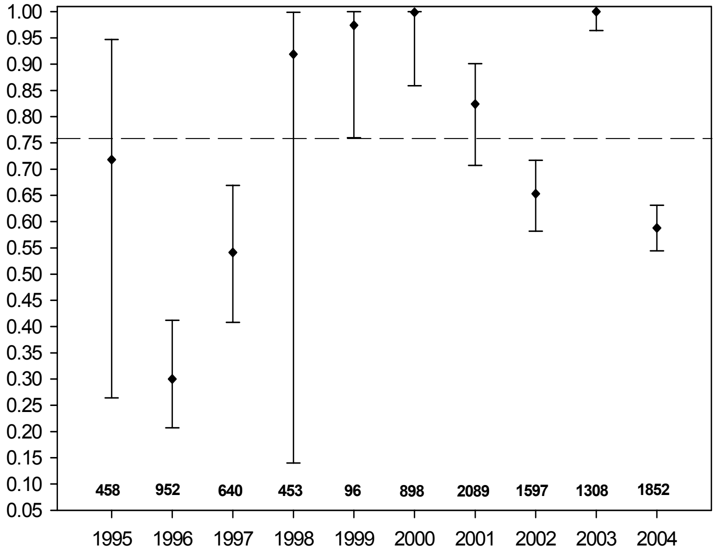


Source: Figure is reproduced with permission from page 16 of Janney and Shively 2007.

Estimates for rate of shortnose sucker population change demonstrate more precise estimates (i.e., narrower confidence intervals) for 2001-02, 2002-03, and 2003-04 than estimates from earlier time periods (Figure 2-8, Janney and Shively 2007). Shortnose sucker population rate change estimates show decreasing populations in every time period except in 2000-01, when the population estimate showed a slight increase (Janney and Shively 2007). The wide confidence interval for the estimate of 2000-01 indicates the estimate may be imprecise. (Figure 2-8, Janney and Shively 2007).

The USFWS has recently recommended downlisting from endangered to threatened for Lost River suckers based on additional information regarding perceived threats at the time of listing in 1988 and the stability of the UKL populations (USFWS 2007 LRS). The USFWS recommended that the endangered status of shortnose sucker remain unchanged due to the continued the threat of extinction for this species and the instability of the shortnose sucker populations in UKL (USFWS 2007 SNS).

Figure 2-8. Apparent annual survival rates and 95% confidence intervals for shortnose suckers in UKL between 1995 and 2004 calculated using capture-recapture data. The numbers presented along the x-axis indicate the sample size captured and released each year. The dotted line represents mean annual survival over the ten year period.



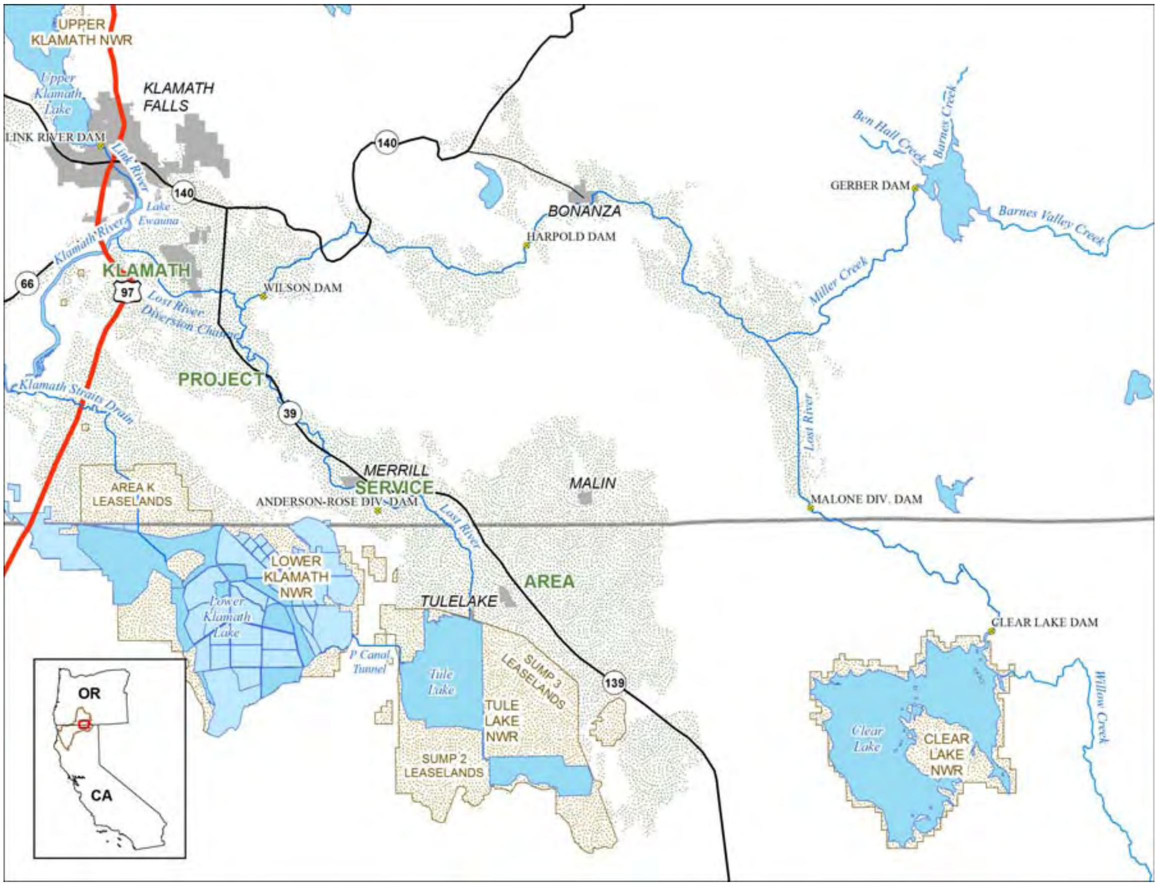
.

Source: Reproduced with permission from page 17 of Janney and Shively 2007.

Clear Lake Reservoir

Both Lost River and shortnose suckers reside in Clear Lake Reservoir. No studies were performed on the fish fauna of Clear Lake prior to construction of the dam in 1910. Because there is no fish passage over Clear Lake Dam, it is reasonable to assume that suckers were present in the lake prior to completion of the dam (Reclamation 2002). Populations of both species in Clear Lake Reservoir have periodically been sampled starting with Andreasen (1975) and most recently with Leeseberg et al. (2007) and Barry et al. (2007 Lost). Spawning by both species principally occurs in Willow Creek, a tributary to Clear Lake (Figure 2-9; USFWS 2002). Shoreline spawning by either secies has not been observed in Clear Lake Reservoir. Data from a study conducting in the 1990s and recent efforts to survey Lost River and shortnose sucker populations in Clear Lake indicate that populations are generally abundant and demonstrate diverse age structures based on length frequency (USFWS 2002, Leeseberg et al. 2007, Barry et al. 2007 UKL). Data from 2004 and 2005 indicated that Lost River and shortnose populations were relatively abundant in Clear Lake although there was a lower frequency of larger individuals present when compared to data from the 1990s (Leeseberg et al. 2007, Barry et al. 2007 UKL). Such a change in length frequency distribution suggests relatively good recruitment but low adult survivorship (USFWS 2002). Shifts in length distribution from the 1980s and early 1990s for both species have also been observed in sucker populations in UKL (Janney and Shively 2007).

Figure 2-9. The Lost River drainage of northern California and southern Oregon and its connections to the Klamath River drainage. Klamath Project lands are shown as shaded.



Populations of suckers in small reservoirs above Clear Lake may have been eliminated due to total or near complete desiccation during the summer of 1992, but probably were reestablished via spawning runs from Clear Lake in the spring of 1993 (Mark Buettner, Fishery Biologist, Reclamation, pers. comm., cited in

USFWS 2002). Investigations are not known to have occurred in these small reservoirs since this time.

Gerber Reservoir

Monitoring within the Gerber Reservoir watershed since 1992 has documented a substantial shortnose sucker population exhibiting multiple size classes. Recruitment in the Gerber Reservoir population of shortnose suckers appear relatively successful based on the presence of small individuals in sampling efforts at the reservoir. While the population of shortnose suckers in Gerber Reservoir appears to have more frequent recruitment than some other populations, the problem of restricted distribution and lack of genetic connectivity with other populations still exists (USFWS 2002). This problem becomes more apparent if sucker populations decline (USFWS 2002). Lost River suckers were not observed at Gerber Reservoir during early and recent fisheries investigations (Barry et al. 2007 Lost, Leeseberg et al. 2007).

Sucker spawning at Gerber Reservoir principally occurs in the tributaries, particularly Ben Hall and Barnes Valley creeks (Piaskowski and Buettner 2003), and possibly Barnes Creek (Figure 2-9). Shoreline spawning has not been observed at Gerber Reservoir. Suckers in Gerber Reservoir appear relatively abundant but demonstrate a trend of fewer, larger adults in recent years when compared to earlier data (Barry et al. 2007 Lost, Leeseberg et al. 2007).

Monitoring since 1992 within the Gerber watershed has documented a substantial shortnose sucker population exhibiting a wide range of size classes. Recruitment in the Gerber Reservoir population of shortnose suckers appear relatively successful based on the high frequency of smaller individuals in sampling efforts at the reservoir. While the population of shortnose suckers in Gerber Reservoir appears to have more frequent recruitment than some other populations, the problem of restricted distribution and lack of genetic connectivity with other populations exists (USFWS 2002). This problem becomes more apparent if basin shortnose sucker populations decline (USFWS 2002). Shortnose suckers in Gerber Reservoir appear relatively abundant but demonstrate a trend of fewer, larger adults in recent years when compared to earlier data (Barry et al. 2007 Lost, Leeseberg et al. 2007). Length frequencies of captured shortnose suckers in 2004 and 2005 were comparable between years, but showed a reduction of larger individuals represented in length frequency data from 2000 (Barry et al. 2007 Lost). The change in shortnose sucker length frequencies in Gerber reservoir can be interpreted as the addition of smaller individuals in the population, the loss of larger individuals in the population, or a combination of the two events. Lost River suckers have not been observed in Gerber Reservoir (Barry et al. 2007 Lost, Leeseberg et al. 2007).

Lost River

The Lost River currently supports an apparently small population of shortnose suckers and very few Lost River suckers (USFWS 2002). Primarily shortnose suckers have been reported from throughout the drainage (Koch and Contreras 1973, Buettner and Scoppettone 1991, Shively et al. 2000 Subbasin). However, the majority of both adults and juveniles are caught above Harpold Dam and to a lesser extent from Wilson Reservoir (Figure 2-9, Shively et al. 2000 Subbasin). Based on length frequency distributions it appears that several year classes were represented within the Lost River during the last fisheries investigations (Buettner and Scoppettone 1991, Shively et al. 2000 Subbasin).

Sucker spawning habitat in the Lost River is very limited. Sucker spawning has been documented below Anderson-Rose Dam (USFWS 2007 Spawning), in Big Springs near Bonanza, Oregon, and at the terminal end of the West Canal as it spills into the Lost River (Figure 2-9; Reclamation 2001). According to Bonanza residents, sucker spawning at Big Springs is now rare (USFWS 2002). Historically, Big Springs may have been an important sucker spawning site that was used as a seasonal fishing site during the sucker migrations by Modoc Indians (Klamath Echos). Suspected areas that have suitable spawning habitat (i.e., riffle areas with rocky substrates) include the spillway area below Malone Reservoir, above Malone Reservoir, immediately upstream of Keller Bridge, immediately below Big Springs, immediately below Harpold Dam, and adjacent to Station 48. Sucker spawning has been documented in Miller Creek, and spawning is suspected in Buck Creek and Rocky Canyon Creeks (Figure 2-9, Shively et al. 2000 Subbasin). Sucker spawning was observed in riffle area of the Lost River above Malone Reservoir in May 2005 (Sutton and Morris 2005). Although the spawning habitat at this location appears to be suitable for sucker spawning under a range of stream discharges, the extent that suckers spawn at this location is largely unknown aside from the observation made in May 2005 (Sutton 2004, Sutton and Morris 2005).

Tule Lake

Historically, sucker spawning migrations from Tule Lake into the Lost River were substantial (USFWS 2002). The Modoc Indians and white settlers captured suckers during these migrations for direct consumption or used them as livestock food (Cope 1879, Coots 1965, Howe 1968). The sucker migrations from Tule Lake into the Lost River once supported several canneries that processed the suckers into canned or dried fish, oil, or other products (Howe 1968, Andreasen 1975).

At present, populations of both species in Tule Lake are a remnant of the historical levels. Sampling at Tule Lake in 1973 captured no suckers (Koch and Contreras 1973). In 1991, individuals of both species were observed spawning below Anderson-Rose Dam, and sampling at Tule Lake in the early 1990s captured and recaptured several adults of each species confirming a small population of both species in the Tule Lake sumps Figure 2-9; USFWS 2002). While accurate estimates of the population size are not possible from the low numbers of captured and recaptured individuals, available information suggests that sucker population sizes for both species in the reach of the Lost River below Anderson-Rose Dam and Tule Lake are limited to a few hundred individuals of each species (USFWS 2002).

Sampling in the 1990s observed adult suckers of both species attempting to spawn in the Lost River spawning below Anderson-Rose Dam in most years (Reclamation 1998 Sucker Spawning). Recent fisheries investigations of Tule Lake have also observed adult sucker spawning below Anderson-Rose Dam and captured larval suckers from this stretch of the Lost River, indicating that some sucker spawning is successful below Anderson-Rose Dam (USFWS 2007 Spawning). Sampling efforts in the Tule Lake sumps have recently captured individuals of varying lengths that indicate recruitment into adult populations occurs in Tule Lake; however, the source of recruitment is uncertain (USFWS 2007 Spawning). Populations of both suckers are likely supported by the spawning activity below Anderson-Rose Dam or immigration of individuals from other populations, as other suitable spawning areas in Tule Lake have not been identified.

Lower Klamath Lake and Sheepy Lake

Prior to 1917, Lower Klamath Lake was seasonally connected to the Klamath River (Weddell 2000). The railroad completely severed that connection by 1917, and by 1924, the majority of the Lower Klamath wetlands had been drained (Weddell 2000). Lower Klamath Lake's connectivity to the remainder of the Klamath Basin is now limited to water delivered through Sheepy Ridge from Tule Lake, and various irrigation canals that connect into the Link River to Keno Dam reach of the Klamath River, primarily the Klamath Straits Drain and both North and Ady canals.

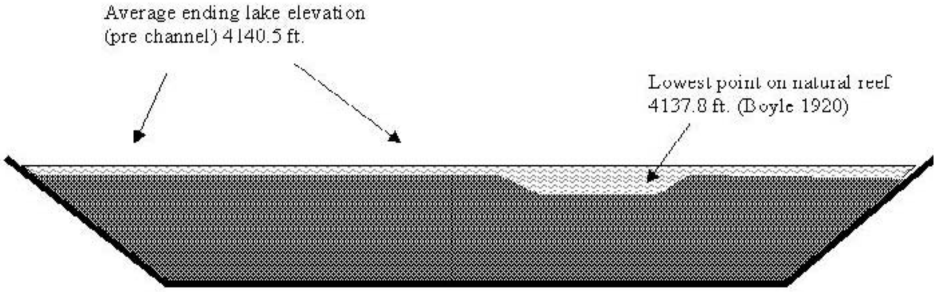
Before about 1924, suckers migrated up Sheepy Creek (a spring-fed tributary to Lower Klamath Lake) in sufficient numbers that they were harvested (Coots 1965). In 1960, small numbers of adult suckers were observed moving up Sheepy Creek in the springtime (Coots 1965). Since 1960, few surveys have been conducted for suckers in Lower Klamath Lake or its tributaries (USFWS 2002) and no suckers were observed during one reported survey of Sheepy Creek and the Klamath Straits Drain (Koch and Contreras 1973).

At present, there are no known populations of suckers in the Lower Klamath Lake sub-basin. The occasional sucker may disperse into this sub-basin from the Keno Impoundment through irrigation canals (USFWS 2002).

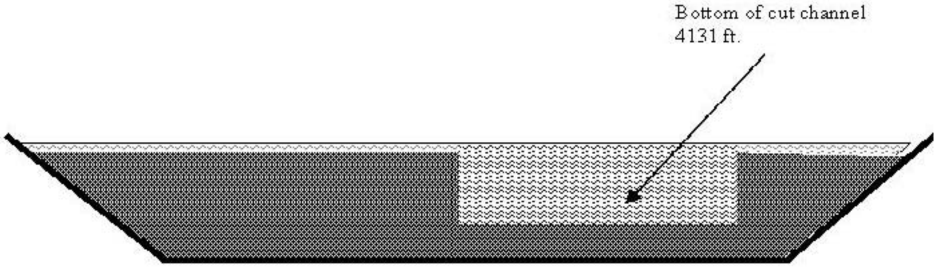
Klamath River Including: Link River, Lake Ewauna, and Keno Impoundment

Before construction of the Link River Dam, there were apparently large spawning runs of suckers migrating up the Link River in March, which were described as "immense congregations" of fish weighing two to six pounds (USFWS 2002). The origin of these runs is not recorded; presumably, fish migrated out of Lower Klamath Lake or the Lake Ewauna/Keno reach, as lake habitat was not available below Keno prior to construction of J.C. Boyle dam. Suckers apparently occupied the Link River even in summer (as evidenced by accounts of stranded 'mullet') when flow to the Link River was cut off by southerly winds producing a seiche (oscillation of the upper surface) in UKL that lowered the level at the outlet to below the sill (Spindor 1996, USFWS 2002).

Figure 2-10. Schematic representation of the natural reef (A) and the modification to lower the natural reef (B) at the outlet of UKL. Modification of the reef included 2 channel cuts, one east of the center channel and one west of center channel. Each channel cut is similar to the schematic.



A **Schematic representation of natural reef/sill before channel was excavated**



B **Schematic representation of natural reef after 100 foot wide channel was cut at time of dam construction**

Source: USFWS 2002.

The natural reef was a long, wide sloping sill unlike the vertical wall of a dam (Figure 2-10, USFWS 2002). Prior to the cutting of the channel, water passing over the sill was directly related to inflows. The average end-of-summer (August 30) lake elevation was 4140.5 ft. (Reclamation data cited in USFWS 2002). The minimum recorded lake level under normal conditions was 4139.9 ft. (Boyle 1987, Reclamation data cited in USFWS 2002). Occasionally, strong South winds have resulted in a cessation of flows over the sill. The last recorded event was in July 1918 when winds shifted water levels northward for a short time, eliminating outflow from the lake (Boyle 1987, Spindor 1996).

The limited information available indicates adult suckers still make an attempt to migrate upstream in the Link River during the spring, and at least juveniles apparently reside in the Link River, Lake Ewauna, and/or the Keno Impoundment below the Link River Dam throughout most of the year (USFWS 2002). Salvage operations conducted below the Link River Dam (Reclamation 2000 Sucker Salvage) and in the irrigation canals below Upper Klamath River such as the Lost River Diversion Channel consistently capture juvenile suckers (Reclamation unpublished data). Young of the year juvenile suckers have been captured in relatively high numbers in a screwtrap operated during summer months on the Link River (Foster and Bennetts 2006, Tyler 2007). While suckers appear to still occupy habitat throughout the Link River in low numbers, the lower Link River is probably crucial to suckers and other fish below UKL, since it may be the best habitat now available in the reach upstream of Keno, Oregon. The lower Link River probably serves as critical refuge for fish during periods of deteriorating water quality conditions (USFWS 2002).

Reithal (2006) indicated that young of the year juveniles occur in Lake Ewauna in relatively high densities. Markle et al. (2007 Juvenile) indicated that the source of larval and juvenile suckers in Lake Ewauna was likely entrained individuals from UKL populations. Screwtrapping results from the Link River indicate relatively high numbers of juvenile suckers present, presumably from UKL (Foster and Bennetts 2006, Tyler 2007). Frequent poor water quality events during the summer months and the limited refugia available in the Lake Ewauna to Keno reach likely reduces the survival of entrained suckers in this reach of the Klamath River.

Connectivity between UKL sucker populations and populations in the Klamath River reservoirs may be maintained through the Lake Ewauna to Keno reach of the Klamath River. Monitoring at a new fish ladder installed at the Link River Dam indicates that some adult suckers are able to return to UKL from the Link River to Keno reach (Reclamation, unpublished data). Adult and juvenile Lost River and shortnose suckers were captured in the Keno Dam fish ladder during a 1997 study to evaluate fish passage at the ladder (PacifiCorp 1997).

Klamath River Impoundments: J.C. Boyle, Copco, and Iron Gate

Downstream of Keno Dam, the Klamath River consists of three primary reservoirs (J.C. Boyle, Copco and Iron Gate) and three riverine reaches. A more detailed description of the reservoirs and riverine reaches is presented in Desjardins and Markle (2000) and Fishpro (2000). Four species of suckers are known from the Klamath River and its reservoirs: Lost River sucker, shortnose sucker, Klamath largescale sucker, and the Klamath smallscale sucker. The high-energy character of the river reaches between the reservoirs, the primarily lacustrine habitat for Lost River and shortnose suckers in this reach of the Klamath River, may exclude the two species except during migrations (USFWS 2002).

Although previous efforts have been made to survey suckers in the Klamath River reservoirs (Coots 1965, Beak Consultants Inc. 1987, Buettner and Scoppetone 1991), the most intensive survey for suckers in this reach was performed in 1998 and 1999 (Desjardins and Markle 2000). Shortnose sucker is the only lake sucker that occurs in abundance in the Klamath drainage below Keno, and adults have consistently been collected in all three reservoirs. Lost River suckers are present in all three reservoirs but only in low abundance (USFWS 2002). Although shortnose sucker adults are more abundant in Copco Reservoir, both Copco and Iron Gate reservoirs contain primarily larger individuals than J.C. Boyle which appears populated with subadults with fork lengths of 100 to 300 mm (~4 to 12 inches, USFWS 2002). Unidentified larval suckers have been caught in all three reservoirs, and shortnose sucker spawning behavior has been observed in Copco Reservoir, but there is no evidence that shortnose suckers consistently survive past lengths of 50 to 100 mm (~2 to 4 inches) in the reservoir (Beak Consultants Inc. 1987, Buettner and Scoppettone 1991, Desjardins and Markle 2000).

Environmental Baseline for Suckers

The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. (50 CFR 402.02, final rule). The USFWS/NMFS Endangered Species Consultation Handbook (USFWS/NMFS, 1998) describes the environmental baseline as: “an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area.” The environmental baseline is a “snapshot” of a species’ health at a specified point in time. It does not include the effects of the action under review in the consultation. (p 4-22, USFWS/NMFS 1988)

The environmental baseline is, therefore: an *analysis* of the *impacts* that past human actions and natural events have had on the species; of the ongoing effect those factors have on the species; and of the effect they will continue to have on the species in the future. Other Federal actions which have already undergone Section 7 consultation are the Williamson River Delta Restoration Project and the removal of Chiloquin Dam. Installation of a fish ladder at Link River Dam and a fish screen at the A-Canal were analyzed in the 2002 Section 7 consultation. Early consultation has occurred on the installation of fish screens on private diversions around UKL which is being conducted in partnership with the State of Oregon. Numerous other habitat enhancement actions undertaken by the Ecological Services Office of the USFWS, walking wetlands on Lower Klamath National Wildlife Refuge, water conservation efforts and habitat improvements on thousands of acres of private land are, and millions of dollars of research on needs of suckers also contribute to the baseline conditions for suckers. Water operations on Lower Klamath River National Wildlife Refuge have not undergone interagency consultation to evaluate the impacts to suckers.

The environmental baseline is used to conduct an analysis of the effects of the action. Effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. In simpler terms, the environmental baseline describes the current conditions a species is facing and those it will continue to face in the future, without the proposed action. The effects of the action are then added to the baseline to project the conditions the species is likely to face in the future.

It is important to keep in mind that the ESA's section 7 consultation requirement is not retroactive to facilities constructed prior to its enactment considering that the ESA expressly exempts from the consultation initiation requirements construction projects that began prior to November 10, 1978. See 16 U.S.C. § 1536(c); see Idaho Department of Fish and Game v. NMFS, 850 F.Supp. 886, 894 (D. Ore. 1994). In this consultation Reclamation is analyzing the continuation of an on-going action, operation of the Klamath Project. That is, it is the continuation of Project operations, not the existence of the Project that is being considered. Past Project operations and the existence of the Project are a part of the environmental baseline.

The environmental baseline for the suckers is characterized by altered landscapes and aquatic ecosystems throughout the Upper Klamath Basin. Primary negative alterations include water depletions for irrigated agriculture, forestry, urbanization, and loss of wetland habitat.

To understand the environmental conditions that both sucker species currently experience, Reclamation provides a brief summary of the perceived threats to the species at time of listing and a description of the current information and understanding of the perceived threats.

Factors at the Time of Listing

The biological understanding of both suckers has advanced since their 1988 ESA listing. To understand the factors potentially influencing both Lost River and shortnose suckers at the present, it warrants a brief recount of perceived threats at the time of listing. At the time of listing, the perceived threats to Lost River and shortnose suckers included (from USFWS 1988):

A. Loss of historical populations and range
B. Habitat loss, degradation, and fragmentation
C. Drastically reduced adult populations
D. Overharvesting by sport and commercial fishing
E. Large summer fish die-offs caused by declines in water quality
F. Lack of significant recruitment
G. Hybridization with the other two sucker species native to the Upper Klamath Basin
H. Potential competition with introduced exotic fishes
I. The inadequacy of existing regulatory mechanisms to provide for the conservation of these species

Although several of the threats to both Lost River and shortnose suckers such as overharvest and lack of regulatory protection, have been removed, other perceived threats from the original listing in 1988 still persist and likely influence sucker populations (ISRP 2005). Since 1988, several fisheries investigations of suckers provide more information and greater detail to the perceived threats at the time of listing. Irrigated agriculture was not identified as a threat at the time of listing.

A. Loss of Historical Populations and Range

The historical range of Lost River and shortnose suckers has been severely reduced by drainage and management of Lower Klamath and Tule Lakes. Historically, both sucker species occurred throughout the Upper Klamath Basin, with the exception of the higher, cooler tributaries dominated by resident trout and the upper Williamson, which is isolated by the Williamson Canyon. At the time of listing, both sucker species were reported as present in UKL, UKL tributaries, Lost River, Clear Lake Reservoir, the Klamath River; and the three larger Klamath River reservoirs (USFWS 2002). Since listing, populations of both species have been identified in Tule Lake, and a shortnose sucker population has been identified in Gerber Reservoir (USFWS 2002).

The loss of historic populations and range is a continued threat to both the Lost River and shortnose suckers. Although the cause for each lost population is not entirely understood, several populations of suckers are now extirpated (USFWS 2002). Populations of suckers were historically noted in Lake of the Woods and Lower Klamath Lake (including Sheepy Lake). Suckers populations were also noted in several small reservoirs on Willow Creek in the Clear Lake sub-basin until consecutive drought years in the 1990s (USFWS 2002). Repopulation of these small reservoirs is probable but not known (USFWS 2002). Suckers once spawned at Barkley Spring on the eastern shoreline of UKL and at several areas along the northwestern shoreline of UKL near Pelican Bay. Sucker spawning activity has not been observed since the early 1990s and is presumed to no longer occur at several of these locations (NRC 2004).

The range of Lost River and shortnose suckers has not expanded nor contracted substantially since listing in 1988. Since 1988, additional sucker populations have been identified in isolated sections of the Lost River drainage, within the historical range for both species that includes a population of shortnose suckers in Gerber Reservoir and small populations of each species in Tule Lake (USFWS 2002). Given the lack of connectivity between populations created by past and present water management and land use practices, suckers are not likely to repopulate several of these locations, such as Lower Klamath Lake on the Lower Klamath National Wildlife Refuge, and Lake of the Woods, without direct human assistance.

B. Habitat Loss, Degradation, and Fragmentation

The diking and draining of wetlands throughout the Klamath Basin have been well documented in previous section 7 consultations (Reclamation 2001, USFWS 2002). In the late 1800s, prior to most watershed development, approximately 223,000-330,000 acres (average = 276,000 acres) of shallow lake and associated wetland habitat existed. Presently, 76,000-122,000 acres (average = 99,000) of shallow lake and wetland habitat exist in the basin (Reclamation 2001). Overall, aquatic habitat available to suckers has decreased approximately 64 percent (or 177,000 acres) over the last century. No assessment of the amount of habitat needed to sustain a viable population is available. A concurrent, substantial decline in sucker populations over this time period was related in part to the large loss of lake and wetland habitat areas and blocked access to spawning and rearing areas and entrainment losses resulting from diversions (Reclamation 2002). Review of recent U.S. Army Corps of Engineers section 7 ESA consultations indicates that some relatively minor wetland losses still occur in the Upper Klamath Basin, but effects of these actions on sucker populations are minimized during project planning and consultation (USFWS 2007 LRS, 2007 SNS).

Dams block sucker migration corridors, isolate population segments, and concentrate suckers in limited spawning areas, possibly increasing the likelihood of hybridization between species (Reclamation 2001). Dams may also result in stream channel changes, alter water quality, and provide habitat for exotic fish that prey on suckers or compete with them for food and habitat (Reclamation 2001). There are seven major Project dams that may affect the migration patterns of listed suckers, including Clear Lake, Link River, Gerber, Malone, Miller Creek, Wilson, and Anderson-Rose Dams. Only the Link River Dam is equipped with a new fish ladder, designed specifically for sucker passage, which was installed and operational at the Link River Dam in spring 2005.

Tule Lake

There is concern regarding Tule Lake's capacity to support populations of both species. A study is currently being conducted to investigate the extent sedimentation impacts on changing depths at Tule Lake. Previous investigations regarding the changing depths of Tule Lake have not provided a reliable measure of the sedimentation issue. Sedimentation of Tule Lake could impair sucker survival in this lake through reduced water depths (USFWS 2002).

Non-Project Water Operations

There are several non-Project dams in the Upper Klamath Basin that block or restrict sucker movement within the range of the endangered suckers (Reclamation 2001). Overall, non-Project dams block or restrict upstream passage and connectivity to approximately 175 stream miles in the Upper Basin. Project dams block access to approximately 100 stream miles. Dams in the basin have prevented fish from migrating to historic spawning and rearing areas, likely impacting spawning and rearing success of both Lost River and shortnose suckers (Reclamation 2001). Depletions of water by irrigators above the Project reduce inflow to UKL and directly affect Reclamation's ability to fulfill irrigation contracts. The State of Oregon is currently adjudicating the water rights for the Klamath River in Oregon. This adjudication will provide an additional tool for Reclamation to maintain lake levels for sucker habitat.

Chiloquin Dam Removal

The most significant non-Project dam with inadequate fish passage facilities within historic sucker habitat is Chiloquin Dam at approximately river kilometer 1.0 (river mile [RM] 0.75) on the Sprague River near Chiloquin, Oregon. Chiloquin Dam with a fish ladder designed for passage of salmonids has been identified as inhibiting or preventing sucker migrations in the Sprague River (USFWS 1993 Sucker, NRC 2004). With the scheduled removal of Chiloquin Dam, sucker migrations in the Sprague River are expected to be uninhibited starting in 2009.

Other Non-Project Diversion Dams

Other private or irrigation district owned flash-board diversion dams on the Lost River lack fish passage facilities including: Bonanza Diversion Dam, Harpold Dam and Lost River Ranch Dam, which restrict upstream passage to 20 to 25 miles of stream/reservoir habitat, respectively, during the spring and summer. These dams are removed from October until April, allowing access to these areas during the fall, winter, and early spring. A removable fish ladder has been is installed on Harpold Dam from April through October of each year, but its efficiency to pass suckers has not been investigated (C. Korson, Reclamation, Chief, Water Quality Division, pers. comm.).

Small earthen dams in the Gerber Reservoir and Clear Lake watersheds block or restrict sucker access to portions of the watersheds that contain potential spawning and rearing sucker habitats (Reclamation 2001). Several removable fish ladders have been installed at irrigation diversion dams along the Wood River and Seven Mile Creek in the UKL watershed. It is not known if these ladders are passable by endangered suckers (Reclamation 2001).

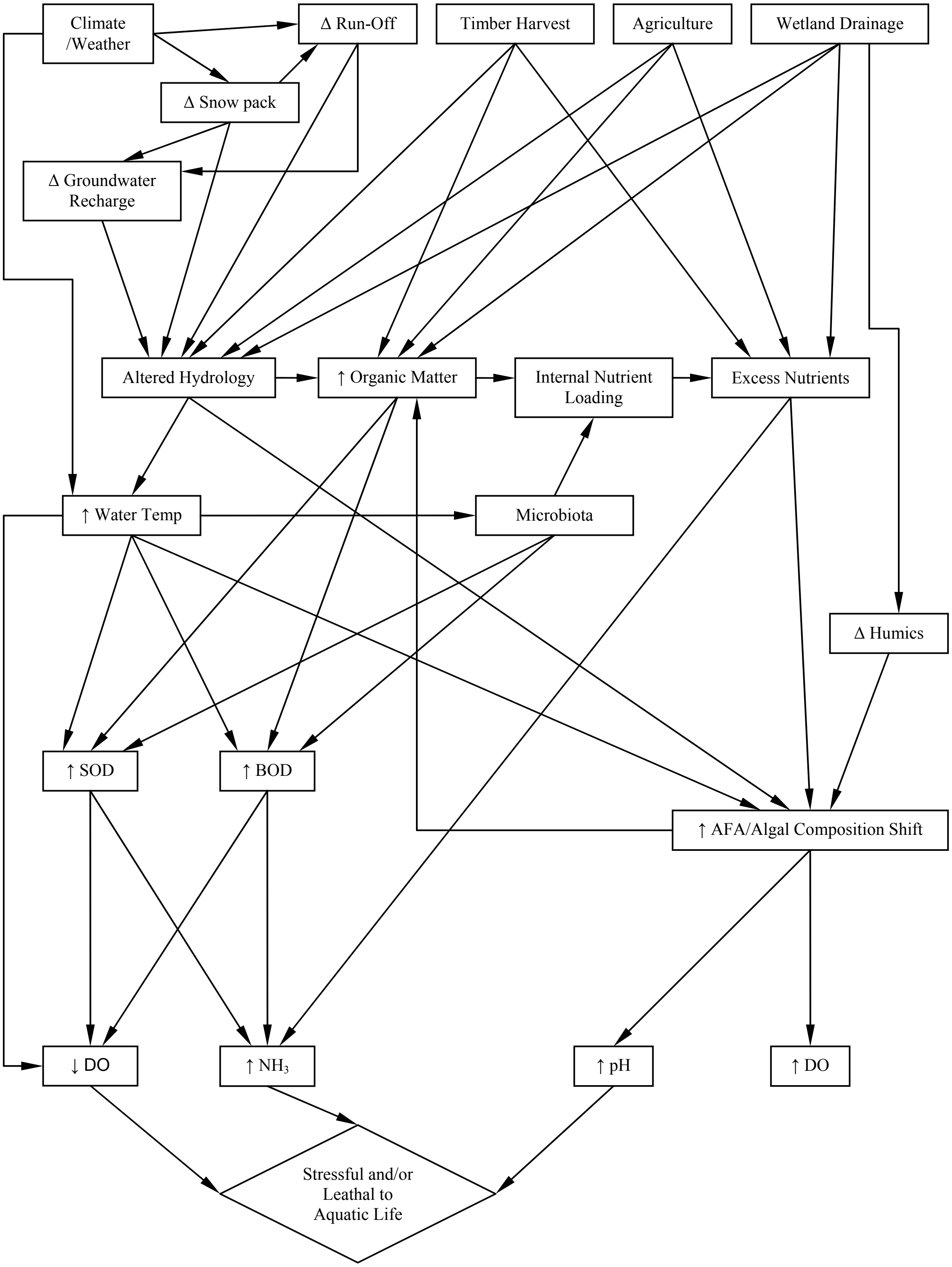
Water Quality in the UKL Watershed

UKL, the primary habitat for endangered suckers, is a hypereutrophic water body that experiences poor water quality on a seasonal basis. Poor water quality in the Klamath Basin is characterized by high water temperatures, low DO concentration (hypoxia), high pH, elevated unionized ammonia concentration and intense growth (blooms) of the blue-green alga (cyanobacterium) *Aphanizomenon flos-aquae* (AFA). Some of the factors and interactions influencing water quality in the Klamath Baisn are presented in Figure 2-11.

Researchers have shown that UKL has been nutrient rich and productive for thousands of years (Sanville et al. 1974; Eilers et al. 2001; Bradbury et al. 2004; Eilers et al. 2004). The UKL watershed is a naturally eutrophic (nutrient rich and supporting high abundances phytoplankton) system, which is consistent with its shallow depth, deep organic-rich sediments, and large watershed consisting of phosphorus-rich soils (Eilers et al. 2004). However, in recent decades, the lake has become hypereutrophic and now experiences extremely poor water quality that has resulted in massive fish die-offs (Bortleson and Fretwell 1993; Kann 1998; Risley and Laenen 1999; Perkins et al. 2000 Water Quality; Eilers et al. 2001; Bradbury et al. 2004; Eilers et al. 2004; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007). Hypereutrophic conditions result from excessive nutrients, which enable dense blooms of AFA to develop in UKL. AFA, nearly absent from UKL a century ago, has showed major increases during the twentieth century, in particular since the 1950s and is now the dominant phytoplankton species (Kann and Walker 1999; Geiger 2001; Geiger et al. 2005; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007).

The poor water quality associated with massive algae blooms has likely contributed to major declines in UKL sucker populations over the last several decades (Perkins et al. 2000 Water Quality; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007). There are many interrelated factors contributing to the complex water quality dynamics and the current conditions observed within the Klamath River watershed. Figure 2-11 depicts the interactions that contribute to the water quality conditions observed within the Klamath River basin and demonstrates the complexity of the interactions impacting water quality.

Figure 2-11. Flowchart of Klamath River Basin water quality interactions.



Watershed Alterations Affecting Water Quality

It has been suggested that large scale watershed development from the late-1800s though the 1900s has contributed to the lake's current hypereutrophic condition (Bortleson and Fretwell 1993; Eilers et al. 2001; Bradbury et al. 2004; Eilers et al. 2004; Geiger et al. 2005). Accelerated sediment and nutrient loading to UKL consistent with land use practices in the Upper Klamath watershed (Eilers et al. 2004) have resulted in algae blooms of higher magnitude and longer duration (Kann 1998). These blooms have led to extreme water quality conditions (high pH, low DO, and high ammonia) that may increase fish stress, negatively impact fish health and increase the size and frequency of fish die-offs (Perkins et al. 2000 Water Quality; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007). In recent decades, the lake has experienced serious water quality problems that have resulted in massive fish die-offs, as well as pronounced horizontal re-distribution of fish in response to changes in water quality (Buettner and Scoppetonne 1990; Banish et al. 2007). While there is general agreement that declining water quality in UKL coincides with the settlement of Upper Klamath Basin, the causal mechanism is yet unclear (Graham et al. 2005).

Agriculture

Agricultural of UKL have likely contributed to the accelerated erosion leading to an increase in sediment and nutrient loading rates to UKL. Most of the agricultural activity in the Upper Klamath watershed is related to livestock grazing, with little crop production occurring upstream of UKL. Livestock, particularly cattle, have heavily grazed flood plains, wetlands, forest, rangelands, and riparian corridors, resulting in the degradation of these areas. The increase in sediment accumulation and nutrient loading are consistent with the changes in land use in the Upper Klamath watershed occurring during the late-1800s through the 1900s (Bortleson and Fretwell 1993; Eilers et al. 2001; Bradbury et al. 2004; Eilers et al. 2004; Geiger et al. 2005). However, the magnitude of impact from agriculture and livestock grazing on nutrient and sediment input to UKL is unquantified. Approximately 35% of the watershed above UKL is used for livestock grazing. Cattle production in Klamath County reached a peak near 1960 with a total of about 140,000 head (Table 2-2; Eilers et al. 2001). In the Wood River Valley approximately 35,000 head of cattle graze during the summer and fall and less than 1,000 during the other months (Eilers et al. 2001). In the Sprague River Valley approximately 20,000 head graze on pastures in summer and approximately 1,500 head graze during winter (Eilers et al. 2001). In recent years the numbers of cattle have been reduced by approximately 50%, in 2007 the number of cattle reported for 2007 is 81,000 from the high in 1960.

Table 2-2. Cattle production in Klamath County, Oregon derived from U.S. Department of Commerce

Year	Number of cattle
1920	30,000
1930	40,000
1940	50,000
1950	60,000
1960	140,000
1970	80,000
1980	110,000
1990	100,000
2000	105,000
2007	81,000

Source: adapted from Eilers et al. 2001 and U.S. Deparrtment of Agriculture web site.

Timber Harvest

Throughout the Upper Klamath Basin, timber harvesting and activities associated with it (such as road building) by Federal, State, tribal and private landowners have resulted in soil erosion on harvested lands and transport of sediment into receiving waters adjacent to or downstream from those lands. Table 2-3 summarizes the timber harvest that occurring in the Upper Klamath watershed (Risley and Laenen 1999). Logging and road building practices in the past did not often provide for adequate soil stabilization and erosion control. Risley and Laenen (1999) reported that timber harvest and associated roads have contributed to the high sediment and nutrient inputs to UKL from tributary watersheds. However, the impact from timber harvest on nutrient and sediment input to UKL is unquantified.

Table 2-3. Approximate annual timber harvest in Klamath County, Oregon in million board feet.

Year	Timber harvest (million board feet)
1920	120
1930	650
1940	800
1950	450
1960	200
1970	400
1980	400
1990	450

Source: Risley and Laenen 1999

Wetland Drainage

Diking and draining for non-Klamath Project agricultural development isolated more than 30,000 acres of wetlands from UKL (Snyder and Morace 1997; Geiger 2001; Graham et al. 2005). This wetland drainage accounts for approximately 65% of the lakeshore wetlands that historically surrounded UKL (Snyder and Morace 1997; Geiger 2001; Graham et al. 2005). The wetlands were drained and converted to agricultural production starting in the 1880's through the 1970s. Table 2-4 (adapted from Snyder and Morace 1997) summarizes the wetlands drained, acreage, and date of drainage. Approximately 20,000 acres of this total have been taken out of agricultural production and are in the process of being restored to wetlands, about 17,000 acres of which are scheduled for reconnection to UKL. It's likely that the physical and chemical characteristics of large lakeshore marshes around UKL historically played an important role in regulating the algal community and other characteristics of the system. The restoration of these wetlands is expected to provide water quality benefits by resuming a role in the nutrient cycling process and possibly reducing the intensity of algal blooms in UKL. However, it's unknown what level of water quality improvement will result. More detail on the effects of wetland drainage on water quality and the role of wetlands in regulating the algal community is discussed in the "Nutrient loading" and "Algal productivity and associated poor water quality" sections below. Also, the section titled "Management Actions Taken In Effort to Improve Species Condition and/or Habitat" discusses the benefits of wetland restoration as sucker habitat.

Table 2-4. Wetlands adjacent to UKL converted to agricultural land. Approximately 8,000 acres, primarily in the Wood River watershed, were converted but are not accounted for in this table.

Site	Acres	Date Converted	Acres (cumulative)	Percent (cumulative)
Wilson Marsh	100	1889	100	0.1
Little Wocus Marsh	260	1889	360	1.3
Big Wocus Marsh	3,800	1896	4,160	15.7
Algoma Marsh	1,200	1914	6,660	25.1
Caledonia Marsh	2,500	1916	7,860	29.6
Hanks Marsh (Cove Point)	1,000	1919-40	8,860	33.3
Ball Bay South	800	1919	9,660	36.3
Williamson River Marsh	6,400	1920	16,060	60.4
Wood River Ranch	2,900	1940-57	18,960	71.4
Ball Bay West	410	1946-47	19,370	72.9
Agency Lake North	2,600	1962	21,970	82.7
Agency Lake West	4,600	1968-71	26,570	100

Source: Adapted from Snyder and Morace 1997.

Sedimentation Due to Watershed Alterations in UKL

Sediment studies in UKL indicate a change in sediment composition and a substantial increase in sediment accumulation rates and nutrient concentrations over the last 150 years corresponding with increases in erosion input from the watershed (Eilers et al. 2001; Eilers et al. 2004; Bradbury et al. 2004). The changes in sediment composition and accumulation rates are consistent with land use activities that occurred during this period, including substantial deforestation, drainage of wetlands, and agricultural activities associated with livestock and irrigation (Eilers et al. 2001; Eilers et al. 2004; Bradbury et al. 2004). Sediment accumulation rates have increased from about 18 grams per square meter per year (g/m2/year) in 1880 to a high of 120 g/m2/year in 1995 (Table 2-5). Eilers et al. (2004) and Bradbury et al. (2004) also found increases in sediment accumulation rates in UKL since the onset of development in the Upper Klamath watershed.

Table 2-5. Sediment accumulation rate from UKL sediment core analysis.

Year	Sediment Accumulation Rate (g/m^2/year)
1880	18
1900	20
1920	20
1940	30
1960	40
1980	60
1995	120

Source: Eilers et al. 2001

Water Temperature

Temperature plays a major role in water quality by directly causing stress to fish, as well as exacerbating other processes affecting water quality such as:

- *DO.* Temperature directly influences DO solubility as well as accelerate oxygen consuming microbial processes (Biochemical Oxygen Demand [BOD] and Sediment Oxygen Demand [SOD]).
- *AFA production.* Higher water temperature stimulates amplified AFA production leading to further water quality degradation. The greatest density of AFA coincides with warmer water temperature (Wood et al. 2006).

Water temperature within UKL annually exceeds 25 degrees Celcius (ºC) during summer months, typically reaching a maximum in late July to early August. These excessively warm water temperatures can be stressful and at times leathal to fishes within UKL. The Oregon Department of Environmental Quality (ODEQ) has identified nearly 25 stream segments flowing into UKL as “temperature limited” (ODEQ 1998). Increased temperatures are symptomatic of degraded stream conditions resulting from increased sedimentation, loss of riparian vegetation, and channel modifications associated with logging, intensive grazing, flow reductions, and agricultural activities. However, air temperature and solar radiation likely have a greater effect on increasing water temperature of UKL than tributary inflows under the current tributary hydrology.

Nutrient Loading

High nutrient loading promotes correspondingly high algae production, which, in turn, modifies physical and chemical water quality characteristics that can directly diminish the survival and production of fish populations. Accelerated phosphorus loading is likely a key factor driving the massive AFA blooms that now dominate UKL. ODEQ established a Total Maximum Daily Load (TMDL) for UKL in 2002 targeted at reduction of phosphorous as a means to reduce AFA production and improve water quality conditions such that water quality criteria would be attained. Through modeling and analysis efforts, ODEQ (2002) determined that phosphorous reduction would be the most effective means of improving water quality conditions within UKL. Although nitrogen is also an important nutrient in structuring algae communities and determining algal productivity, AFA is able to fix atmospheric nitrogen to meet its nitrogen needs in what may otherwise be a nitrogen-limiting environment (ODEQ 2002). Thus, phosphorous loading is of particular importance in UKL in determining algal productivity and biomass, which in turn influences water quality conditions affecting native fishes (ODEQ 2002). However, there is debate as to whether external phosphorous load reduction will improve water quality conditions within UKL (NRC 2004) due to internal nutrient loading driven by the release of phosphorous from lake bed sediments (Laenen and LeTourneau 1996; Fisher and Wood 2004; Kuwabara et al. 2007).

External Nutrient Loading

Although there have always been high background phosphorus levels in Upper Klamath Basin tributaries, data exists from several studies to indicate that phosphorus loading and concentrations are elevated above these background levels (Miller and Tash 1967; USACE 1982; Campbell 1993b; Kann and Walker 1999; Bradbury et al. 2004; Eilers et al. 2004). This accelerated phosphorous loading occurred at the same time as an increase in development and intensive land use activities in the Upper Klamath Basin, including substantial deforestation, drainage of wetlands, and agricultural activities (Bradbury et al. 2004; Eilers et al. 2004). Parameters that determine phosphorus loading and concentrations in UKL include inflow of phosphorus and water volume from tributaries and internally regenerated phosphorus from sediments (internal loading).

One of the earliest nutrient loading studies (Miller and Tash 1967) indicated that despite accounting for only 12% of the water inflow, direct agricultural input from pumps and canals account for 31% of the annual external total phosphorus budget. Other studies show that drained wetlands in agricultural production consistently pump effluent containing 2-10 times the phosphorus concentration of tributary inflows (Campbell 1993b), and that nitrogen and phosphorus are liberated from drained wetland areas, leach into adjacent ditches, and are subsequently pumped to UKL or its tributaries (Snyder and Morace 1997). Coupled with the considerable but diffuse non-point contribution stemming from wetland loss, flood plain grazing, flood irrigation, and channel degradation, the total phosphorous (TP) input from anthropogenic sources likely accounts for a far greater percentage than that indicated by the 31% contributed due to direct pumping alone (Kann and Walker 1999).

The Williamson River and Wood River together accounted for 67% (48% and 19%, respectively) of the 1992-1998 TP load, with springs and ungaged tributaries contributing another 10% (Kann and Walker 1999). Precipitation, Sevenmile Creek and agricultural pumping accounted for the remaining 23% (Kann and Walker 1999). Unlike water contribution, where Wood River, Sevenmile Creek, and agricultural pumps contribute 25% of the water load, these same sources contributed 39% of the average annual TP load (Kann and Walker 1999). In contrast, springs contributed 16% of the water input, but contributed only 10% of the TP load (Kann and Walker 1999). This appears to be partially due to the consistently higher volume weighted TP concentration occurring in the pump effluent, and Wood River and Sevenmile Creek systems (Kann and Walker 1999).

Walker (1995) estimated an increase in Agency Lake inflow concentration from 81 to 144 parts per billion TP due to anthropogenic activities, Kann and Walker (1999) estimated that approximately 40% of the phosphorus load to UKL can be attributed to man-caused sources, Gearheart et al. (1995) estimated that over 50% of the annual TP load from the watershed could be reduced with management practices, and Anderson (1998,Ris cited by Kann and Walker 1999) likewise estimated that in-lake TP concentration could be reduced by using watershed management strategies.

Kann and Walker (1999) estimated the particulate phosphorus (PP) load as the TP load minus the soluble reactive phosphorus (SRP) load. These data clearly show an increase in the loading of PP relative to SRP during high runoff events for the Williamson and Sprague Rivers. During these high flow events, which typically occur from January-May, PP can increase to 60% of the TP load, compared to less than 5% during summer low flow periods. There are also noticeable spikes of PP load occurring in the Wood River and 7-Mile Canal systems, but they are not limited to high run-off periods. This pattern could be consistent with flood irrigation practices that would tend to be pulsed in nature, and where overland runoff could increase the proportion of particulates. The increase in PP loading is indicative of degraded watershed conditions. In a healthier watershed (e.g., intact riparian areas and flood plains) the concentration should tend to decrease at high flows through dilution, and particulate loading should only increase slightly (Kann and Walker 1999).

Nutrient Loading from Drained Wetlands

The disassociation of the wetlands from the UKL has meant a substantial loss of nutrient uptake capacity (Geiger 2001). However, wetlands are both sinks and sources of nutrients depending on the time of year. During winter and spring, wetlands are major sources of nitrogen and phosphorus due to wetland plant senescence and decomposition. During the summer growing season, wetland vegetation will assimilate and “lock-up”nutrients into plant structure. The timing of nutrient release and uptake is an important factor driving the lake’s water quality dynamics.

The drained wetlands are also a source of nutrients to UKL. Direct phosphorous loading from drained wetland properties surrounding UKL are also very high (188 kg/km2). Nutrient loading studies indicate that despite contributing only 3% of the water inflow (43,000 af/year), direct agricultural input from pumps that remove water from the drained wetlands around UKL accounted for 11% of the annual external total phosphorus budget (21 metric tons/year) and as much as 32% of the total during the peak pumping period of February through May (Kann and Walker 1999).

Internal Nutrient Loading

Internal phosphorus loading is another significant component of the nutrient budget affecting algal bloom dynamics and water quality in UKL (Barbiero and Kann 1994; Laenen and LeTourneau 1996; Kann 1998; Kann and Walker 1999). Nutrient loading studies show that the largest flux of phosphorus to UKL during the summer months comes from internal sources (Kann and Walker 1999). On average, the internal loading accounts for approximately 60%, while external loading accounts for approximately 40% of the annual phosphorous load to UKL (Walker 2001).

Photosynthetically elevated pH can be an important mechanism for releasing phosphorus in shallow productive lakes (Jacoby et al. 1982; Sondergaard 1988; Welch 1992). Elevated pH levels can increase phosphorus release from the sediments to the water column by solubilizing iron-bound phosphorus in both bottom and re-suspended sediments (Kann and Walker 1999). Evidence for this exists in UKL where phosphorus associated with hydrated iron oxides in the sediment was the principal source of phosphorus to the overlying water, and iron-phosphorus fractions of lake sediment decreased from May to June and July (Wildung et al. 1977). It appears that elevated pH increases the probability of internal phosphorous loading (Kann and Walker 1999). Empirical evidence from UKL indicates that as the bloom progresses and elevated pH increases the flux of phosphorus to the water column, increased water column phosphorus concentration further elevates algal biomass and pH, setting up a positive feedback loop (Kann and Walker 1999).

The total nitrogen balance indicates that UKL is a seasonally significant source of nitrogen. Kann and Walker (1999) estimated a net negative retention of TN on an annual basis (average annual negative retention is 143%). On a seasonal basis, TN retention ranges between –259% and –627% (Kann and Walker 1999). The main source for this increase in internal nitrogen loading is nitrogen fixation by AFA (Kann 1998). Another potential source is the mobilization of inorganic nitrogen from lake sediments during anaerobic bacterial decomposition (Kann and Walker 1999).

Algal Productivity and Associated Poor Water Quality

In hypereutrophic lakes with large amounts of nutrient input, algal production increases and algal biomass accumulates until something (e.g., light or nutrients) limits further growth. As biomass increases, the available soluble forms of nitrogen and phosphorus decrease, because the nutrients are progressively accumulated in the algal biomass and are therefore unavailable for further algal production. The nutrient needed for growing that is in the shortest supply, thus becomes the limiting nutrient. When light, nutrients, or other conditions for algae become unfavorable, the production of the algal bloom will cease or rapidly decline, resulting in an algal "crash."

The massive blooms of AFA and the subsequent rapid decline (crash) can cause extremes in water quality including elevated pH, low DO concentrations (hypoxia), and elevated levels of un-ionized ammonia, which can be toxic to fish (Kann and Smith 1993; Kann and Smith 1999; Perkins et al. 2000 Water Quality; Walker 2001; Welch and Burke 2001; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007). In the process of rapid growth, algal biomass can form extremely dense blooms, which can vary in magnitude depending on the availability of growth-promoting conditions (Kann and Smith 1993; Kann and Smith 1999; Perkins et al. 2000 Water Quality). During the same bloom conditions and following a bloom crash, particularly when coupled with high rates of nighttime respiration, DO can drop to levels that restrict fish growth and that can be lethal (Kann and Smith 1993; Kann and Smith 1999; Perkins et al. 2000 Water Quality). In addition, when dense algae blooms die off, the microbiological decomposition of the algae and organic matter in the bed sediment can further deplete DO and produce increased concentrations of ammonia (Kann and Smith 1993; Risley and Laenen 1999; Kann and Smith 1999; Perkins et al. 2000 Water Quality; Walker 2001; Welch and Burke 2001; Wood et al. 2006; Kuwabara et al. 2007; Morace 2007). The potential for low DO concentration increases later in the growing season (July-September) when the algae blooms have crashed and considerable organic matter has accumulated in the sediments. During this same period, increased water temperature increases water column oxygen depletion rates as decomposition and respiration take place at a faster rate, and oxygen concentration in the water column tends to be lower because solubility of oxygen decreases as water temperature increases.

Nutrient Input →Algal Growth→Water Quality Changes→Fish Survival and Propagation

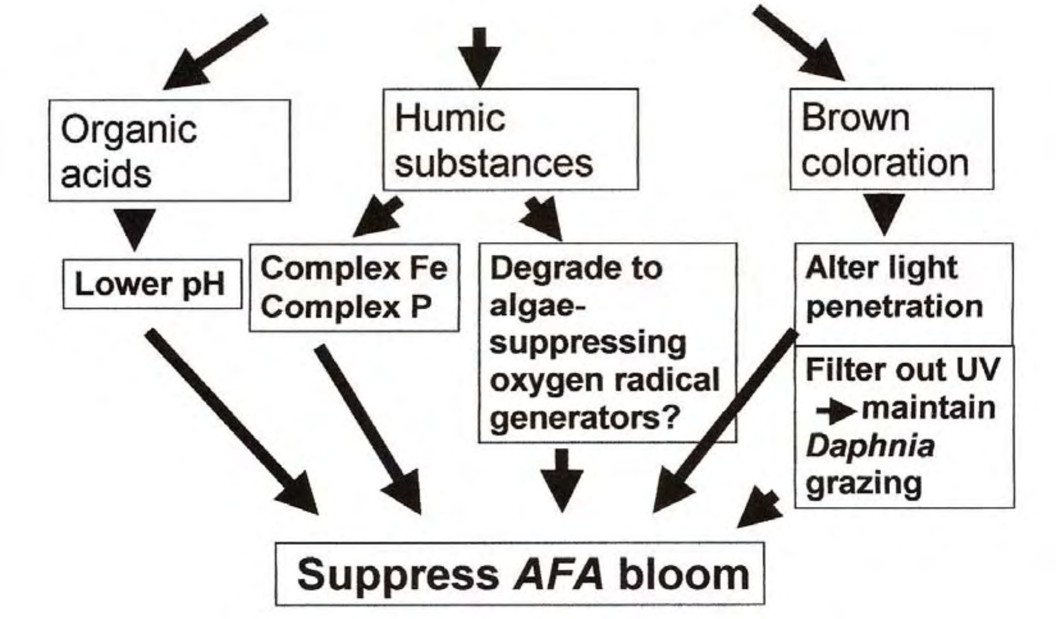
Wetlands may affect water quality through production and release of decomposition products, particularly dissolved humic[1] substances that appear to inhibit AFA growth (Geiger et al. 2005). Figure 2-12 shows how humic substances from wetlands may inhibit AFA growth (Geiger et al. 2005). The absence or reduction of this algae species just downstream, at or within marsh environments has been noted at Hanks Marsh (Forbes et al. 1998) and Upper Klamath National Wildlife Refuge (Sartoris and Sisneros 1993, cited by Campbell 1993a). Perdue et al. (1981) noted the absence of AFA in UKL at a location

---

[1] From humus, which are dark organic material in soils, produced by the decomposition of vegetable or animal matter and essential to the fertility of the earth.

heavily influenced by the Williamson River, which transports water originating from the Klamath Marsh. Both wetlands in the lake and reclaimed wetlands behind the dikes as well as winter flooded farm fields are potentially large reservoirs of what may be a valuable blue-green algae suppressant (Geiger 2001). The loss of in-lake wetlands, diffusing these humic compounds differently and at different times depending on hydrologic setting, have likely resulted in lower lake concentrations of dissolved humic substances (Geiger et al. 2005).

Figure 2-12. Factors with potential for suppressing growth of AFA.



Source: Geiger et al. 2005

Forbes et al. (1998) investigated the physical, chemical, and biological characteristics of Hanks Marsh. This study provides detailed information of water quality in littoral wetlands in UKL and allows for comparison with water quality conditions in pelagic areas. Results of this study are for the most part consistent with what is known about physical and chemical conditions in littoral wetland areas. Forbes et al. (1998) found that several parameters within the marsh were distinctly different from open waters, forming a horizontal gradient as distance from the pelagic zone increased. These differences are related to the dominance by emergent vegetation and resulting sheltered conditions that lead to hydrologic isolation. Conductivity, dissolved solids, pH, phosphate, and nitrate ions, and total phosphorus formed a horizontal gradient of increasing concentrations. Planktonic algae blooms that are so prevalent in open water areas were not observed in the marsh (Forbes et al. 1998).

Although the exact mechanisms are not well understood, the relationship between humate content and inhibition of many planktonic algae species has been established on both a local and national level (Phinney et al. 1959; Perdue et al.

1981; Forbes et al. 1998; Geiger et al. 2005). Most parameters exhibited substantial seasonal variations. On a study-wide basis, however, phosphorus, inorganic nitrogen, and chlorophyll-a concentrations were similar to lake water. The results of this study do not address the flux of material between the pelagic and littoral zones. Some of the data suggest, however, that pelagic conditions influence the outer areas of Hanks Marsh. Conversely, processes within the marsh may form water quality gradients that extend into the pelagic zone.

It's likely that the physical and chemical characteristics of large lakeshore marshes around UKL historically played an important role in nutrient cycling, regulating the algal community and other characteristics of the system. Littoral wetlands in UKL have been drastically reduced in size due to agricultural reclamation. However, approximately 17,000 acres of drained wetlands are in the process of being restored to littoral wetlands, which may improve the lake's ability to regulate the algal community.

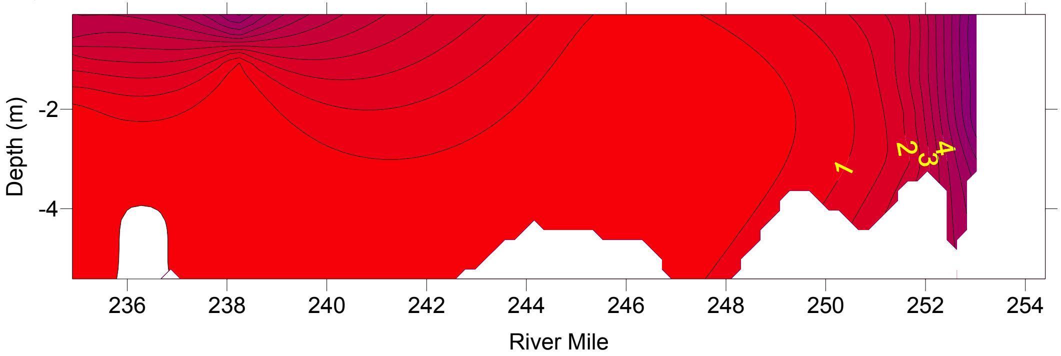
Water Quality in the Klamath River from Lake Ewauna to Keno Dam

The Lake Ewauna to Keno reach of the Klamath River (Link River to Keno Dam) is approximately 29 km (18 miles) long and 90 to 790 m (300 to 2,600 feet) wide; maximum depths range from 2.7 to 6 m (9 to 20 feet). Summer water quality is extremely poor, with heavy AFA growth, low DO concentrations, and high pH and water temperature (CH2M Hill 1995; NRC 2004; Deas and Vaughn 2006; Reclamation, unpublished data).

The Klamath River, from source to mouth, is listed as water quality impaired (by both Oregon and California) under Section 303(d) of the Federal Clean Water Act (CWA). In 1992, the California State Water Resources Control Board proposed that the Klamath River be listed under the CWA as impaired for both temperature and nutrients, requiring the development of TMDL limits and implementation plans. U.S. Environmental Protection Agency (EPA) and the North Coast Regional Water Quality Control Board accepted this action in 1993. The basis for listing the Klamath River as impaired was aquatic habitat degradation due to excessively warm summer water temperatures and algae blooms associated with high nutrient loads, water impoundments, and agricultural water diversions. However, the Klamath River has probably historically always been a relatively warm river (Hecht and Kamman 1996).

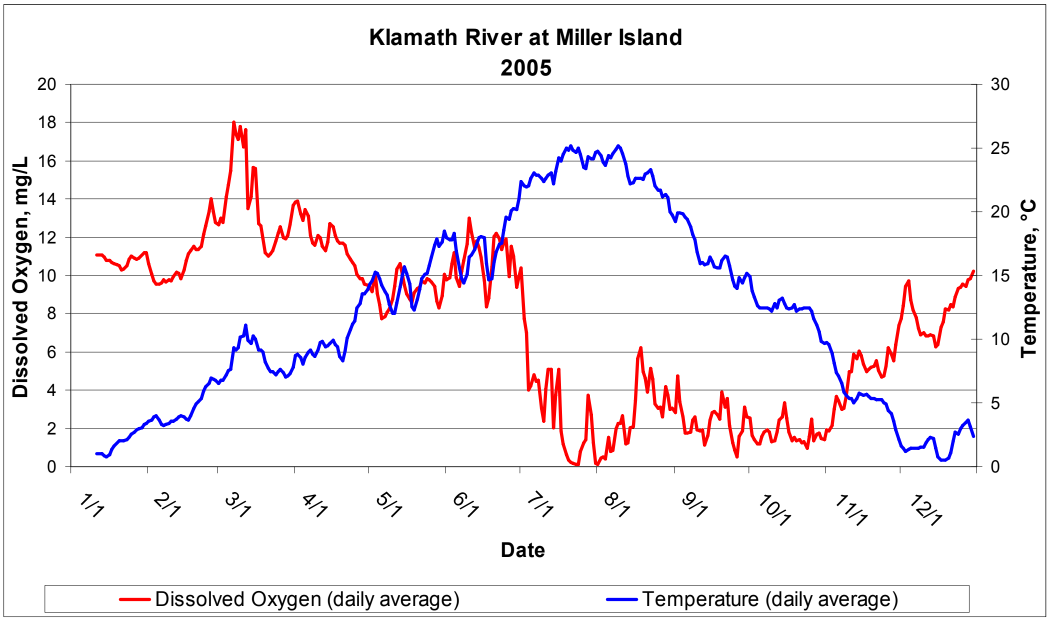
The Lake Ewauna to Keno reach of the Klamath River experiences seasonal poor water quality during summer months with water temperature exceeding 25ºC, pH approaching 10 units, dense agal blooms dominated by AFA, and DO concentrations below 4 mg/L (hypoxia). Like UKL, dense blooms of AFA affect the water quality within the Lake Ewauna to Keno reach of the Klamath River. However, the AFA blooms are typically less intense and are spatially and temporally move variable than those observed in UKL (Reclamation, unpublished data). Persistent hypoxic events establish in this reach of the Klamath River and can last for several days or even weeks where the DO will remain less than 4 mg/L and are associated with high levels of unionized ammonia (Deas and Vaughn 2006; Reclamation, unpublished data). These hypoxic conditions can establish throughout much of the 18-mile river reach and persist for several weeks at some locations (Deas and Vaughn 2006; Reclamation, unpublished data). Figure 2-13 shows DO concentrations for the Lake Ewauna to Keno reach of the Klamath River on July 26, 2005. Dissolved oxygen was less than 4 mg/L throughout the water column for much of the 18-mile reach on July 26, 2005 (Deas and Vaughn 2006; Reclamation, unpublished data).

Figure 2-13. Plot of DO in the Klamath River from Lake Ewauna to Keno Dam on July 26, 2005



Source: Deas and Vaughn. 2006

Figure 2-14. Graph of DO and temperature in the Klamath River near Miller Island boat ramp, river mile 246.



Source: Reclamation, unpublished data)

The most persistent hypoxic conditions are typically observed at river mile 246, near the Miller Island State Wildlife Area, where DO will drop in early July and remain less than 6 mg/L until November (Reclamation, unpublished data). Figure 2-14 shows the annual variation of temperature and DO at river mile 246 (Reclamation, unpublished data).

The severe and persistent hypoxia observed in the Lake Ewauna to Keno reach of the Klamath River is likely due to poor quality water entering from UKL containing large amounts of organic matter with an associated high BOD (Doyle and Lynch 2005; Deas and Vaughn 2006). In addition to the high BOD rates of source water from UKL, the bed sediments have high SOD rates which further exacerbate the hypoxic conditions. Doyle and Lynch (2005) found that SOD rates in the Lake Ewauna to Keno reach of the Klamath River ranged from 0.3 to 2.9 grams of oxygen per square meter per day (O2/m2/day) with a median value of 1.8 O2/m2/day. “Taken together, the SOD and [BOD] can more than account for the severe hypoxia that develops in the reach of the Klamath River from July into October of most years” (Doyle and Lynch 2005).

Particulate organic matter that originates or is a result of nutrients released from UKL is overwhelmingly the largest source of nutrients relative to other nutrient sources, including agricultural, municipal, and industrial inputs in the Klamath Falls area (Reclamation, unpublished data). Although the water returned to the Klamath River from the Klamath Project and the Tule and Lower Klamath Lake National Wildlife Refuges typically has higher nutrient concentrations than UKL or the Klamath River, the net nutrient load of the diverted water is reduced as it flows through the Klamath Project and the National Wildlife Refuges. Table 2-6 summarizes nutrient concentrations observed at the UKL and Klamath Straits Drain outlets.

Table 2-6. Summary of 2002 UKL and Klamath Straits Drain Nutrient Concentrations.

Location	Ammonia	TKN	NO_2+NO_3	Total P	Ortho P
	mg/L	mg/L	mg/L	mg/L	mg/L
Median Observed Concentrations					
UKL at Link Dam	0.13	2.45	0.07	0.20	0.08
KSD at Hwy 97	0.31	2.60	0.15	0.43	0.38
Minimum Observed Concentrations					
UKL at Link Dam	0.06	0.40	0.03	0.11	0.03
KSD at Hwy 97	0.07	1.90	0.06	0.22	0.03
Maximum Observed Concentrations					
UKL at Link Dam	0.97	3.50	0.25	0.42	0.46
KSD at Hwy 97	0.80	3.60	1.40	0.85	0.68
All nutrient loads, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite (NO_2+NO_3) loads are for the period of mid-April through mid-August.					

Source: Reclamation, unpublished data

Nutrient loads diverted into the Klamath Project and discharged to the Klamath River, from UKL and the Klamath Straits Drain, were estimated for the period of April to October 2002, except for nitrate plus nitrite, which is estimated for the period of April to August 2002. The nutrient loading estimates show that the Klamath Project and the Tule and Lower Klamath Lake National Wildlife Refuges are a net sink for nutrients and provide substantial nutrient reduction of diverted waters. The nutrient load reduction is estimated at 83 percent, 69 percent, 85 percent, 62 percent, and 73 percent for ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively.

The 2002 estimates show that approximately 133.2, 32.1, 978.9, 57.6, and 105.9 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively, were diverted into the Klamath Project and 22.3, 10.0, 147.3, 21.8, and 28.2 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively, were returned to the Klamath River. This equates to a net nutrient load reduction of 110.9, 22.1, 831.6, 35.8, and 77.7 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively (Reclamation, 2007, unpublished data). Only a fraction of the nutrient load diverted into the Klamath Project is returned to the Klamath River though the Klamath Straits Drain. If not diverted, the nutrient load to the Klamath River would be nearly twice the current level. Table 2-7 summarizes 2002 nutrient loading to the Upper Klamath River and the Klamath Project (Reclamation, unpublished data).

Water quality conditions and the mechanisms affecting water quality in the Lake Ewauna to Keno Dam reach of the Klamath River, including watershed alterations, temperature, nutrient loading, and algal productivity, are similar to those observed in UKL. See the watershed alterations, water temperature, nutrient loading, and algal productivity discussions in the UKL watershed section for more detail.

Table 2-7. Upper Klamath Basin Nutrient Loading 2002.

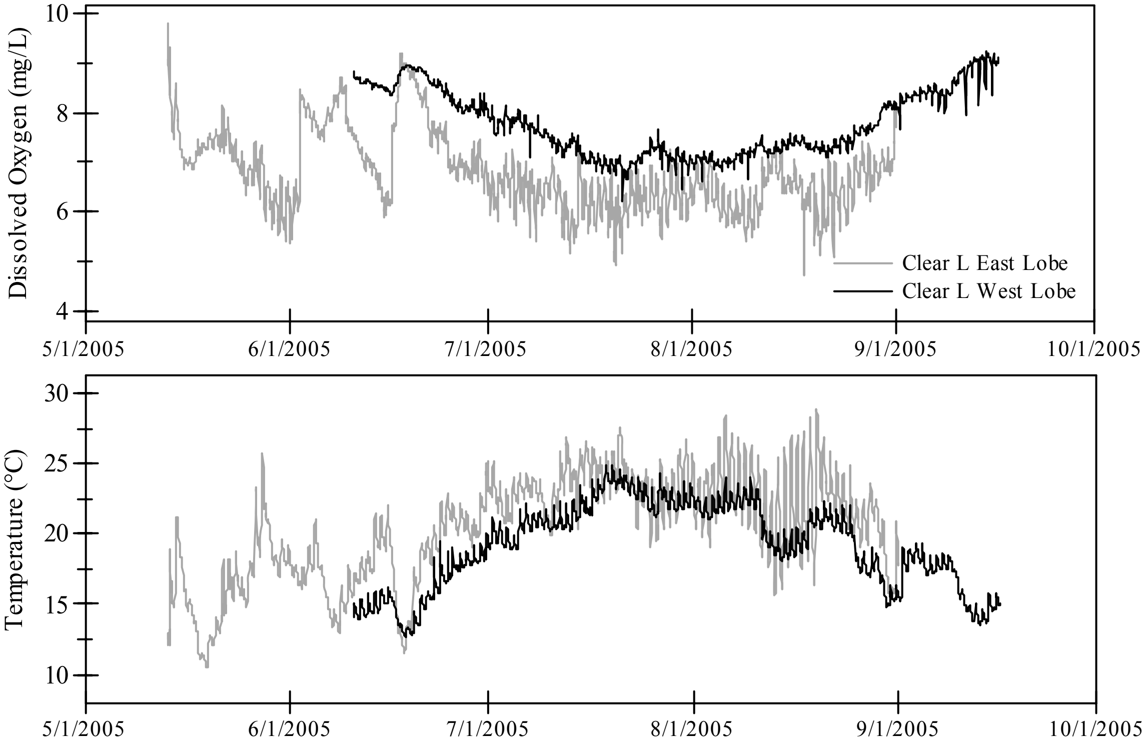
Location	Ammonia	NO_2+NO_3	TKN	Ortho P	Total P
	Metric Tons	Metric Tons	Metric Tons	Metric Tons	Metric Tons
Nutrient Load from UKL (UKL) to the Klamath River					
UKL at Link Dam	107.0	26.3	778.4	41.4	81.6
Nutrient Load diverted to the Klamath Project from UKL and the Klamath River					
A-Canal	87.7	24.3	678.6	39.6	70.6
LRDC	16.3	4.7	131.0	5.8	14.2
North Canal	11.9	0.8	55.7	4.2	6.9
Ady Canal	17.4	2.2	113.7	8.0	14.2
Total Load to KP	133.2	32.1	978.9	57.6	105.9
Nutrient Load Returned to the Klamath River from the Klamath Project					
KSD at Hwy 97	22.3	10.0	147.3	21.8	28.2
Nutrient Load Reduction Within the Klamath Project					
Net Reduction	-110.9	-22.1	-831.6	-35.8	-77.7
All nutrient loads, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite (NO_2+NO_3) loads are for the period of mid-April through mid-August.					

Source: Reclamation, unpublished data

Lost River Watershed

Clear Lake: Much of the Lost River watershed upstream of Clear Lake is publicly owned under the jurisdiction of the U.S. Forest Service (Modoc National Forest) and the USFWS (Clear Lake National Wildlife Refuge). The condition of the watershed is relatively good because of the management focus of the two agencies on water quality and habitat protection. Several riparian restoration projects have been implemented upstream of Clear Lake, improving stream habitat and water quality. Extremely poor water quality isn't observed within Clear Lake and its tributaries, therefore this portion of watershed is not currently listed as water quality impaired. However, low DO conditions have been observed during late summer in the East Lobe of Clear Lake near the outlet when lake levels are low and water depth is shallow (Reclamation, unpublished data). These low DO conditions near the outlet occur infrequently and persist for short durations. Figure 2-15 shows daily average DO and temperature for Clear Lake East and West Lobes during 2005 when lake levels were low.

Figure 2-15. Graph of daily average DO and temperature in the West and East Lobes of Clear Lake.

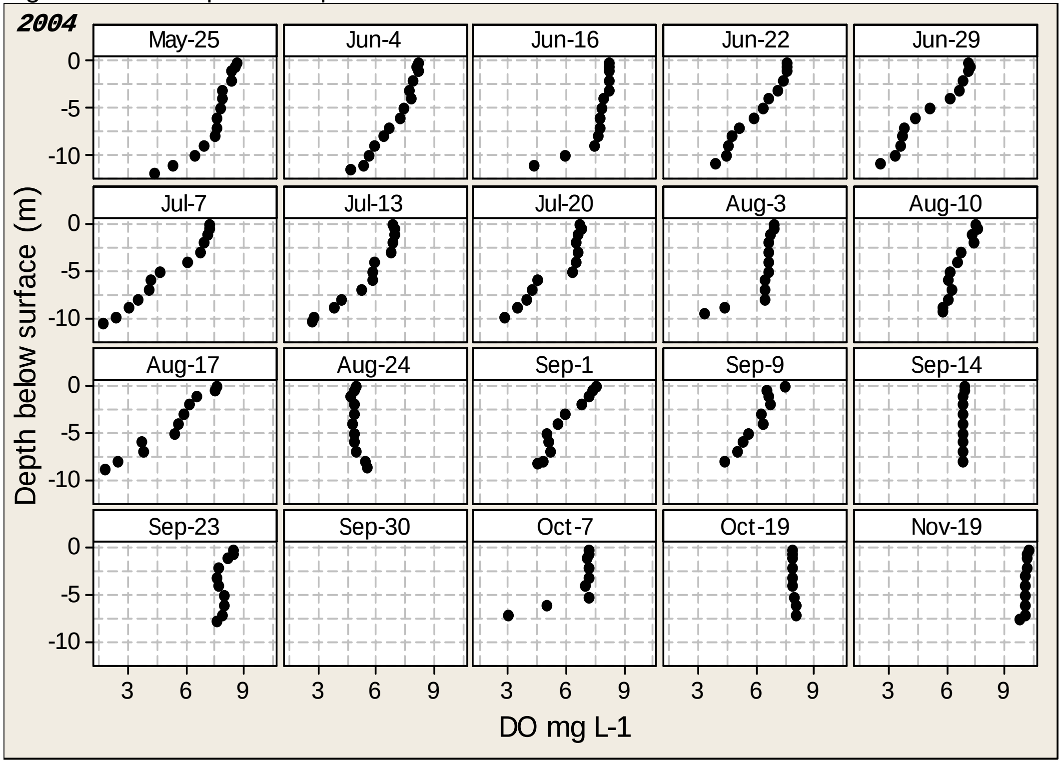


Source: Reclamation, unpublished data

Gerber Reservoir: In the Gerber Reservoir watershed, about 3/4 of the land is publicly owned under the jurisdiction of the U.S. Forest Service (Fremont National Forest) and the Bureau of Land Management (BLM) (Klamath Resource Area). Severe water quality impairment has not been observed within Gerber Reservoir and its tributaries, but some undesirable water quality conditions do exist. The condition of the watershed upstream of Gerber Reservoir is relatively good because management focuses on the agencies to protect water quality and riparian areas, although Barnes Valley and Lapham creeks are listed for exceeding temperature criteria (ODEQ 1998). The impaired temperature regimes of these creeks are a symptom of degraded riparian and floodplain conditions generally resulting from overgrazing.

During summer and early fall, stratification of the water column develops periodically in a small portion of Gerber Reservoir where depth is greatest near the reservoir outlet at the dam. When the reservoir is stratified, DO concentrations of less than 4 mg/L can be observed at depths greater than 5 meters. This stratified condition, and associated hypoxia, typically persists for a short duration over a small portion of the reservoir (Reclamation, unpublished data). Figure 2-16 shows observed DO values in Gerber Reservoir.

Figure 2-16. Graph of DO profile data from Gerber Reservoir near the dam.



Source: Reclamation, unpublished data

Mainstem Lost River

Most of the land ownership in the Lost River sub-basin below Clear Lake is private. Agriculture and grazing are the primary land uses. The condition of the watershed is fairly good in the areas upstream of Malone Reservoir and generally poor downstream to Tule Lake (Reclamation, unpublished data). Poor water quality is observed in most of the Lost River downstream of Malone Dam and is listed on the ODEQ 303(d) list for water quality limited streams for the following criteria: chlorophyll-a, DO, temperature, and fecal coliform.

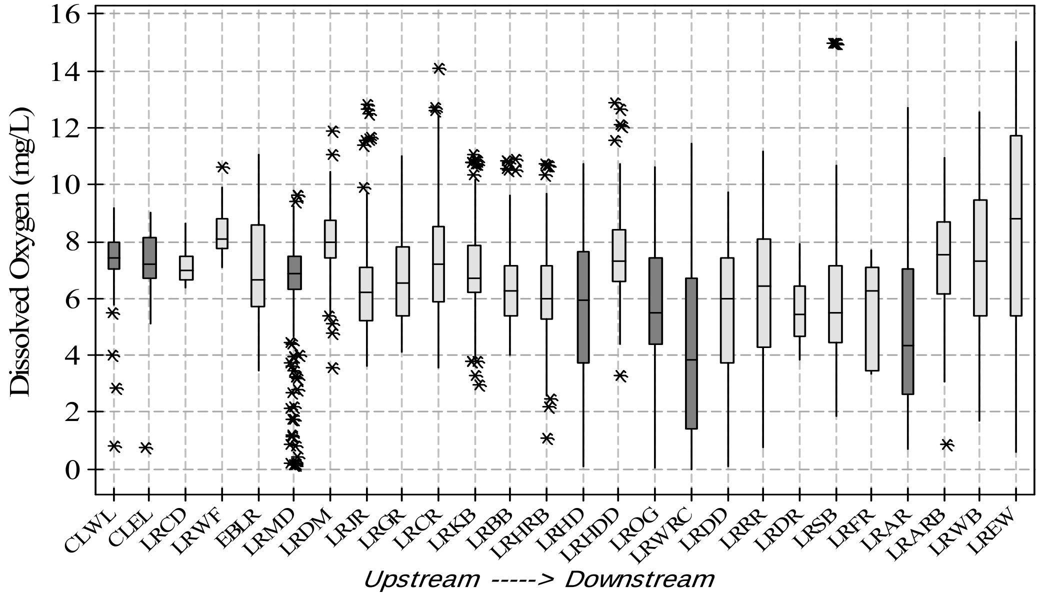
Water temperatures greater than 25° Celsuis (C), pH values approaching 10 units, excessive growth of aquatic vegetation and phytoplankton (AFA), and DO concentrations of less than 4 mg/L are frequently observed throughout much of the mainstem Lost River downstream of Malone Dam during summer months (Reclamation, unpublished data). Persistent events of hypoxia can last for several days where the DO will remain less than 4 mg/L, which can be stressful or leathal to aquatic organisims including the endangered suckers.

Most of the flow in the Lost River downstream of Harpold Dam originates from UKL and the severely degraded water quality conditions observed in the Lost River are in large part due to poor quality water entering the Lost River from UKL containing large amounts of organic matter with an associated high BOD. Also, as with UKL and the Klamath River, the bed sediments likely have high SOD rates, which consumes oxygen and further exacerbates the severe hypoxia.

These extreme hypoxic events are more prevalent in the mainstem Lost River impoundments, particularly in Wilson Reservoir, where the aquatic vegetation and AFA are most abundant (Reclamation, unpublished data). Figure 2-17 is a graph showing DO concentrations longitudinally upstream to downstream throughout the Lost River (Reclamation, unpublished data). Table 2-8 lists the locations and site identification information for the data displayed in Figure 2-17. In general, observed DO concentrations decrease as you move downstream through the Lost River watershed and tend to be lowest in the mainstem Lost River impoundments.

As with the Klamath River, water quality conditions in the Lost River, and the mechanisms affecting water quality, are similar to those observed in the UKL watershed. See the watershed alterations, water temperature, nutrient loading, and algal productivity discussions in the UKL watershed section for more detail.

Figure 2-17. Graph of DO data from Lost River water quality monitoring locations, 1993-2005. Dissolved oxygen data is represented as a box (median, 25th and 75th percentiles) and whisker plot with outliers represented with an asterisk.



Source: Reclamation, unpublished data

Table 2-8. List of Lost River monitoring locations. Locations are listed upstream to downstream.

Site ID	Site Description
CLWL	Clear Lake West Lobe
CLEL	Clear Lake East Lobe
LRCD	Lost River downstream of Clear Lake Dam
LRWF	Lost River at Walter Flat Bridge
EBLR	East Branch of the Lost River
LRMD	Lost River upstream of Malone Dam (Malone Reservoir)
LRDM	Lost River downstream of Malone Dam at Langell Valley Road
LRJR	Lost River at Johnson Road Bridge
LRGR	Lost River at Gift Road Bridge
LRCR	Lost River at Cheese Factory Road Bridge
LRKB	Lost River at Keller Bridge
LRBB	Lost River at Big Springs Bridge - Bridge on E. Langell Valley Road
LRHRB	Lost River at Harpold Road Bridge
LRHD	Lost River Upstream of Harpold Dam (Harpold Reservoir)
LRHDD	Lost River Downstream of Harpold Dam
LROG	Lost River at Olene Gap Bridge (upstream end of Wilson Reservoir)
LRWRC	Lost River at Wilson Reservoir at Crystal Springs Road Bridge
LRDD	Lost River downstream of Lost River Diversion Dam
LRRR	Lost River at Reeder Road Bridge
LRDR	Lost River at Dehlinger Road Bridge
LRSB	Lost River at Stukel Bridge
LRFR	Lost River at Favey Road Bridge
LRAR	Lost River at Anderson-Rose Reservoir
LRARB	Lost River at Anderson-Rose Bridge downstream of Anderson-Rose Reservoir
LRWB	Lost River at Wooden Bridge
LREW	Lost River at East West Road Bridge

Tule Lake

Much like UKL, Tule Lake is a hypereutrophic water body that experiences poor water quality during summer months, characterized by high water temperature and pH, low DO, elevated unionized ammonia and nutrient concentration, and intense growth phytoplankton. One difference between Tule Lake and UKL is the fact that filamentous green algae dominate the phytoplankton community within Tule Lake rather than AFA. Because Tule Lake is shallow and nutrients are abundant, aquatic vegetation and phytoplankton are very productive, which causes a large variation in the levels of DO and pH.

Tule Lake experiences extremely poor water quality on a seasonal basis during summer months with water temperature exceeding 25ºC, pH exceeding 10 units, and DO concentrations below 4 mg/L. Water quality conditions in Tule Lake, and the mechanisms affecting water quality, are similar to those observed in the UKL watershed. See the watershed alterations, water temperature, nutrient loading, and agal productivity discussions in the UKL watershed section for more detail.

C. Drastically Reduced Adult Populations

See discussion in Sucker Description, Life History, Habitat, Distribution, and Abundance: Sucker Distribution and Habitat section.

D. Overharvesting by Sport and Commercial Fishering

Historically, the Klamath Tribes on UKL, its tributaries, and the Lost River used Lost River and shortnose suckers for a subsistence fishery. From the 1960s until 1987, a popular sport snag fishery harvested spawning adult suckers mostly on the Sprague and Williamson rivers and shoreline spawning areas of UKL (Andreasen 1975, Bienz and Ziller 1987). Over this period, the annual harvest of fish on the Sprague and Williamson rivers declined 95 percent from about 12,500 to 680. In addition, several spawning groups at Barkley Springs, Harriman Springs, Odessa Springs, and other small springs along the eastern shoreline of UKL were extirpated (Perkins et al. 2000 Water Quality, Reclamation 2001).

On the Lost River, spring sucker runs were relied upon by not only Native Americans but also local settlers for both food consumption and livestock feed (Coots 1965, Howe 1968). A cannery was established and other commercial operations processed the suckers into oil, dried fish, and other products (USFWS 1993 Sucker).

Harvest of adult suckers was very detrimental to the UKL sucker populations, which were already negatively affected by loss of spawning and rearing habitat and poor water quality (Reclamation 2001). Several shoreline spawning groups likely were extirpated by removing reproducing adults from the population. The threat of overharvesting adult suckers has essentially been removed with the voluntary closure of the tribal fisheries by the Klamath Tribes in 1986 and the State closure of the sport fishery in 1987.

E. Summer Fish Die Off Events

Fish die-off events in the 1990s are reflected in the length frequency distributions of suckers in UKL. In addition to the die off events of the 1990s, a small number of dead and moribund adult suckers were recovered in 2003 (Foott 2004).

Water quality in UKL consistently reaches levels known to be stressful to suckers and periodically reaches lethal levels in August and September, resulting in die-offs (USFWS 2002). Fish die-offs have been recorded at UKL since the late 1800s but may have increased in frequency in the last few decades. Small, localized fish die-offs have been observed annually on UKL since 1992 when extensive research and monitoring activities began (USFWS 2002). In 1995, 1996 and 1997 a series of major fish die-offs in UKL reduced adult sucker populations of Lost River and shortnose suckers UKL by an estimated 80-90 percent (USFWS 2002). Adult sucker die-offs in the 1990s were likely caused by stressful and lethal water quality conditions. Perkins et al. (2000 Water Quality) reported that some adult suckers died several weeks after critically low DO concentrations were observed during the 1990s fish die offs. For further discussion on Upper Klamath Basin water quality see Environmental Baseline section titled Water Quality in the UKL watershed.

The delay between dying adult suckers and critically low water quality parameters implicates that fish health, such as infection by pathogens or parasites, is a factor during die off events. The extent of a 2003 fish die-off in UKL is unknown, however, only small numbers of dead adult suckers were recovered (Foott 2004). Dead and moribund suckers recovered during the 2003 fish die-off were infected with several pathogens and parasites (Foott 2004). Fish die-offs of the 1990s may have also been, in part, a result of parasite and pathogen infections in fish as adult suckers were observed dying in the weeks that followed critically low DO events (Perkins et al. 2000 Water Quality).

Disease and parasite prevalence were not identified as threats at the time of listing for either suckers species. However, information since 1988 indicates that pathogens and parasites affect sucker health and survival, especially during adverse water quality events (USFWS 2007 LRS, 2007 SNS). Fish susceptibility to parasite and pathogen infections in the Upper Klamath Basin may, in part, be increased by stressful water quality conditions.

Adverse water quality conditions in Clear Lake and Gerber Reservoirs is primarily determined by shallow reservoir depths, which reduce available habitat and cause declines in DO. Results of fish crowding into reduced habitat and reduced available DO can stress suckers and reduce individual fitness. Available habitat in Tule Lake is severely limited by shallow depths and further limited by seasonal declines in water quality. All three water bodies (UKL and both Clear

Lake and Gerber reservoirs) are subject to potential winter fish die-offs when poor water quality, especially low DO, is associated with prolonged ice-cover and shallow depths (USFWS 2002). The frequency and duration of ice-cover on each of these lakes has not been accurately recorded, nor have water quality conditions beneath the ice been monitored.

F. Lack of Significant Recruitment

As discussed in the Sucker description, Life History, Habitat, Distribution, and Abundance: Sucker Distribution and Habitat section, there has been limited recruitment of both sucker speices to the adult population in UKL (Janney and Shively 2007, Janney et al. 2007). However, recruitment of adults has been sporadic in Lost River sucker populations of UKL making it difficult to identify substantial population growth through consecutive years from the available data (Janney and Shively 2007, Janney et al. 2007). Shortnose suckers have not demonstrated measurable recruitment from 1997 through 2004, and show a net population decline over this period (Janney and Shively 2007, Janney et al. 2007). Lost River sucker populations in UKL declined substantially in a series of fish die-offs that occurred in the 1990s, but are currently stable at lower levels than prior to the series of fish die-offs (USFWS 2007 LRS).

Sucker populations in Clear Lake and Gerber reservoirs show evidence of frequent recruitment (USFWS 2007 SNS). Recruitment of suckers in these populations since the 1990s is evidenced by the relatively high frequency of smaller adults observed at these reservoirs in recent years (Leeseberg et al. 2007, Barry et al. 2007 UKL).

Sucker populations in Tule Lake are believed to number a few hundred adults of both species (USFWS 2007 LRS, 2007 SNS). Tule Lake suckers are isolated from upstream spawning areas and a lack of suitable spawning habitat in the lake likely prevents these populations from being self-sustaining (USFWS 2007 LRS, 2007 SNS).

G. Hybridization with the Other Two Sucker Species Native to the Upper Klamath Basin

Hybridization was identified at the time of listing as a threat to both sucker species. Research since listing suggests that hybridization amoung four Klamath Basin suckers (shortnose sucker, Lost River sucker, Klamath largescale sucker, and Klamath smallscale sucker [*Catostomus rimiculus*]) probably does occur (Dowling 2005, Markle et al. 2005, Tranah and May 2006). There is evidence that sucker populations in Clear Lake and Gerber reservoirs may have experienced extensive hybridization (ISRP 2005). However, scientists familiar with Klamath suckers do not consider hybridization among the Klamath suckers to be unusual (Dowling 2005, Tranah and May 2006, USFWS 2007-review). The evidence indicates that hybridization has been common throughout the evolutionary history of suckers, in general, and Klamath Basin suckers, in particular (Dowling 2005, ISRP 2005, USFWS 2007 LRS, 2007 SNS). Field identifications of Upper Klamath Basin suckers are difficult in some bodies of water (Barry et al. 2007 Lost). This may be, in part, related to high hybridization occurring at these locations.

H. Potential Competition with Introduced Exotic Fishes

In highly modified habitats like Lost River, Klamath River and Klamath River reservoirs, introduced fish appear to have a greater negative impact on endangered suckers (Desjardins and Markle 2000). Many of the non-native fish species are more tolerant of habitat degradation and occupy a wider range of habitats than the suckers. The degraded habitats have resulted in less shoreline vegetation that provided suckers protection from predation by introduced fish (NRC 2004). In UKL, there is evidence that annual abundances of two non-native fish species (i.e., Fathead minnows and yellow perch) are negatively correlated with sucker abundances (Markle and Dunsmoor 2007). However, relatively stable sucker populations co-exist with abundant non-native fish populations in Clear Lake and Gerber Reservoir indicating that more than interaction with exotic fishes alone is impacting sucker populations (Reclamation 2001).

Other non-natives established in UKL include pumpkinseed sunfish, largemouth bass, yellow perch, fathead minnows, bullhead (both black and brown), and crappie (both white and black). Competition for resources with native species including endangered suckers is likely but difficult to quantify in a large, nutrient-rich natural system, such as UKL. Scoppettone and Vinyard (1991) reported that 84.5 percent of the fish biomass in UKL is comprised of introduced species, and Logan and Markle (1993) reported that introduced fishes were 58 percent of the fish captured in trap nets and 92 percent of the beach seine fish fauna. Fathead minnows represented 59 percent of the fish in trap net samples in Agency Lake and 27 percent in UKL in 1992 (Simon and Markle 1997). The latter also reported that declines in fathead minnow abundance from 1991-1995 were associated with an increase in some native fish species. Since 1995, patterns have been more complex. In 1998, the year following the 1995-1997 fish die-offs, beach seine catch rates for age 0 native fishes declined (suckers, blue chub, tui chub) but rose for exotic age 0 yellow perch and were unchanged for fathead minnows (Simon and Markle 2001, Markle and Dunsmoor 2007). Since 2002 fathead minnow abundances have been relatively high and juvenile sucker abundances have been relatively low in comparison to the seven preceding years (Markle and Dunsmoor 2007). Predation by fathead minnow on sucker larvae is an interactive relationship with access to physical habitat for larval suckers (Markle and Dunsmoor 2007).

Non-native fishes are abundant in the Upper Klamath Basin by species and, possibly, by biomass (Table 2-9). The impact of non-native fishes on suckers remains difficult to generalize. Fathead minnows are the most abundant both numerically and by biomass (Simon et al. 2000). Markle and Dunsmoor (2007) were able to demonstrate predation by fathead minnow adults on larval suckers in a controlled environment. The authors surmised that the opposite trends of fathead minnow and juvenile sucker abundances in UKL through the last decade could, in part, be related to predation. In other Upper Klamath Basin waters, such as Gerber Reservoir, relatively health sucker populations co-occur with non-native fishes that may outnumber the suckers. Non-native fishes such as the brown bullhead, fathead minnow, Sacramento perch, pumpkinseed, green sunfish, bluegill, and largemouth bass have been accidentally or intentionally introduced into the Clear Lake, Gerber Reservoir, Klamath River, and Lost River watersheds (Buettner and Scoppettone 1991, Scoppettone et al. 1995, Reclamation 2000 Sucker Salvage, Desjardins and Markle 2000).

Table 2-9. List of Upper Klamath Basin nonnative fishes. Pond habitats include reservoir impoundments.

Species	Adult Habitat	Status[1]
Goldfish	Lake, river, pond	U
Golden shiner	Lake, river, pond	R
Fathead minnow	Lake, pond	A
Brown bullhead	Lake, pond, warm stream	A
Black bullhead	Lake, pond	U
Channel catfish	Lake, river	?
Kokanee	Lake	U
Rainbow trout	Lake, river, cool stream	C
Brown trout	River, cool stream	C,R
Brook trout	Cool stream	C
Sacramento perch	Lake, pond, river, warm stream	C
White crappie	Lake, river	U
Black crappie	Lake, pond	U
Green sunfish	Pond, warm stream	C
Bluegill	Pond, warm stream	U
Pumpkinseed	Lake, river, pond	C
Largemouth bass	Lake, river, pond	C
Yellow perch	Lake, river, pond	A

[1] Status column indicates Upper Klamath Basin status: A, abundant; C, common; R, rare; U, uncommon.

Source: Table information adapted from NRC (2004).

Concern about the potential impacts of the fathead minnow on sucker larvae prompted the Klamath Tribes to assess their predatory capabilities (Klamath Tribes 1995, Markle and Dunsmoor 2007). Predation by fathead minnows on larval suckers is related to physical habitat and depth (Klamath Tribes 1995, Markle and Dunsmoor 2007). The research shows that as water depth increases, the surface orientation of the sucker larvae and the bottom orientation of the fathead minnows result in enough separation to almost eliminate predation, even when the fathead minnows are hungry (Klamath Tribes 1995, Markle and Dunsmoor 2007). The presence of vegetation structure did not significantly influence survival rates in any of the trials with shortnose suckers and in two of seven trials with Lost River suckers (Klamath Tribes 1995). The interactive term of depth and structure combined was not significant in any of the trials (Klamath Tribes 1995). Although survival of sucker larvae in shallow water treatments without structure was not always deemed significantly lower than in treatments with structure, survival of larvae younger than 35 days in shallow water treatments without structure was always significantly lower than in deep water treatments regardless of the presence or absence of structure (Klamath Tribes 1995).

Although yellow perch predation on captive larval suckers has been observed (Kent Russell, USFWS Liaison, USFS, pers. comm.), there is no assurance that the effects of depth and vegetation structure will occur for other predators of larval suckers, such as largemouth bass, yellow perch, pumpkinseed fish, and chubs, as it does with fathead minnows. Non-native bass and pumpkinseed are rare in UKL nearshore regions, whereas native sculpins are abundant in UKL (Simon et al. 2000). Sculpins are benthic ambush predators, and so the depth effects on predatory interactions between sucker larvae and sculpins may be similar to those described between fathead minnows and larval suckers. However, decreased predatory efficiency in structurally complex habitats has been documented in the literature for these and closely related species (Savino and Stein 1982, Heck and Crowder 1991 as cited by Klamath Tribes 1996).

As sucker larvae grew, they became less vulnerable to predation by fathead minnows, and the pattern of decreasing vulnerability differed by species, depth, and structure (Klamath Tribes 1996). Size-related survival of sucker larvae in deep water treatments differed by species: shortnose suckers larger than 12.5 mm (~0.49 in) were seldom eaten, while Lost River suckers larger than 11 mm (~0.43 in) were seldom eaten (Klamath Tribes 1996). In contrast, median survival rates were near 50% for shortnose suckers 13.0-13.2 mm (~0.51 in) and 30% for Lost River suckers 13.0 mm (~0.51 in) long in the 0.3 m (~1 ft) depth without structure. Their study did not use shortnose larvae larger than 13.2 mm (~0.52 in), but showed that fatheads could still prey on Lost River larvae 17 mm (~0.67 in) long.

I. The Inadequacy of Existing Regulatory Mechanisms to Provide for the Conservation of these Species

Federal and State regulations in Oregon and California directly or indirectly affect sucker population in the Upper Klamath Basin (USFWS 2007 LRS, 2007 SNS). The ESA has provided the primary regulatory protection mechanism for both the shortnose and Lost River suckers since listings in 1988. Application of the existing ESA authorities, especially section 7, is probably maintaining existing sucker habitats, and leading to reductions in mortality and improvements in habitat (USFWS 2007 LRS, 2007 SNS).

Both shortnose and Lost River suckers were listed under the California Endangered Species Act (CESA) in 1974 (California Department of Fish and Game [CDFG] 2006 in USFWS 2007 LRS, SNS, review). Both species are also listed as a fully protected species under California Fish and Game Code section 5515(a)(3)(b)(4). Fully protected species in California may not be legally taken or possessed at any time, except for scientific research or recovery efforts.

Both shortnose and Lost River suckers are listed as endangered under the Oregon Endangered Species Act of 1987, as amended (USFWS 2007 LRS, 2007 SNS). This State action prohibits the take (to kill, take possession of, or control) of both suckers. However, this action only affects Oregon agencies on State-owned or leased lands and requires formal consultation between Oregon agencies and ODFW (USFWS 2007 LRS, 2007 SNS). ODFW has made it illegal for the recreational sport fishery take of suckers in Klamath County, Oregon, since 1987.

Some added species protection is provided indirectly through Federal and State water quality and quantity regulations (USFWS 2007 LRS, 2007 SNS).

Management Actions Taken in Effort to Improve Species Condition and/or Habitat

While the knowledge regarding sucker biology and ecology in Klamath Basin continues to increase, there are certain management actions and biological interactions that remain unclear or unquantified. The following section is meant as a discussion identifying other actions that may affect Upper Klamath Basin sucker populations; however, the actual impact of actions is yet unmeasured and present interpretation is hypothetical.

Wetlands Restoration

The effort to restore the Williamson River Delta is a cooperative wetland restoration project between TNC, Reclamation, and USFWS. The purpose of the project is to increase wetland habitat in the northern portion of UKL. Young fish access into wetland habitats along the shoreline of UKL may increase survivorship between larval and juvenile life history stages of endangered suckers in the lake. Increased survivorship at earlier life history stages may increase the number of individuals recruiting into the adult populations.

Levees surround the TNC property, known as Tulana Farm, keep lake and river water from flooding the agricultural lands inside the levees. The agricultural lands within the levees have subsided through the years as a result of farming and the nature of the soil type dominating the area. The Nature Conservancy has attempted to restore wetland vegetation prior to removing the levees and inundating the fields. At present, TNC estimates approximately 800 to 1000 acres of established wetland vegetation at elevations that will remain as emergent wetland following levee breaches (Elseroad 2004, M. Barry, Williamson River Preserve Director TNC, Williamson River Preserve, pers. comm.).

While it is certain that water depth in the new areas of emergent vegetation will fluctuate with lake elevation, it is relatively uncertain how much of the 800 to 1000 acres of vegetation will be available to larval sucker use at any one time. Recognizing that depth is a component of sucker habitat in and near emergent vegetation, previous work has indicated that larval suckers use emergent vegetation habitat, nearshore in shallow water (Dunsmoor et al. 2000, NRC 2004, Markle and Dunsmoor 2007). Assuming that only half of the presently established vegetation (800 to 1000 acres) is accessible to larval suckers following levee breaching and the average depth of water in this area is 1 ft at the time larval suckers arrive in the habitat during spring 2008, then emergent vegetation habitat is available in a volume of about 7,424,000 to 21,780,000 ft^3 (493,392 to 616,740 m^3). Although emergent habitat volume is influenced by lake elevation, the increase in emergent vegetation habitat that will be readily available to larval and juvenile suckers in northern UKL during spring 2008 is a substantial increase after levee breaching than prior to levee breaching (Dunsmoor et al. 2000).

Elseroad (2004) estimated the surface area to be colonized by particular vegetation communities based on surface elevations of the Williamson River Delta area and UKL water management of the 2002 BO (USFWS 2002). The estimates of unvegetated open water, deep water wetland, emergent wetland, riparian/wet prairie, and upland plant communities varied with lake elevation. However, the most stable vegetation community by surface area through the four water management scenarios of the 2002 BO was emergent vegetation (Elseroad 2004). The estimated nearly 2200 total acres of emergent vegetation yet to establish on the Williamson River Delta is a large increase from the existing estimates of emergent vegetation in this area (Dunsmoor et al. 2000). Should only a fraction of this habitat be used by larval and juvenile suckers, the habitat increase could result in increased survivorship and numbers of suckers at the two earliest life history stages. This becomes especially true if habitat has been a limiting factor for sucker survivorship in UKL.

Restoration efforts at the Williamson River Delta include reshaping the mouth of the river through several levee breaches and channel reformation. The levee breaches will divide the inflow from the Williamson River so that portions of the total inflow will reach UKL through multiple mouths rather than the total inflow arriving through the single, present-day mouth. Larval suckers carried to the lake environment via the Williamson River will likely arrive through the future multiple mouths. The distribution of larval suckers in UKL may be influenced by the reshaping of the river mouth, particularly if larval suckers are more easily transported to nearby wetlands where they may be retained longer (Markle et al. 2007 Juvenile).

Agency Lake Ranch and the Barnes properties totaling 9830 acres along the northern and northwestern shores of Agency Lake have been acquired by Reclamation and used as water storage areas. This action has undergone informal section 7 consultation and Congress has approved funding for this action. The properties will be managed in the future by USFWS as an addition to Upper Klamath National Wildlife Refuge. Levees along these properties will be breached in the foreseeable future (i.e., 2 to 3 years). During water storage on these properties over the last several years wetland plant communities have re-established (Jason Cameron, Physical Scientist, Reclamation, pers. comm.). Thus, when levee breaching occurs on these properties vegetation habitats should already be relatively established. At present, it is not understood how fish will use these future wetland habitats on the ALR and Barnes properties.

Although the impacts to fish of restoring wetland habitats along northern Upper Klamath and Agency lakes have not yet been studied, it is reasonable to assume that the restoration of wetlands in this area may benefit sucker populations in UKL. The extent of the benefits remains largely unknown until results of monitoring activities are compiled.

Chiloquin Dam Removal

The 2008 removal of Chiloquin Dam on the Sprague River will increase fish access to habitats in the upper Sprague River watershed where sucker spawning and rearing has been recently documented (Tyler et al. 2007, Ellsworth et al. 2007, Parrish 2007 draft). Although continued monitoring will determine the impact of dam removal on suckers in the watershed, the perceived benefits of dam removal are increasing fish access to the upper watershed through a redistribution of spawning adult suckers. A redistribution of spawning adult suckers from the lower river stretches to habitats upstream may increase sucker production in the Williamson and Sprague rivers if spawning habitat in the lower rivers was a limiting factor to survival of fertilized eggs. Furthermore, redistribution of spawning suckers will reduce risks associated with catastrophic events, such as flood scour, that can impact concentrated spawning.

The long-term benefit of dam removal may be increased sucker populations in UKL. An increase in the numbers of spawning suckers further upriver may increase production of suckers available to recruit into the adult population. There is some evidence that larval suckers are able to grow in the riverine environment (Parrish 2007 draft, Ellsworth et al. in review). Larvae produced further upstream in the watershed may benefit from the opportunity to grow during migration to the lake environment. Larger larvae and juvenile suckers may demonstrate improved survivorship when compared to smaller larvae upon entering the lake environments. Probable mechanisms that improve survivorship of larger larvae and juveniles in the lake include reduced competition (i.e., feeding on a wider range of prey) and reduced predation (i.e., outgrown gape-limited predators such as fathead minnows). Larger individuals may also demonstrate a longer retention time in the northern portion of Upper Klamath and Agency lakes than smaller individuals. Increased retention in northern UKL may reduce the risk of emigration from UKL (Markle et al. 2007 Juvenile).

Barkley Spring Restoration

Barkley Spring is a historic sucker spawning site along the eastern shore of UKL. Sucker spawning at this site has not been observed since the 1970s (Perkins et al. 2000 Biology). The local watershed council, USFWS, and Reclamation are working cooperatively to restore this spring as spawning and rearing habitat for native fishes and mollusks. Barkley Spring restoration efforts are focused on augmentation of spawning substrates, channel reconfiguration, and point of diversion change and screening.

Re-establishment of shoreline spawning sites for suckers was identified as a key strategy for species recovery by NRC (2004). Re-establishment of historic spawning sites may decrease the risk at a population level should other spawning sites fail to produce viable larvae. Re-established spawning sites have the potential to increase sucker populations. Increased native fish habitat, the return of spawning suckers, and a reduction of potential entrainment at this site will have positive benefits to sucker populations.

Fish Passage Improvement Facilities

Reclamation has made significant progress to meet entrainment reduction and fish passage responsibilities at federally owned facilities since the last BO on the Klamath Project was issued in 2002.

Klamath Fish Passage Technical Committee

Reclamation's KBAO formed the Klamath Fish Passage Technical Committee (KFPTC) in 2002 to help guide efforts to install Federal and State approved fish screens and/or fish ladders on the Klamath Project and in the Upper Klamath Basin. The KFPTC, composed of biologists, engineers, and water users, meets approximately bi-monthly in an open forum to discuss, review, plan, and design fish screen/passage issues and concepts. KFPTC members include the USFWS, ODFW, CDFG, KID, LVID, TID, Klamath Tribe, Klamath Watershed Council, and Klamath Water User Association. Depending on which facility in the Upper

Klamath Basin is being reviewed for screening or passage, Reclamation invites other interested and/or affected entities to participate in the KFPTC's planning, design, and technical discussion process.

A-Canal Fish Screen and Fish Bypass Facility

Reclamation completed construction of a state-of the-art fish screen at the entrance to the A-Canal in UKL in March 2003 to reduce the high rates of fish entrainment known to occur at this diversion site. The Lost River sucker and shortnose sucker were particularly vulnerable to entrainment at A-Canal before the screen was installed.

The A-Canal fish screen was designed to satisfy State of Oregon and Federal fish screen criteria, agreed upon in a June 29, 2000 meeting between Reclamation, ODFW, USFWS, and Klamath Irrigation District (KID). The A-Canal screen and bypass criteria are the same standards specified by NMFS to protect juvenile (> 30 mm) anadromous fish from being entrained into irrigation diversions

The screen is designed to protect most age 0 (greater than 30 mm) and subadult suckers which can pass through the trash rack openings. In addition, the screen is believed to provide an additional benefit to larval suckers (10-20 mm), which in theory are able to pass through mesh openings, due to the hydraulic conditions which create positive sweeping flows across the screen surface.

Reclamation conducts annual fish salvage activities in the forebay of the fish screen facility each year when water deliveries are normally shut off in mid to late October. KID closes the headgates downstream of the fish screen to terminate water deliveries at this time and then inserts bulkheads in the canal prism upstream of the screens to dewater the facility. The result is that fish located in the forebay between the bulkheads and screens are trapped in a standing pool of water which has no circulation or limited flow-through dynamics. Water quality can quickly degrade in this fore bay area, due to the poor circulation, large concentrations of fish present, and generally poor ambient water conditions which may exist in early October. When water quality deteriorates, fish which are trapped will likely expire before water levels in the fore bay have dropped sufficiently to allow KBAO staff to salvage suckers.

After KID installs the bulkheads, KBAO staff monitors DO levels in the fore bay as water levels are lowered to look for evidence of physical stress in the fish isolated in the forebay. When water depth in the forebay is lowered to approximately 18 inches, KBAO crews salvages all fish using backpack electro-fishers and beach seines and then returns all collected fish to UKL west of the bulkheads. This annual procedure alleviates potential mass mortality of non-target fish at the fish screen as water is removed.

Link River Dam Fish Ladder

Reclamation constructed a new vertical slot fish ladder at Link River Dam from July-December 2004 between the stilling basin and Keno Canal with the fish exit in the eastern-most canal gate bay. The new ladder is specifically designed to allow fish that are not strong jumpers (i.e., suckers) to easily swim through the slots and migrate above Link River Dam.

Chiloquin Dam Removal

Reclamation is working in partnership with the Bureau of Indian Affairs to complete the studies and planning process leading to the removal of Chiloquin Dam located at river mile (RM) 0.87 on the Sprague River, a short distance upstream from its confluence with the Williamson River. The dam was built by the United States Indian Service in 1914 as an irrigation diversion dam. Ownership of the dam was transferred to the Modoc Point Irrigation District (MPID) through the Klamath Termination Act of 1954.

The USFWS identified Chiloquin Dam as being a partial barrier for endangered suckers to reach upstream spawning habitat in the Sprague River and one of the anthropogenic factors leading to their endangered species listing in 1988. Congress subsequently recognized that there is inadequate fish passage at Chiloquin Dam and authorized legislation in 2002 to conduct studies to improve fish passage, including removing the dam. The Farm Security and Rural Investment Act of 2002 (7 USC §§ 7901 et seq., Section 10905) (P.L. 107-171) authorized the Secretary of the Interior, in collaboration with MPID (MPID), Klamath Tribes, ODFW, and other interested parties, to study providing adequate upstream and downstream passage for fish at Chiloquin Dam. Reclamation was assigned the task to complete the first phase of the Chiloquin Dam Fish Passage Appraisal Study in 2003 (Reclamation 2003).

U.S. Bureau of Indian Affairs (BIA) and Reclamation worked cooperatively in the second phase to complete the necessary NEPA process leading to a Federal decision to remove Chiloquin Dam. BIA has subsequently provided the funds to allow the dam removal Project to be implemented starting in 2007. Reclamation has supported BIA throughout the 5 year study process by providing Project coordination and engineering design assistance. Reclamation is presently assigned the role to provide construction management and contract administrative services needed to ensure the Project is successfully completed on-the-ground. Reclamation and BIA recently awarded a contract to allow the Chiloquin Dam removal to be implemented in 2 phases:

(1) Construct new MPID Pumping Plant and 2 small pump stations for a private landowner on the Williamson River from June – December 2007

(2) Construct new pump station for a private landowner and remove Chiloquin Dam on the Sprague River form June – December 2008.

Clear Lake Dam Fish Screen

Reclamation modified Clear Lake Dam in 2001 to correct known safety deficiencies under the Safety of Dams Program. As part of this action, Reclamation installed two permanent fish screens in the outlet works to prevent endangered suckers from Clear Lake from being entrained into the Lost River. The fish screens are wedge wire with ¼ inch mesh openings and were designed to meet USFWS criteria in place at that time.

Upper Klamath Lake Fish Screening

Reclamation recently proposed focusing its fish screen activities by working to install State and Federal approved fish screens on privately owned diversions in UKL. Reclamation and USFWS biologists believe this action is warranted because screening non-Federal diversions in UKL will provide the greatest potential benefits to endangered sucker populations where they are most abundant, populations are relatively robust, and the larger number of juvenile suckers in UKL is particularly vulnerable to entrainment if private diversions on UKL remain unscreened. Reclamation initiated a process for the UKL Fish Screen Program by issuing a grant to ODFW (ODFW) and leveraging Federal and State funds to provide 90 percent of the cost of constructing fish screens for willing landowners.

Lost River System

Clear Lake Dam, Malone Dam, Gerber Dam, Wilson Dam, Anderson Rose Dam, Station 48, and Lost River Diversion Channel are Klamath Project facilities located within the Lost River system. There are no fish ladders installed on these Reclamation Project facilities in the Lost River system at the current time. Clear Lake Dam is the only Project facility equipped with a fish screen.

In the Gerber Reservoir watershed, fish passage is further restricted at Dry Prairie Dam on Ben Hall Creek (tributary to Gerber Reservoir). This earthen dam, located on private and U.S. Forest Service lands, blocks access to about 5 miles of potential shortnose sucker spawning and rearing habitat (Reclamation 2001).

Above Clear Lake on Willow, Boles, and Fletcher Creeks there are at least 43 small earthen dams on U.S. Forest Service lands and private lands that potentially restrict access to upstream sucker habitat. The dams most likely to restrict sucker passage include Boles Meadow, Fletcher Creek, Avanzino, Weed Valley, and Four Mile Valley. They restrict access to a total of about 20 miles of stream habitat (Reclamation 2001).

There are other private or irrigation district owned flash-board diversion dams on the Lost River lacking fish passage facilities including Bonanza (Island Park), Harpold Dam, and Lost River Ranch Dam, which restrict upstream passage to 20, 4, and 5 miles of stream/reservoir habitat, respectively, during the spring and summer. These dams are removed from October until April, allowing access to these areas during the fall, winter, and early spring. ODFW recently installed a modified version of a vertical slot ladder at the Island Park (Bonanza) Diversion Dam in 2006; this fish ladder may provide suckers with an opportunity to move above this dam in the summer when water quality conditions in the lower Lost River deteriorate.

Reclamation has collected data showing that entrainment of suckers is occurring in the Lost River Diversion Channel and the Miller Hill Pumping Plant located within the Lost River Diversion Channel. For this reason, Reclamation is currently in the process of developing a design to install vertical traveling screens at the Miller Hill Pumping Plant and is planning to install this fish screen facility in 2008. Reclamation is currently in the informational section 7 consultation process for screen installation at Miller Hill Pumping Plant.

It is unclear whether entrainment reduction and/or fish passage at these remaining Project facilities continue to be biologically warranted to help recover suckers in the Lost River system, given the substantial costs to construct them. The USFWS's Sucker Recovery Plan is expected to address the relative biological importance of additional screening and/or passage improvements in the Lost River system, including the Tule Lake Sump.

Klamath River Mainstem Reservoirs

PacifiCorp owns and/or operates five dams on the Klamath River including Keno, J.C. Boyle, Copco 1, Copco 2, and Iron Gate. No fish passage facilities are present at Iron Gate or at Copco 1 and Copco 2 dams. Fish ladders are present at J.C. Boyle and Keno dams. Although suckers have been observed to use these ladders, they were not designed for sucker passage and generally are inadequate for sucker passage.

Additional Improvement Actions

Section 7(a)(1) of the Act directs agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered species. Regulations (50 CFR §402.02) implementing section 7 of the ESA define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat. The 2002 BO listed 3 RPAs, 3 Reasonable and Prudent Measures (RPM), and nine conservation measures (CM). Conservation measures may be implemented at the Action Agency's discretion, and are not binding. Tables 2-10 and 2-11 list these RPAs, RPMs, and CMs, along with the results.

Conservation Implementation Program (CIP) and ESA Recovery Implementation

Through the CIP, Reclamation has annually funded projects since 2004 throughout the Klamath River drainage system that included enhancement and restoration of habitat conditions, improved water quality conditions, removed fish passage barriers, reduced entrainment through the installation of fish screens, monitoring, research, and increased water conservation efficiencies.

Over $10 million has been expended on major items funded by the CIP and for ESA Recovery Implementation from 2004 to 2007 which include, but are not limited to:

- Funding of 5 Chadwick Meetings
- Funding of contract to hire an organizational specialist
- Funding of 50% of Water Master Salary for Shasta/Scott for two years
- Funding of continuation of the Salmon River gauge
- Funding of spring run Chinook genetic study
- Funding of radio telemetry, Chinook
- Funding of Shasta/Scott groundwater study completion
- Funding of Oregon Water Resources support
- Funding support for Hardy study due to natural flow study
- Funding of National Academy of Science Study of Hardy/natural flow
- Contributed to 5-year sucker review
- Funding of collection of electronic and/or existing restoration plans throughout the basin to aid in avoiding duplication and to ensure coordination with existing groups.
- Funding of conducting 6 Public meetings to receive public input on the draft CIP document
- Funding of Upper Klamath Basin Working Group Science Panel (involving sucker review, etc)
- Funding of purchase and installation of Weirs used to monitor sucker movement
- Funding of Radio Telemetry, Juvenile Coho
- Funding of Thermal Refugia Study in Klamath River
- Partial Funding of a Data Portal being developed by the Trinity Restoration Office with potential to be expanded for the entire Klamath River; IIMS Partnership
- Funding of training course on the data collection for the 2-D modeling for the Trinity River
- Funding of Natural Flow Study
- Funding of OSU Public Outreach meetings
- Funding of Temperature Control Device Investigation for PacifiCorp Reservoirs
- Funding of Karuk Tribes Fisheries Monitoring Efforts
- Funding of Indian Creek Gauge

- Funding of Yurok Tribes Fisheries Monitoring Efforts
- Funding of Escapement data upon sun setting of Task Force
- Funding of Green Sturgeon Monitoring
- Funding of Lamprey Monitoring
- Funding for InterTribal Fish and Water Commission
- Funding of TMDL Model Review for Lost River
- Funding for Collier Map Model

Additionally, in a May 18, 2007 new release, Reclamation's Klamath Basin Area Office (KBAO), in partnership with other Federal and State agencies (California and Oregon), participated in a basin-wide technical review process to evaluate and rank a total of 16 proposals submitted under the Fiscal Year 2007 solicitation. Reclamation was able to increase the available funding from the original solicitation total of $650,000 to a total of over $1.6 million and, therefore, was able to award grants to fund 13 proposals in FY 2007 The proposals were sought to (1) restore the Klamath River ecosystem; (2) help enhance populations of threatened coho salmon and endangered shortnose and Lost River suckers; and (3) further the fulfillment of the Federal government's tribal trust responsibilities as they relate to the natural resources in the Klamath River watershed. The projects funded in FY 2007 represent a variety of restoration, scientific research, and planning approaches, with project grants varying from $48K to $366K.

The projects funded in FY 2007 were: Shackleford Creek Diversion Improvement (Siskiyou County RCD); Bluff Creek Habitat Protection – Road Decommission (Karuk Tribe); Lower Klamath River – Upslope Erosion Control (Yurok Tribe Watershed Restoration Dept.); Keno Reservoir Treatment Wetlands Feasibility, Phase II (Rabe Consulting); Whites Gulch Migration Barrier Removal Project (Trinity County Planning Dept.); Plan, Coordinate, Manage Restoration Projects in the Shasta Valley (Shasta Valley RCD); Baseline Habitat and Habitat Usage: Salmonids of the Shasta River (Center for Watershed Sciences - University of California at Davis); Cotton Creek Fish Passage Improvement (Resource Management); Water Quality Sampling/Monitoring below IGD (Yurok Tribe Environmental Program); Hotelling Gulch Stream Modification Feasibility (Salmon River Restoration Council); Red Cap/Camp Creek Fisheries Monitoring (Mid-Klamath Watershed Council); Fluvial Geomorphology and Vegetation Monitoring – Sprague River (Klamath Tribes); Salmon River Temperature Dynamics (Salmon River Restoration Council).

In Fiscal Years 2007 and 2008, Reclamation budgeted $4.8 million for CIP and Endangered Species recovery activities to be expended within the CIP.

Table 2-10. Reclamation actions taken in response to USFWS 2002 BO recommendations and requirements.

Element	Recommendation/Requirement	Action	Completion Date
FWS RPA 1	Reduce effects of adverse water quality & habitat loss	Incorporated a 50% exceedence factor and NRCS's April 1 forecast to refine the water year type.	Occurs annually
FWS RPA 2	Reduce Entrainment of suckers at Link River Dam & associated Hydropower intake bays	PacifiCorp operated intakes during the daytime & minimized night flows from mid-July to mid-October annually. Since 2003, Reclamation has been working to evaluate different entrainment reduction methods and to improve fish passage at Link River Dam. Link Dam fish ladder was completed in 2004. Spill study will occur in 2008.	Bulkhead construction occurred in 2003; monitoring is ongoing
FWS RPA 3	Study factors affecting water quality; implement actions to reduce die-off frequency and increase access to Refuge habitat; assess ongoing sucker population monitoring, implement improvements, develop annual assessment report. Development and implementation of plans required under this RPA element shall be undertaken through a collaborative process; the following development and implementation dates are suggested.		
FWS RPA 3a	Develop a DO risk assessment model for UKL and incorporate results into project management.	Developed and received approval of plan. Field data collected during the summer of 2002. Reclamation completed the Risk assessment model and prepared a final report in Fall 2005	July 16, 2002 plan approved Model completed 2005
FWS RPA 3b	Assess and manage UKL sucker water quality refuge areas	Reclamation funded a number of research studies with USGS between 2002 and 2007	Reports submitted to USFWS in 2005, 2006, & 2007
FWS RPA 3c	Assess ongoing sucker population monitoring and implement needed improvements; develop Annual assessment report	Reclamation funded research studies with USGS & OSU to conduct on-going larval, juvenile and adult monitoring activities. Reclamation funded & assisted USFWS for monitoring suckers in Gerber & Clear Lake in 2004. Reclamation continued to fund USGS to complete the Gerber and Clear Lake studies since 2005. Reclamation hosts an annual workshop/meeting, in addition to other meetings, to discuss sucker population monitoring, data collection, study design, ad data analysis.	Begun in 2003, continues annually

Element	Recommendation/Requirement	Action	Completion Date
FWS RPA 3d	Sucker die-off monitoring and assessment	Reclamation completed a sucker die-off and assessment plan in June 2002. Reclamation continues to work with stakeholders since developing the plan to assure the plan is properly and effectively implemented if a fish kill should occur.	2002 and implemented annually as needed
FWS RPM 1	Minimize entrainment throughout the Project. Development and implementation of plans required under this RPM element shall be undertaken through a collaborative process; the following development and implementation dates are suggested.		
FWS RPM 1a	Assess and implement methods to reduce entrainment of larval suckers		
FWS RPM 1b	Assess and implement methods to reduce entrainment of juvenile, subadult, and adult suckers at project diversions	Completed construction of A-Canal Fish Screen. Testing showed the screen reduced entrainment of larval suckers by 46%. Installed and operate fish bypass pump at A Canal; several years of monitoring of all screened diversions to ensure proper operation and effectiveness. Installed fish screens at Clear Lake in 2002. Perform annual maintenance of screens and automated cleaning brushes to ensure proper operation; Conduct annual salvage activities throughout the Project each fall at end of irrigation season and submit reports to the Service; Chair of Klamath Fish Passage Technical Committee to ID screening needs; provided a grant to ODFW to install screens on private diversions on UKL; continual monitoring of ALR screens; purchased INTRALOX screens for ALR, but will now install at Miller Hill as ALR dikes to be breeched in 2008	April 2003 On-going, annually On-going, annually Implement Miller Hill screens in 2008
FWS RPM 1c	Implement methods to reduce entrainment of juvenile, sub-adult, and adult suckers at A-canal prior to completion of proposed fish screen	Completed A-Canal Fish Screen	April 2003

Element	Recommendation/Requirement	Action	Completion Date
FWS RPM 2	Monitor, implement, and report on water quality in project delivery area	Conducted water quality monitoring throughout the Project since 2002 in UKL, Lost River, and Lake Ewuanna in coordination with USFWS	On-going since 2002
FWS RPM 3	Minimize habitat alteration in project lakes and reservoirs as a result of project operations		
FWS RPM 3a	Provide adequate Link River habitat and assess sucker habitat needs in the Link River and downstream in Lake Ewauna and the Keno Reservoir	Provide releases of at least 250cfs June – Oct annually; Initiated Link River-Lake Ewuanna-keno habitat & water quality studies from 2003 to present. Continue to monitor and research sucker habitat use/distribution and water quality improvement w/ constructed wetlands	On-going annually since 2003
FWS RPM 3b	Provide adequate habitat below Clear Lake and Gerber Reservoir Dams	Monitor flows and water quality in the upper Lost River & Miller Creek; conducted fisheries assessment of Miller Creek; monitor fisheries and water quality data on Clear Lake and Gerber	On-going, annually since 2003
FWS RPM 3c	Assess habitat conditions and endangered sucker needs in the Lost River	Began collecting information in 2003.	Expected completion of report in 2008
FWS RPM 3d	Determine habitat needs for larval suckers and implement actions to provide additional habitat	Funding research projects with OSU, USGS, FWS, and others since 2003; Acquired and managed ALR and Barnes properties to improve wetland habitats; continue to work with TNC & FWS on Williamson River Delta restoration project	On-going, annually since 2003
FWS RPM 3e	Determine juvenile habitat distribution in UKL relative to bathymetry and lake elevations	Completed shoreline substrate and bathymetry study, submitted report to USFWS	2003
FWS RPM 3f	Analyze risk to sucker populations from multiple dry and critically dry years and develop management plan to reduce that risk	Research projects model correlations of population levels in responses to lake surface elevations	Final report due December 2007

Table 2-11. Reclamation actions taken in response to USFWS 2002 BO conservation measures.

Number	Measure	Status
1	Coordinate with BLM, USGS, ODFW, CDFG, Klamath Tribes, and the Service to establish a population of Lost River suckers in Gerber Reservoir with brood stock from Clear Lake	Reclamation has funded USGS to conduct monitoring surveys in Gerber and Clear Lake. Information from these studies could be used to identify brood stock for reintroduction purposes. The fish present in Gerber appear to be a hybrid of Klamath Largescale and shortnose suckers. Reclamation has implemented this recommendation to the limit of our authority
2	Serve as a clearing house for water quality data from the Upper Klamath Basin	Parties and stakeholders cannot agree upon parameters to measure, locations to collect data, or who should be the clearing house
3	Fish passage at Chiloquin Dam-secure funding to improve passage	Along with BIA, received funding for construction of new pumping plant and dam removal. Pumping plant construction currently underway, scheduled for completion in late 2007/early 2008, Chiloquin Dam scheduled for removal in 2008. Reclamation continues to monitor effects to suckers pre and post removal
4	Work with Tule Lake NWR, CDFG, & irrigation districts to protect suckers in Tule Lake sump	Reclamation coordinates with USFWS and TID to manage lake surface elevations of the sumps to protect suckers
5	Coordinate with EPA and States of CA and OR on the Lost River TMDLs	Reclamation provided data in support of this effort and is coordinating as appropriate
6	Implement a pilot project to enhance sucker spawning at known spawning sites along the eastern shoreline of UKL	Reclamation has funded USGS to monitor spawning activities at these sites
7	Develop an operations plan for ALR	ALR will become part of the Refuge system; therefore, it is more cost effective for the long term property owner to develop the operations plan.
8	Develop a plan to maximize the efficient delivery and use of water within the Project delivery area using local expertise from water users.	Reclamation conducted an efficiency study in 1998 of the Project and determined it is 93% efficient (Reclamation 1998 Water Use). Through the Water Conservation Program, Reclamation has provided 18 miles of pipe to Irrigation Districts to replace open canals between 2002 and 2007. An additional 2 miles is scheduled to be installed in 2008.

Number	Measure	Status
9	Assess the potential relationship between flood-induced, sediment loading inflows into UKL and catastrophic fish die-offs. Include a model to determine how operation of Project facilities could affect the storage of storm-mobilized organics and nutrients	Reclamation and USGS continue to study nutrient loading into UKL and fish die-off to further understand whether or not there is a correlation. Currently, insufficient data is available to develop a model at this time.

In addition to actions taken by Reclamation, the KWUA and Irrigation Districts have implemented conservation and restoration actions. Table 2-12 describes these actions, which Reclamation believes have contributed to reduced agricultural demand for water in the Upper Klamath Basin.

Table 2-12. Conservation and restoration actions taken by the KWUA and irrigation districts in the Upper Klamath Basin.

Topic	Goal	Action
KWUA Ecosystem Enhancement and Sucker Recovery Efforts	On-the-ground, effective and scientifically sound ecosystem enhancement projects in the basin.	Sprague River riparian improvements: 14 miles of riparian fencing and other improvements at a cost of $250,000. Assessments of grazing allotments in Modoc National Forest lead to change in use patterns and frequency.
Fish Passage Improvement Projects	Entrainment of listed suckers and lack of connectivity between sucker populations has identified effects of Klamath Project Operations. Project irrigators have played an active role in improving fish passage.	Screening the A Canal ($15M) Chiloquin Dam: participating in collaborative process ODFW Fish Passage Improvements: 13 projects for $250,000; 40 more planned at estimated cost of $1.3M (Jan 2003 estimate). Participation in technical committee to develop fish screen implementation plan for diversions throughout the Project Construction of the Link Dam Fish Ladder in 2003
Local efforts to improve water quality	Reduce agricultural nonpoint pollution loads and achieve load allocation under the TMDL.s	Landowner advisory councils working with OR Dept of Ag to address water quality management on the Lost and Klamath Rivers. UKL Pilot Oxygenation Study Strategic water treatment ponds located through the project based on objectives, location and cost criteria. Implementation of 'Walking Wetlands. Improved working relationships and management activities with Tule Lake National wildlife Refuge for wetlands, water quality, and listed sucker management Reduced numbers of cattle in Klamath County from 1997 to 2007 by 32.9% (NASS website 10-4-07). Acreage removed from agricultural production and converted to wetlands between 1996 and 2007 totals approximately 25,033.

Other Impacts

Fish Health

Disease and parasite prevalence were not identified as threats at the time of listing for either suckers species. However, information since 1988 indicates that pathogens affect sucker health and survival, especially during adverse water quality events (USFWS 2007 LRS, 2007 SNS). Fish susceptiblility to pathogens in the Upper Klamath Basin may, in part, be affected by stressful water quality conditions.

Although the quality of water in lakes throughout the upper basin can surpass critical thresholds that may lead to direct die off of adult suckers (Loftus 2001), poor water quality events periodically occur below these thresholds and, while not lethal, may stress suckers. Stress during poor water quality events may make suckers more susceptible to a host of naturally-occurring diseases, parasites, and other ailments in the waters of the upper basin.

Year-old juvenile suckers have been typically scarce in recent sampling efforts of UKL. Body conditions and general fish health has been indicated as a factor influencing survival and abundance of juvenile suckers between autumn and the following spring. Investigation of several health parameters of juvenile suckers captured in UKL and in the A-canal fish bypass indicated a general decline in growth occurred in September (Foott and Stone 2005). The poor growth in late summer-early autumn may be a result of reduced feeding (Foott and Stone 2005). Reduced feeding may be a response to many things including stress from seasonal poor water quality events.

Examination of age 0 juvenile suckers captured from the early 1990s through 2003 indicated an increasing prevalence of ectoparasites (i.e., Digenea and *Lernaea sp*.) through time (Simon and Markle 2004). It is not yet understood how, or if, these external parasites impact sucker populations but the increase in infection rates through the last decade indicate another potential stressor on suckers.

Furthermore, there is evidence that disease outbreak may have played a role in the adult sucker die off event of 2003 (Foott 2004). Septicemia (blood-borne bacteria) appeared increased following in the samples following April. The identified bacteria responsible for septicemia tend to be opportunistic pathogens often associated with stress or are part of multiple infections (Foott 2004). Blood and plasma samples from these fish captured in April, July, and August, typically were no different from each other. General health of ‘sick’ or moribund fish was poorer than that of other sample groups, and Columnaris was the primary pathogen associated with morbidity (Foott 2004). Disease outbreak and poor health conditions may be exacerbated from poor, but not lethal, water quality events.

Emigration from Upper Klamath Lake

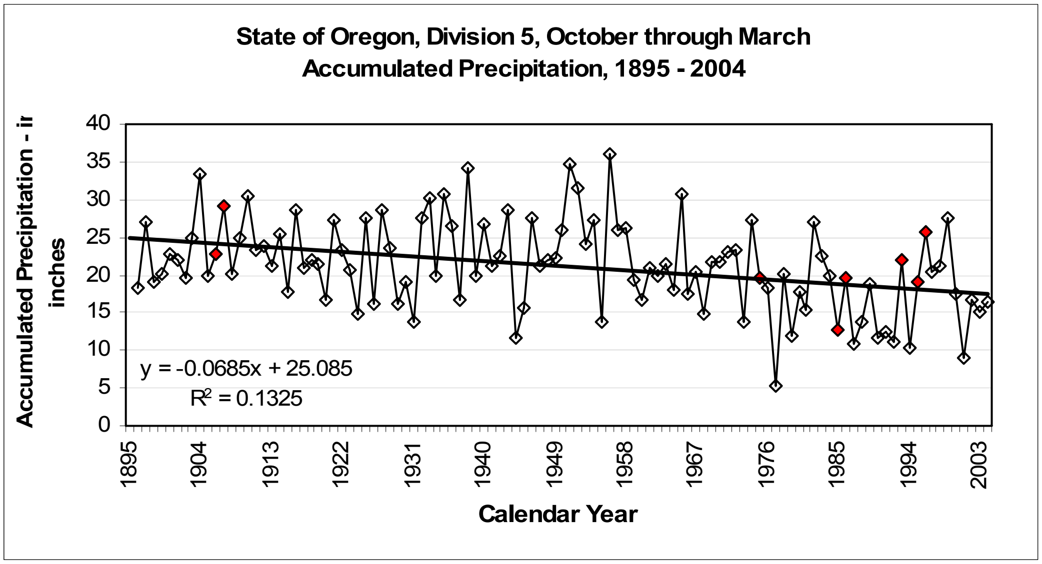
Retention of juvenile suckers in UKL likely aids recruitment of adult suckers into population. Although not fully quantified, there is evidence that larval and juvenile suckers leave UKL via the Link River in relatively large numbers from June through September (Gutermuth et al. 1999, 2000, Foster and Bennetts 2006, Tyler 2007, Markle et al. 2007 Juvenile). Two factors that appear to influence sucker emigration from UKL are entrance and retention of suckers by the internal gyre in the lake, which is influenced by wind events, and the coarseness of the shoreline (i.e., wetland vegetation; Markle et al. 2007 Juvenile). Water quality conditions in the Keno reach of the Klamath River, from Lake Ewauna to Keno, more frequently reach thresholds lethal to suckers for longer periods than UKL (see water quality discussion). Thus, the unknown numbers of young suckers that leave UKL via the Link River must find suitable habitat in a hostile environment until they reach a size capable of using the Link River fish ladder, presumably several years, to return to UKL. The fate of emigrant suckers is not fully understood but it has been hypothesized that UKL is a better environment for suckers due to its food rich environment, the loss of connectivity between habitats below the Link River, and frequent poor water quality events in the Link to Keno reach of the Klamath River (Reithel 2006). The overall impact to the total sucker population resulting from emigration from UKL is not yet fully understood; however, retention of more juvenile suckers in UKL increases the likelihood of adult recruitment in this popualtion.

Future Climate Conditions

Climate variability may play a large role in driving fluctuations water abundance in the Upper Klamath Basin. Such indices as the El Nino-Southern Oscillation and Pacific Decadal Oscillation (PDO) can influence weather patterns on a regional scale. The indices are useful in providing a likelihood forecast for general weather patterns in the Pacific Northwest. As a generality, in the Klamath Basin, warm years tend to be relatively dry with low summer stream flow and light snow pack. Conversely, cool years tend to be relatively wet with high summer stream flow and heavy snow pack. (SCS 2004).

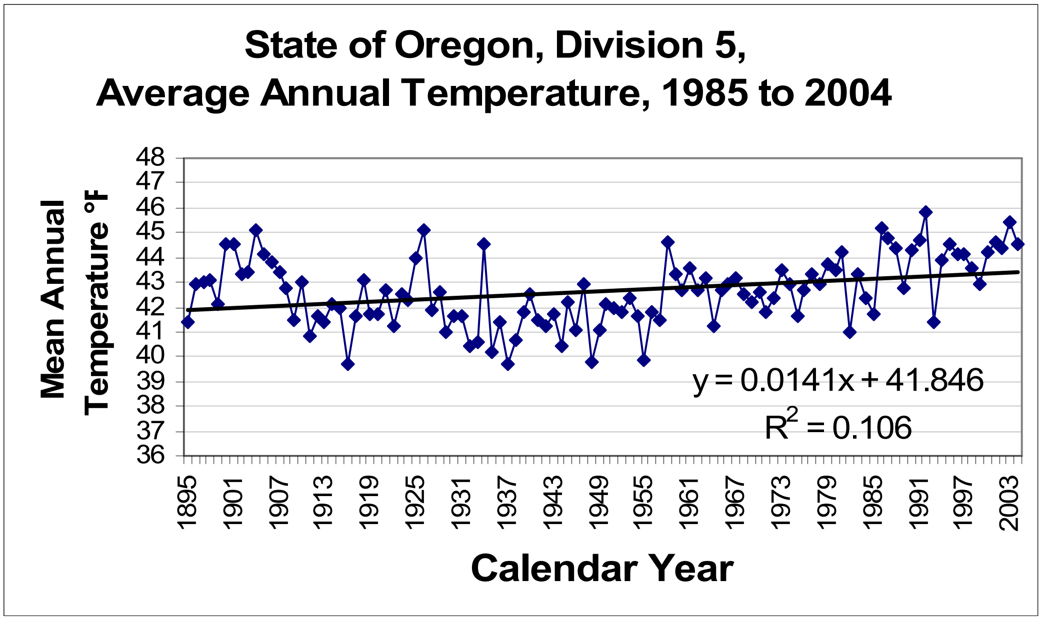
On a broader time scale, information suggests that Upper Klamath Basin has been receiving less precipitation (Figure 2-18) and has been warming (Figure 2-19) since at least 1895. Such climatological changes as less precipitation or warming trends that alter the form of precipitation will present challenges to water management that may place additional stress on the environment and suckers, as well as increase the conflicts between interest groups. Although the general trend indicates drier and warmer conditions over the last 100+ years, the year to year changes in precipitation and temperature are subtle. There is little indication from the long term climate data that precipitation and temperature over the next 10 years will be dissimilar in ranges and frequencies that have been experienced over the last 10 years.

Figure 2-18. State of Oregon, Division 5, October through March, accumulated precipitation, 1895 to 2004. Less precipitation may place additional stress on the environment, suckers, and of water resource uses. |



Source: J. Hicks, Chief, Planning Division, Reclamation, pers comm. June 2007.

Figure 2-19. State of Oregon, Division 5, average annual temperature, 1895 to 2004. In the Pacific Northwest, warm years tend to be relatively dry with low summer stream flow and light snow pack.



Source: J. Hicks, Chief, Planning Division, Reclamation, pers comm. June, 2007

Effects of the Proposed Action on Endangered Suckers

In accordance with the provisions of the ESA implementing regulations and the USFWS Section 7 Handbook, Reclamation used the following definitions to make its effects determinations for each listed species:

"*May affect:* " This is the appropriate conclusion when an action agency determines its proposed action may pose any effects on listed species or designated critical habitat. When the Federal agency proposing the action determines that a "may affect" situation exists, it must either initiate formal consultation or seek written concurrence from the Services that the action "is not likely to adversely affect" listed species.

"*No effect:* " This is the appropriate conclusion when the action agency determines its proposed action will not affect listed species or critical habitat.

The approach to determine proposed action effects on suckers is habitat oriented at each life history stage. Reclamation principally considered the proposed action's impact on habitat availability for each life history stage of the two endangered sucker species. The approach in the effects analysis also considered, to a lesser extent, the action of storage and delivery of water on water quality and larval sucker entrainment.

Upper Klamath Lake Habitat

In UKL, sucker access to suitable habitat may change with water management decisions and lake elevations. Each life history stage demonstrates a specific habitat requirement in UKL:

- Larval suckers enter the lake environment April through July where they occupy habitats that are characterized as shallow, nearshore, and vegetated, except in systems that lack nearshore vegetation (NRC 2004). Submergent vegetation appears less important for larval rearing than emergent vegetation (Cooperman 2002). Suckers continue to occupy habitats with these characteristics in common until they reach juvenile stage, which typically occurs at about a total length of about 20 to 25 mm (~0.75 to 1 in) in late July (USFWS 2002).

- Juvenile suckers use nearshore habitats. A general characterization of juvenile nearshore habitat use is more difficult, as different studies indicate juvenile suckers may use several different nearshore substrate types (Buettner and Scoppettone 1990, Simon et al. 2000, Hendrixson et al. 2007a, 2007b). Juvenile suckers become increasingly difficult to observe using standard sampling gear during late summer and fall and may shift toward offshore or deeper water at this time of year (Terwilliger 2006).

- Adult suckers appear to occupy habitats in the northern end of UKL from June through late September that are defined, in part, by water quality thresholds for the species (i.e., temperature, DO, and pH [Martin and Saiki 1998, Loftus 2001]) and depth. In general, both adult Lost River and shortnose suckers selected for depths between 3 and 5 m and avoided depths < 2 m (Reiser et al. 2001, Banish et al. 2007) until lake water quality conditions deteriorated or adults were redistributing throughout the lake in autumn (Banish et al. 2007). When water quality conditions deteriorated below thresholds in Loftus (2001), adult suckers were observed in habitats of improved water quality, such as near or in Pelican Bay, regardless of depth (Banish et al. 2007).

Clear Lake and Gerber Reservoirs Habitat

Sucker habitat requirements are less understood for endangered sucker populations in both Clear Lake and Gerber reservoirs. In USFWS 2002 BO, minimum lake elevations in these two reservoirs were proposed and evaluated for volume and depth of the remaining pool to provide juvenile, subadult, and adult habitat and access to spawning habitat in the reservoirs' tributaries. The current proposed action results in no change to the lake elevation minimums from the 2002 BO. Recent fisheries investigations in these two reservoirs indicate that populations of endangered suckers appear stable based on Catch per Unit Effort (CPUE) data with evidence of recruitment into the populations through comparison of length frequency data to earlier investigations (Leeseburg et al. 2007, Barry et al. 2007 Lost).

Tule Lake Habitat

Sucker habitat requirements are also less understood for endangered sucker populations in Tule Lake than for in UKL. Management of water deliveries to Tule Lake makes water depth in the relatively shallow, marsh habitat a concern for the persistence of sucker populations in Tule Lake. Reclamation's proposed action for deliveries to Tule Lake remains unchanged from the action analyzed in the USFWS 2002 BO.

Review of Proposed Action

Upper Klamath Lake

The Proposed Action is to store and deliver water from UKL in accordance with end of the month elevations (feet above mean sea level) in Table 2-13. From February to September, end of month lake elevations are based on perceived biological requirements of both sucker species to provide access to habitat and some benefit against poor water quality events. From October to March, end of month lake elevations are based on operational targets to refill UKL to maximize water availability for federally endangered and tribal trust species and irrigation to the Klamath Project.

Relative to minimum end of month lake elevations are the projected exceedences for UKL. Exceedences are interpreted as the percent frequency, based on water records from 1961-2006, that end-of-month lake elevations are at or above an elevation (Table 2-14). As an example, end-of-month lake elevation was at or above 4140.1 ft for October 50% of the time between 1961 and 2006 (Table 2.14).

Table 2-13. Proposed end-of-month minimum lake elevations, both biological and operational, in feet above mean sea level for UKL, Oregon.

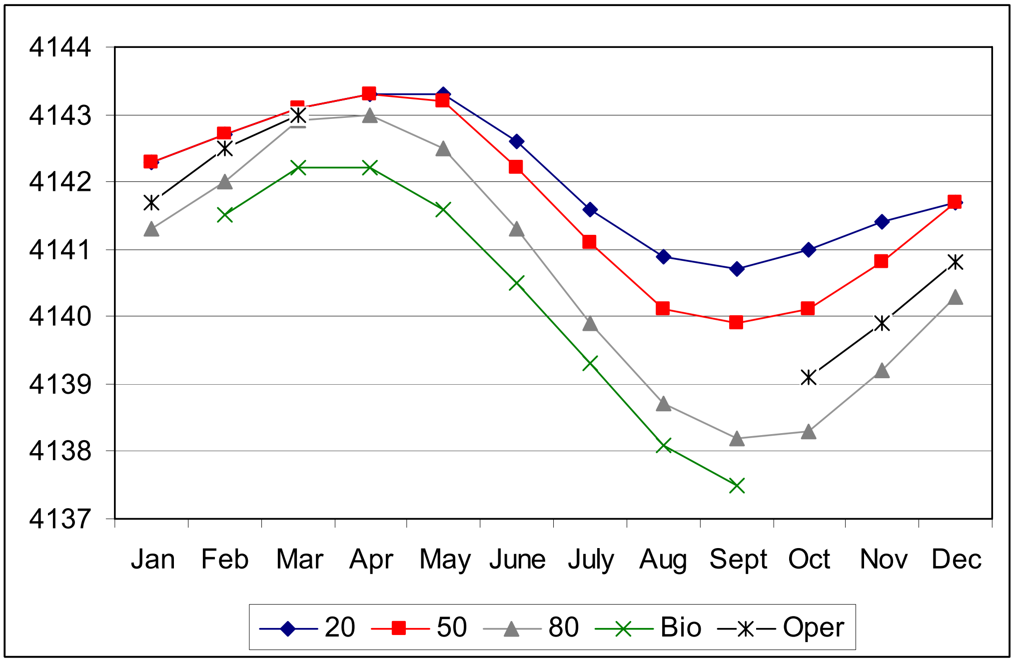
	Biological Minimum Elevation – USBR Datum	**Operational Refill Targets**
October		4139.1
November		4139.9
December		4140.8
January		4141.7
February	4141.5	4142.5
March	4142.2	4143.0
April	4142.2	
May	4141.6	
June	4140.5	
July	4139.3	
August	4138.1	
September	4137.5	

Table 2-14. Percent exceedence for end-of-month elevations in UKL, Oregon. Exceedences are interpreted as percent frequency that lake elevations are at or above the figure indicated. Exceedences are based on the period of record 1961 through 2006.

	95	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**
Oct	4137.8	4137.9	4138.3	4139.2	4139.8	4140.1	4140.4	4140.8	4141.0	4141.2
Nov	4138.1	4138.5	4139.2	4139.8	4140.5	4140.8	4141.2	4141.4	4141.4	4141.4
Dec	4138.6	4139.2	4140.3	4141.0	4141.5	4141.7	4141.7	4141.7	4141.7	4141.7
Jan	4139.6	4140.1	4141.3	4141.9	4142.2	4142.3	4142.3	4142.3	4142.3	4142.3
Feb	4140.6	4141.1	4142.0	4142.6	4142.7	4142.7	4142.7	4142.7	4142.7	4142.7
Mar	4141.4	4142.1	4142.9	4143.1	4143.1	4143.1	4143.1	4143.1	4143.1	4143.1
Apr	4141.8	4142.6	4143.0	4143.2	4143.3	4143.3	4143.3	4143.3	4143.3	4143.3
May	4141.6	4142.0	4142.5	4142.7	4143.1	4143.2	4143.3	4143.3	4143.3	4143.3
Jun	4140.5	4140.7	4141.3	4141.7	4142.0	4142.2	4142.3	4142.5	4142.6	4142.8
Jul	4139.4	4139.5	4139.9	4140.3	4140.8	4141.1	4141.3	4141.4	4141.6	4141.8
Aug	4138.4	4138.5	4138.7	4139.6	4139.8	4140.1	4140.4	4140.7	4140.9	4141.0
Sep	4138.0	4138.0	4138.2	4139.1	4139.4	4139.9	4140.3	4140.4	4140.7	4140.8

Figure 2-20. Graphical representation of end of the month lake elevations in UKL with the Biological lake minimums (Bio, green x) and Operational lake targets (Oper, black

asterik). The other lines represent 20% (blue diamond), 50% (red square), and 80% (gray triangle) exceedences for lake elevations.



In many years, Reclamation should be able to store and divert water from UKL and maintain elevations above the biological minimum lake elevations (Figure 2-20). End of the month lake elevations in UKL are over one foot higher than the biological minimum at the 50% exceedence level (Figure 2-20). Fifty percent of the time, end of the month lake elevations are one foot or greater than the minimum biological lake elevations. By September, end of the month elevations differ between the 50% exceedence curve and the biological minimum curve by over 2 feet (Figure 2-20). UKL management will target refilling the lake every year to ensure water supply for endangered species, tribal trust species, and irrigation demands. The operational lake targets are above the biological lake minimums throughout the year, but particularly from January through March and from October through December (Figure 2-20).

Another aspect of Reclamation's proposed action is the recommendation for managing available water. A recommendation will be routinely sought by Reclamation from a group of fisheries resource managers for the management of available water that would benefit endangered and tribal trust species. Water from UKL should be available after biological minimums and irrigation deliveries are met to provide species conservation target flows and lake elevations for both the Klamath River and the lake. As part of the recommendation process, the group of fisheries managers is tasked with developing conservation targets for both coho and suckers. Reclamation intends to operate lake elevations and Klamath River flows as close to these conservation targets as possible without falling below river flow and lake elevation biological minimums. With the group's recommendation, the realized lake elevations during larval life history stage will most likely be above the proposed minimum for all years unless there is an extreme shortage of water such as would happen during multiple drought years. During drought conditions, the first priority for UKL water is to meet the needs of endangered species.

The proposed minimum operating lake elevations of UKL will impact available larval sucker habitats. This impact is difficult to quantify and is likely offset, in part, through the projected increase in near-shore wetland vegetation that is available and will become available in the next few years through ongoing restoration activities along northern Upper Klamath and Agency lakes. The impact to larval suckers in UKL is likely further offset through Interactive Management of available water which will provide the opportunity to manage lake elevations toward species conservation targets and not solely the biological minimums.

Clear Lake and Gerber Reservoirs

The proposed action includes no change to minimum lake elevations at Clear Lake and Gerber reservoirs from the USFWS 2002 BO (USFWS 2002), and no change in operations of lake elevation at the two reservoirs from the 2003 amendment to USFWS 2002 BO (USFWS 2003 Amendment). The minimum lake elevations are provided in Table 2-15.

Table 2-15. Proposed action minimum lake elevations, for Clear Lake and Gerber reservoirs.

Reservoir	Minimum Lake Elevation
Clear Lake Reservoir	4520.6 ft
Gerber Reservoir	4798.1 ft

Upper Klamath Lake Water Quality

Water quality in UKL consistently reaches levels known to be stressful to suckers and periodically reaches lethal levels in August and September that resulted in sucker die-offs during the 1990s (Perkins et al. 2000 Water Quality, USFWS 2002). Adult sucker die-offs in the 1990s were likely caused by stressful and lethal water quality conditions. The extent of a 2003 fish die-off in UKL is unknown, however, only small numbers of dead adult suckers were recovered (Foott 2004). Dead and moribund suckers recovered during the 2003 fish die-off were infected with several pathogens and parasites (Foott 2004). Fish die-offs of the 1990s may have also been, in part, a result of parasite and pathogen infections in fish as adult suckers were observed dying in the weeks that followed crticially low DO events (Perkins et al. 2000 Water Quality). The delay between dying adult suckers and critically low water quality parameters implicates that fish health, such as infection by pathogens or parasites intensified by poor water quality conditions, may be a factor during die-off events.

Adult suckers in the northern portion of UKL were seldom observed in areas where median DO was below 4 mg/l and pH was above 9.75, critical thresholds identified by Loftus (2001) for suckers (Banish et al. 2007, Reiser et al. 2001). Banish et al. (2007) indicated that several adult suckers were encountered in areas where water temperature had exceeded the low stress threshold (>25°C; Loftus 2001) for suckers in 2005 and 2006. Although adult suckers were typically observed in areas with adequate water quality conditions in UKL in 2005 and 2006, there were brief periods during both years that adult suckers encountered water conditions that should be considered stressful (Banish et al. 2007). During these periods of deteriorated water quality conditions in UKL, many adult suckers appeared to move toward areas of improved water quality, such as near Pelican Bay (Banish et al. 2007).

Water quality conditions also appear to affect suckers at the juvenile life history stage. Investigation of several health parameters of juvenile suckers captured in UKL and in the A-canal fish bypass indicated a general decline in growth occurred in September (Foott and Stone 2005). The poor growth in late summer and early autumn may be a result of reduced feeding (Foott and Stone 2005). Reduced feeding may be a response to many things, including stress from seasonal poor water quality events.

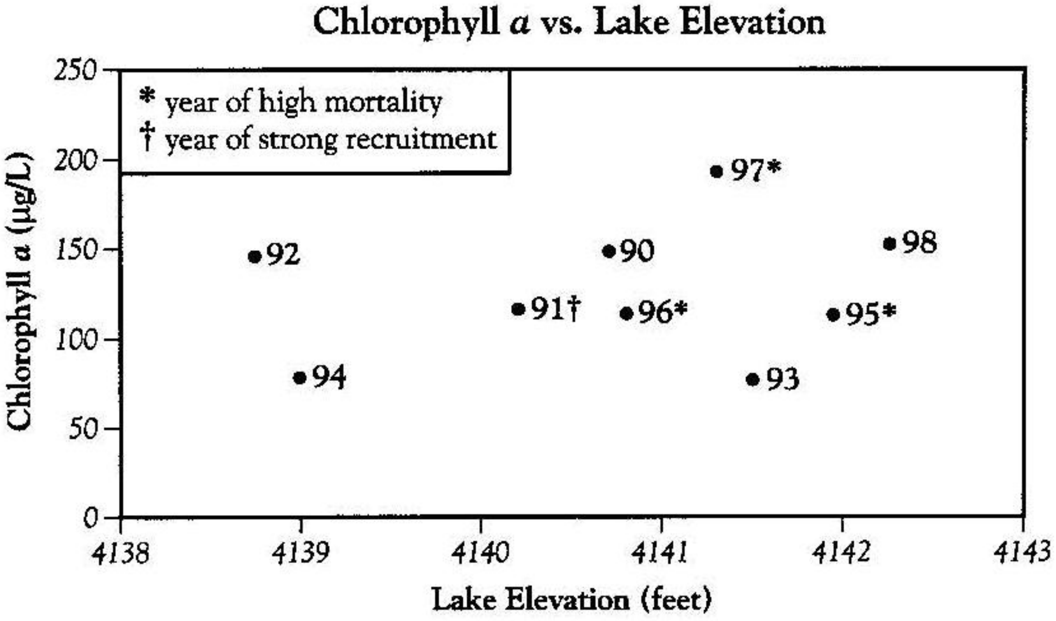
There has been considerable debate and many hypotheses have been posed concerning the effect of UKL elevation (depth) on water quality. It has been speculated that greater lake depth mitigates low DO values, improves under-ice and winter water quality, reduces un-ionized ammonia concentrations, reduces AFA biomass by reducing light intensities, delays AFA bloom initiation in the spring, dilutes internal phosphorus loading, dilutes pH, and reduces AFA biomass (USFWS 2002). However, in-depth analysis of existing UKL water quality data has failed to demonstrate a relationship between lake depth and poor water quality (Wood et al. 1996, NRC 2002, Morace 2007).

The National Academy of Science’s National Research Council conducted a scientific evaluation of the USFWS and NMFS BOs on the threatened and endangered fishes of the Klamath River basin (NRC 2002, NRC 2004). This evaluation included analyzing existing data for the Klamath River basin and reviewing the 2002 BOs. NRC (2002) concluded that “there is no substantial scientific support for the USFWS BO recommendations concerning minimum water levels for UKL and there is presently no sound scientific basis for recommending an operation regime for the Klamath Project that seeks to ensure lake levels higher on average than those occurring between 1990 and 2000.” Considering the fact that intense AFA blooms have been attributed to causing the poor water quality conditions in UKL (Bortleson and Fretwell 1993, Kann 1998, Risley and Laenen 1999, Perkins et al. 2000 Water Quality, Eilers et al. 2004, Wood et al. 2006, Kuwabara et al. 2007, Morace 2007), the effect of lake level on algal biomass is of particular importance. Upon analysis of existing data, NRC (2002) found no relationship between UKL level and AFA density (represented by chlorophyll concentration) and the idea of reducing algal density by phosphorous dilution with higher lake levels is "not consistent with the irregular relationship between chlorophyll and lake level." As depicted by Figure 2-21 from NRC (2002), there is no apparent association between lake level and the intensity of AFA blooms.

Also, NRC (2002) was unable to identify a quantifiable relationship between UKL depth and extremes of DO or pH. In fact, the most extreme pH conditions recorded for UKL during the 10-year period from 1990-2000 occurred in 1995 and 1996, which were intermediate water depth years, and not during 1992 and 1994 when water levels were the lowest (NRC 2002). The 10-year period that NRC (2002) analyzed from 1990-2000 were within the historical range of operations for UKL. The years of 1995, 1996, and 1997 (Figure 2-21), where extensive fish die-off events were observed, were intermediate lake level years. Further, 1991 was a low lake level year and yet was also a year of good sucker recruitment (NRC 2002).

USGS has conducted extensive analyses of existing water quality data from UKL. Wood et al. (1996) and USGS, concluded that there was no evidence for a relation between any of the water quality variables considered (chlorophyll, DO, pH, and total phosphorus) and lake depth on the basis of seasonal distribution of data or a summary seasonal statistic. The analysis found that low DO, high pH, high phosphorus concentrations, and heavy blooms of AFA were observed each year regardless of lake depth. The USGS repeated this analysis with a 17-year dataset (1990-2006) and the inclusion of eleven more years of data did not demonstrate a discernable relationship between lake depth and water quality (Morace 2007). Wood et al. (1996) did find that lower lake levels coincided with an earlier onset of the AFA bloom; however, these findings were not supported by Morace (2007) with the analysis of the more robust 17-year dataset. Both Wood et al. (1996) and Morace (2007) found a relationship between spring temperatures and the timing of the onset of the AFA bloom. The onset of the AFA bloom was delayed when spring air temperatures were cooler (Wood et al. 1996, Morace 2007). These analyses suggest that climactic conditions may have a greater influence on UKL water quality than lake level and the other variables considered. This is not to say that water depth has no effect on water quality, but that existing data and analyses have not shown a discernable relationship between UKL elevation and water quality over the range of depths that UKL has been operated at during the period from 1990-2006.

Figure 2-21. Relationship between chlorophyll and median August lake elevation.



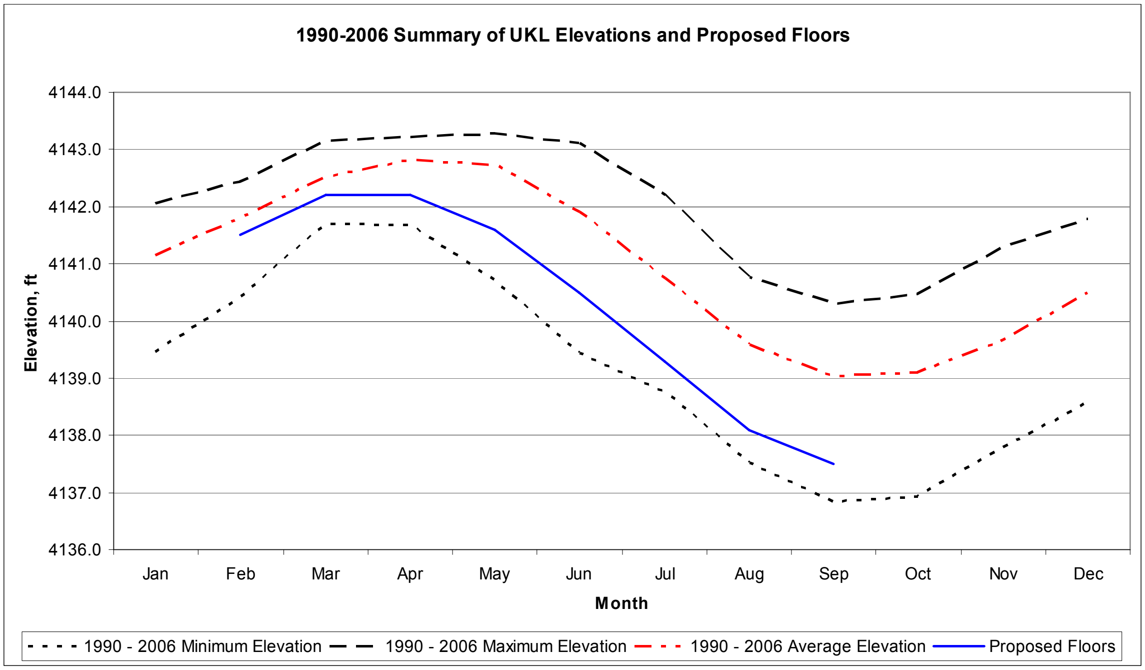
Source: NRC 2002

In addition, USGS has developed a hydrodynamic model of UKL that shows that wind-driven currents play a large role in determining the water quality in the lake (Wood and Cheng 2006, Morace 2007). This hydrodynamic model (Wood and Cheng 2006), as well as other experiments conducted by USGS, indicate that the deep trench along the western shoreline of UKL is important because it is an area of net consumption of DO (Wood and Cheng, 2006, Morace 2007). In the long-term, the hydrodynamic modeling effort and the water quality datasets currently being collected by USGS will likely provide more insight than the previous analyses conducted by Wood et al (1996) and Morace (2007) into the complex interactions of processes that influence the water quality of UKL (Morace 2007).

It is important to note that the data used for the Wood et al. (1996), NRC (2002), and Morace (2007) analyses were collected as part of monitoring program designed to assess long-term trends in water quality and not to address the relation between UKL water quality and various forcing functions (Morace 2007). The major limitation of the dataset used for these analyses is the two-week sampling interval, which is too infrequent to capture the variation in water quality that occurs within UKL where water quality conditions can vary significantly on time scales as short as a few days (Wood et al. 1996, Morace 2007). Additional water quality data collection conducted by USGS has confirmed that water quality varies significantly in time scales much shorter than the two-week interval of the dataset used for the analyses (Wood et al. 1996, Morace 2007), therefore the dataset may be insufficient for the analyses performed by Wood et al. (1996), NRC (2002), and Morace (2007) to detect a relationship between lake level and water quality in UKL. However, if a particular variable, including lake level, was of overwhelming importance, and particularly if the predominant time scale were a month or more, then these analyses would be able to demonstrate this strong relation (Morace 2007).

In conclusion, the proposed minimum UKL elevations for Project operation are within the range of lake elevations during the 1990-2006 time period, where in-depth analyses have shown no discernable relationship between UKL elevation and water quality (Wood et al. 1996, NRC 2002, Morace 2007). Figure 2-22 summarizes UKL elevations from 1990-2006 and the proposed minimum elevations for future operation of UKL. USFWS (2002) has proposed that greater lake depth improves water quality within UKL. However, in-depth analyses of existing UKL water quality data have not found a strong relationship between poor water quality conditions and any one factor, including lake depth (Wood et al. 1996, NRC 2002, Morace 2007). Considering the complexity of factors and interactions influencing water quality in UKL, one would not expect to find a direct relationship between lake level and water quality. In fact, it appears that many variables are of nearly equal importance, and the lack of statistically significant, strong correlations between water quality conditions, lake level, and climatic factors does not necessarily show that these factors do not influence water quality (Morace 2007). Rather, water quality conditions within UKL are a result of complex interactions between several processes that affect water quality (Morace 2007).

Figure 2-22. Summary of 1990-2006 UKL elevations.



Access to Pelican Bay may become limited at low lake elevation. Pelican Bay, an area of better water quality, has been used by adult suckers during poor water quality events in UKL (Reiser et al. 2001, Banish et al. 2007). At a lake elevation of 4138 ft, adult sucker access to Pelican Bay is altered as water depth > 3 ft is approximately 0.5 miles east of the entrance to Pelican Bay (USFWS 2002). The influence that better water quality extends away from the refuge area and into the lake proper is poorly understood (USFWS 2002).

Sucker Entrainment and Passage

Since 2001, Reclamation has installed fish screens at both A-canal and the outlet of Clear Lake. The fish screen at A-canal was designed to protect most juvenile and subadult suckers (greater than 30 mm total length) which can pass through the trash rack openings. Adult suckers are unable to pass through the openings on the trash rack in front of the A-canal fish screen. The design of the fish screen creates positive sweeping flows across the screen surface that is believed to provide an additional benefit by deflecting larval suckers (10-20 mm) which are of a size that could pass through mesh openings. Similar sweeping velocities at a facility near Red Bluff, California, reduced fish entrainment by successfully bypassing up to 46% of larval Sacramento suckers (Borthwick and Weber 2001). Similarly, preliminary tests by Reclamation showed a comparable percentage of larval suckers and other larval fish were successfully bypassed at the A-Canal screen in 2003 (Bennetts et al. 2004).

Although no fisheries investigations have been conducted to evaluate the fish screen at Clear Lake, fish salvage operations in the Lost River downstream of Clear Lake have captured very few suckers since installing the fish screen (Reclamation, unpublished reports).

Reclamation and other agencies continue to recognize the large number of unscreened diversions in the Upper Klamath basin. Reclamation is working with other agencies, including USFWS and ODFW, to identify and screen the numerous unscreened diversions in UKL. Reclamation and USFWS biologists believe this action is warranted because screening non-Federal diversions in UKL will provide the greatest potential benefits to endangered sucker populations where they are most abundant, populations are relatively robust, and the larger number of juvenile suckers in UKL is particularly vulnerable to entrainment if private diversions on UKL remain unscreened. Reclamation initiated a process for the UKL Fish Screen Program by issuing a grant to ODFW and leveraging Federal and State funds to provide 90 percent of the cost of constructing fish screens for willing landowners.

Presently, entrainment of larval, juvenile, and adult suckers at other Project facilities including Gerber Reservoir, Miller Creek, Tule Lake, and diversions in the Lost River and Klamath River may occur as a result of the proposed action (Reclamation 2002). However, Reclamation proposes to work with other stakeholders to determine if and where other efforts to reduce entrainment are needed. Fish stranded below outlet structures will likely not survive through the ensuing winter season. Salvage and relocation back to their source waters will improve their chances for survival. Reclamation has regularly conducted fish salvage operations throughout the Klamath Project at areas known to result in entrained fishes.

For suckers of the Klamath River drainage, it has been hypothesized that UKL is a better environment for the survival of suckers due to the food rich environment there and the frequency and duration of poor water quality events in the Lake Ewauna to Keno reach of the Klamath River (Reithal 2006, Markle et al. 2007 Juvenile). Wetland habitat would appear suitable for suckers in the Lake Ewauna to Keno reach. The frequency and duration of poor water quality events may adversely affect sucker survival in this reach in most years. The Link River fish ladder was installed by Reclamation to permit suckers that do survive in this reach an opportunity to return to UKL. There is presently evidence that adult suckers have used the Link River fish ladder to return to UKL since the ladder's completion in 2005; however, the age at which suckers are able to successfully negotiate the fish ladder is largely unknown. It is feasible that some suckers that have emigrated from UKL can survive in the Lake Ewauna to Keno reach to an age or size that permits the use of the fish ladder.

Reclamation and PacifiCorp release water from UKL through the Link River Dam for multiple purposes. Prominent among the purposes for water releases are downriver endangered and tribal trust species. As result of Reclamation's past and present Section 7 ESA consultation with the NMFS on endangered coho, water releases at Link River Dam will likely continue. Undoubtedly, larval and juvenile suckers are transported downstream from UKL with water releases at Link River Dam (Foster and Bennetts 2006, Tyler 2007). Emigration of suckers from UKL is likely a natural occurrence; however, emigration rates are likely influenced by storage and delivery of water in UKL.

Emigration rates from UKL may also be influenced by fish health issues as juvenile suckers captured at the Link River in 2006 were heavily infested with external parasites (Banner 2006 in USFWS 2007 Section 7). The general poor health of juvenile suckers emigrating from UKL may in part explain their emigration. Given the unstable environment of frequent poor water quality in the Lake Ewauna to Keno reach of the Klamath River, water releases at Link River Dam may adversely affect sucker populations in UKL.

Infrastructure, particularly dams, that permit water delivery throughout the Klamath Project also have an adverse impact on suckers. Fish passage issues at these dams prevent the exchange of individuals between sucker populations. Reclamation installed and monitors a newly constructed fish ladder at the Link River dam intended to reconnect sucker populations in the Klamath River and UKL. It is currently unknown how the isolation of sucker populations in the

Klamath River and Lost River drainages affects recovery of sucker populations in the Upper Klamath Basin, but it is assumed that the impact of inadequate fish passage has an adverse impact on suckers through the reduction of genetic exchange. Although not a Klamath Project dam, the removal of Chiloquin Dam on the Sprague River is believed to provide substantial benefit to suckers (see discussion of fish passage and Chiloquin Dam in the Environmental Baseline).

Reclamation has reduced entrainment and improved fish passage at several Klamath Project facilities. Reduced entrainment at A-canal and the Lost River at Clear Lake have provided a benefit to suckers by keeping suckers in environments that provided better survival. Improved fish passage at the Link River Dam and Chiloquin Dam provides sucker access to other, and potentially better, habitats. In spite of the advancements already made to reduce entrainment and improve fish passage, more fish passage and entrainment reduction projects are likely necessary in the Upper Klamath Basin. Reclamation's proposed action to store and deliver water in the Klamath Basin may affect and will likely adversely affect suckers through continued larval, and some juvenile, sucker entrainment and inadequate fish passage for juvenile and adult life history stages at some facilities.

Effects of Diverting Flows

Diversions of flows to storage at Barnes and ALR may affect endangered suckers in UKL even though flow diversions occur during the winter and spring when inflows generally exceed the flood control levels of UKL (USFWS 2003 Opinion). Water not stored on ALR would likely be spilled at Link River Dam. Much of the water diversion to ALR occurs before larval suckers are present. The diversion to ALR is screened against juvenile and adult fish entrainment. During fisheries monitoring of water storage on the ALR from 2003 to 2007, only 4 juvenile or subadult suckers have been captured behind the screens used to reduce entrainment (Reclamation, unpublished data). The very few juvenile and subadult suckers observed during sampling and the lack of larval suckers present in UKL during winter and early spring months indicate that the impact to suckers of diverting seasonal run-off to Barnes and Agency Lake properties is minimal.

Flow diversion from Clear Lake and Gerber reservoirs are likely to have an unmeasured negative impact on endangered suckers in the Lost River and Miller Creek respectively because flows are cut off after the irrigation season at Clear Lake Dam and a small flow of about 1 cfs remains below Gerber Dam. Flows in the Upper Lost River (Clear Lake to Bonanza) and Miller Creek are very low during the fall and winter. However, they do increase downstream from tributary and spring accretions. Lost River flows also increase as a result of weather patterns and low elevation run-off from fall through spring, prior to irrigation season.

Water diversion from UKL into A-canal has long been a site for entrainment of suckers at each life history stage. This diversion was screened prior to the start of the 2003 irrigation season. The screen is designed to prevent juvenile and adult fishes from entering the A-canal and diverts them back into UKL. Larval suckers still become entrained but approach velocities divert a portion of the larval suckers into the fish bypass. Since shortly after installation and evaluation of the fish screen at A-canal, USFWS has not required extensive fish salvage efforts in the Project diversion canals (letter communication from USFWS to Reclamation dated 08 November 2005, #81450-2006-0022). Similarly, a screen has been installed on the Lost River at the Clear Lake outlet that prevents the emigration of juvenile and adult suckers from Clear Lake. Larval suckers likely still emigrate from Clear Lake through the screen in unknown quantities.

The storage of water in the Lost River drainage has resulted in a later peak in flows than an unaltered hydrograph. Flows in the Lost River drainage during spring months of some years are sufficient to promote attempted sucker spawning in some stretches of the mainstem Lost River (Sutton and Morris 2005, USFWS 2007 Spawning). Sucker spawning has been documented in Miller Creek and is suspected in Buck Creek and Rocky Canyon Creeks. This spawning may contribute individuals to this section of the Lost River (Shively et al. 2000 Subbasin). Larval, juvenile, and adult sucker health and survival may be reduced because of stranding, increased predation, potentially harmful water quality conditions, increased stress from crowding and lack of food, and higher incidence of disease exacerbated by water management in the Lost River.

In the Lost River below Bonanza to Wilson Dam, flow diversions at Clear Lake and Gerber reservoirs are not likely to have a negative effect on suckers and their habitat because unregulated streams, groundwater springs and runoff maintain adequate habitat and flows in the fall and winter. Adequate flow and habitat conditions are likely to occur during spring and summer.

Flow diversion in the Lost River at Wilson Dam (to the Klamath River) during the fall and winter may negatively affect suckers and their habitat in the Lost River downstream of the dam to Tule Lake. Low flows may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality and fish die-offs.

At Anderson-Rose Dam, flow diversion during the irrigation delivery period may result in poor access for spawning fish from Tule Lake to spawning areas below the dam, inadequate flows for sucker spawning, egg incubation, larval rearing and emigration, and summer and fall juvenile rearing habitat. However, there does not appear to be a clear association between lake levels, river flows, and the health of the species.

The effects of diverting flows may adversely affect suckers.

UKL Habitat

Larval Suckers

Nearshore flooded wetlands, particularly emergent vegetation at least 6 inches deep, provides habitat to larval suckers in the lake environment (NRC 2004). This type of emergent vegetation affords early larval suckers with protection from predators (Markle and Dunsmoor 2007), and possibly diverse food resources and protection from waves during storm events (Dunsmoor et al. 2000). Markle and Dunsmoor (2007) demonstrated improved survivorship of larval suckers with predatory fathead minnows present when vegetation and water depth were provided for cover. As lake level decreases, so does the area of available emergent vegetation in UKL. Thus, lake elevation in UKL influences larval suckers' access to nursery habitat (Dunsmoor et al. 2000, IMST 2003, Terwilliger 2006, Markle and Dunsmoor 2007).

Dunsmoor et al. (2000) estimated the total volume of emergent vegetation in the nearshore wetland areas of the lower Williamson River, west of the river mouth to near the Agency Straits (approximately 5 km of shoreline), and east of the river mouth to near Modoc Point (approximately 9 km of shoreline). Estimated emergent vegetation was greatest at full pool lake elevation (4143.3 feet): west of river mouth at 578,375 ft3, 286,813 ft3 east of the river mouth, and 42,624 ft3 in the lower Williamson River (Table 2-16; Dunsmoor et al. 2000). Dunsmoor et al. (2000) determined the relationship between lake elevation and inundated emergent vegetation is relatively linear. Thus, flooded vegetation is most available at full pool lake elevation (4143.3 feet) and diminishes as lake elevation drops. At about 4139 feet lake elevation, emergent vegetation in the lower Williamson River and to the east and west of the river mouth along UKL becomes essentially dewatered to a depth insufficient for larval sucker habitat use (Table 2-16; Dunsmoor et al. 2000). The relationship between available emergent vegetation habitat and lake elevation in UKL has been cited in subsequent sucker habitat literature (Reiser et al. 2000, IMST 2003, NRC 2004, Markle and Dunsmoor 2007).

The minimum elevation for UKL proposed by the end of June is 4140.5 feet above mean sea level (msl) in the Proposed Action. Much of the emergent vegetation habitat becomes dewatered in the northern portion of UKL at this lake elevation. However, the peak of larval sucker emigration from the Williamson River typically occurs during mid May (Ellsworth et al. in review). The proposed lake elevation of 4141.6 ft at the end of May still provides over 15% of inundated emergent vegetation habitat in the lower Williamson River and over 34% of the same habitat in the areas east and west outside the river mouth (Table 2-16). Although larval emigration from the tributaries to UKL continues into July (Ellsworth et al. in review), the majority of larval suckers will have had access to emergent vegetation habitat for approximately five to six weeks before the end of June. At juvenile life history stages, suckers in UKL appear to transition into a variety of nearshore habitat types (Terwilliger 2006, Hendrixson et al. 2007a, 2007b).

Table 2-16. Emergent vegetation and lake elevation relationships for endangered larval and juvenile suckers at heavily used areas including the lower Williamson River, and Tulana, and Goose Bay sites combined.

Upper Klamath Lake elevation (feet above mean sea level)	Lower Williamson (percent inundated)	East and West of River Mouth (percent inundated)
4143.3	100.0	100.0
4143.0	83.6	87.1
4142.5	56.6	68.0
4142.0	33.2	50.2
4141.5	15.4	34.4
4141.0	4.4	20.4
4140.5	0.8	10.1
4140.0	0.0	3.9
4139.5	0.0	1.3
4139.0	0.0	0.0
4138.5	0.0	0.0
4138.0	0.0	0.0
4137.5	0.0	0.0

Source: Dunsmoor et al. 2000

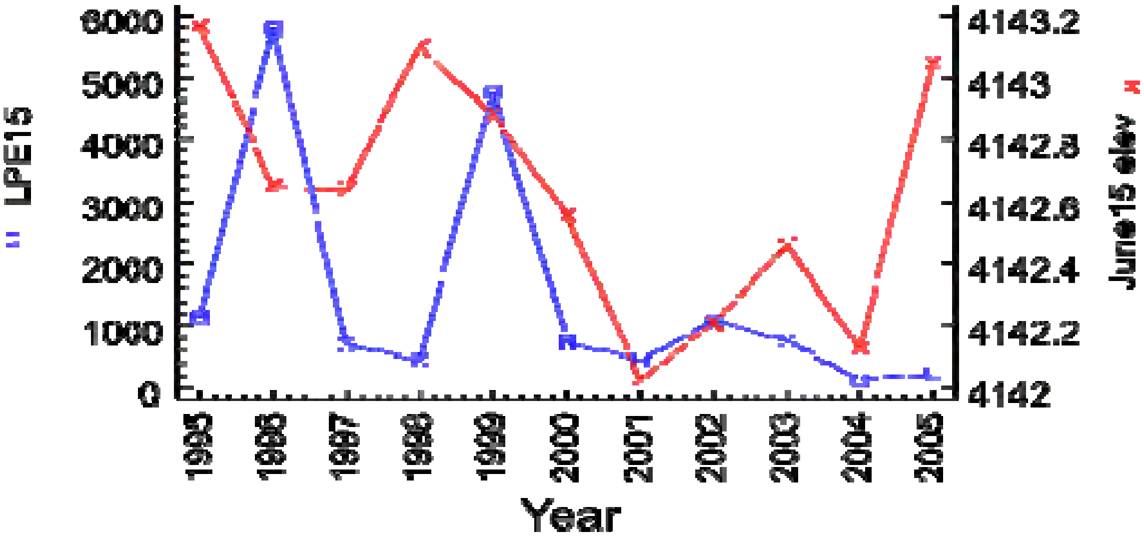
Benefits of Emergent Vegetation

Although emergent vegetation habitat likely provides a benefit to sucker populations through improved survivorship from the larval to juvenile life history stages (Dunsmoor et al. 2000, Markle and Dunsmoor 2007), quantifying the benefit remains difficult. Relatively strong recruitment into the adult sucker population occurred with the 1991 year class (NRC 2002). Individuals of this year class encountered end of June lake elevations of 4141.5 feet as larvae in 1991. The NRC (2002) compared the 1991 recruitment class and larval sucker use of inundated vegetation, and determined that the causal relationships between lake elevations and recruitment events do not have strong scientific support.

Examination of a larger data set indicates that lake elevations may partly explain larval sucker abundance on an annual scale (Figure 2-23; Markle 2007). From 1995 to 2005, there have been a string of poor year classes despite a June 15 lake elevation > 4142 ft in UKL (Markle 2007). Mid-June lake elevations below 4142.5 ft would be expected to create low larval survival and less retention based on reduced wetland habitat in the north end of UKL at lower lake elevations (Markle et al. 2007 Juvenile, Markle 2007). In five of seven years where June 15 lake elevation was at or greater than 4142.5 ft between 1995 and 2002, larval production for size 15 mm total length was relatively low (1995, 1997, 1998, 2000, and 2005; Figure 2-23, Markle 2007).

In the other two years where June 15 lake elevation was above 4142.5 ft, larval sucker abundances were the highest observed larval abundances in the 10-year record presented. In years when mid-June lake elevation were below 4142.5 ft, larval sucker production was low, but similar to larval abundances in 8 of the 10 study years, including years when mid-June elevation was higher than 4142.5 ft. Markle (2007) indicates that larval sucker production, or year class formation, appeared to respond to largescale climate indices and that the lake management regime from 1995 to 2005 may have resulted in better year class formations under different climate regimes.

Figure 2-23. UKL relationship between June 15 lake elevation (red x) and larval sucker abundance for larvae of 15 mm total length (LPE15; blue square) from 1995 through 2005.



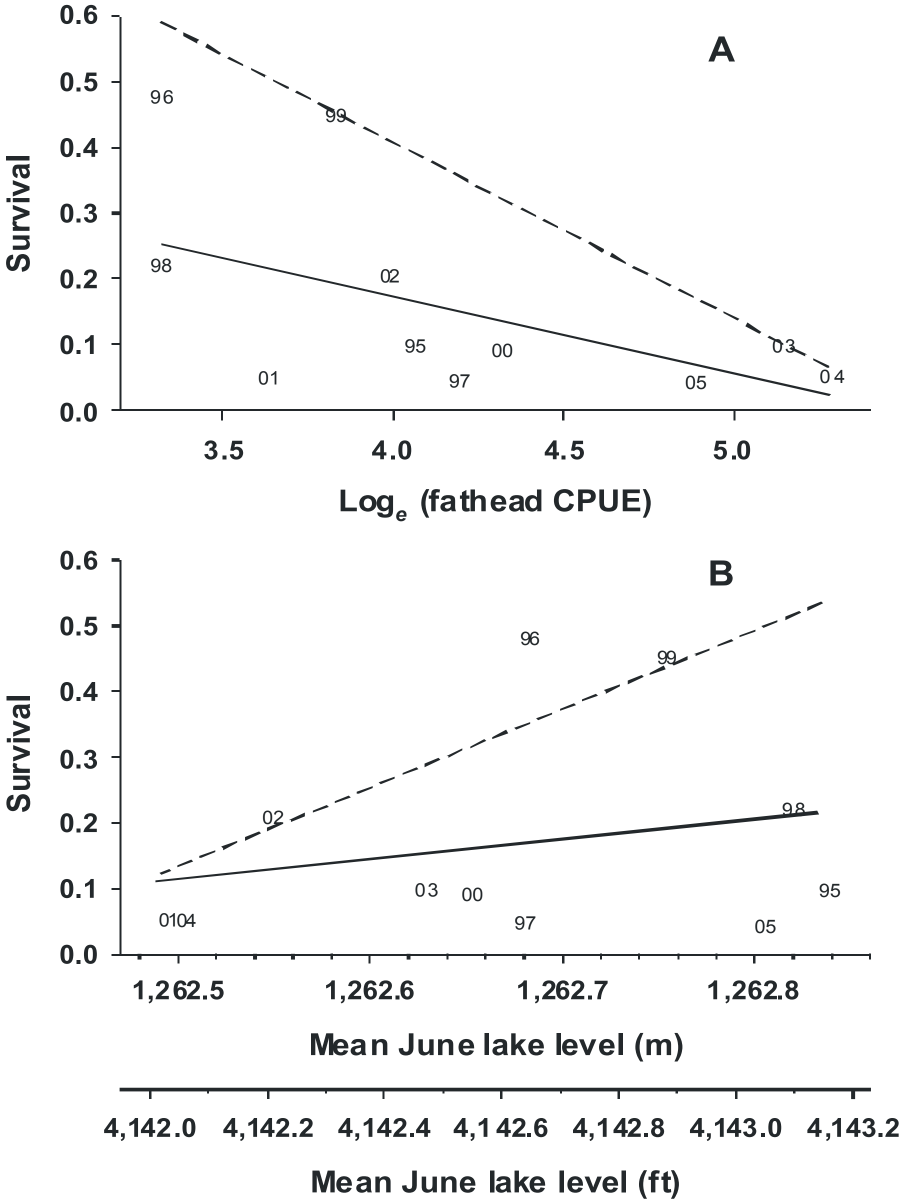
The relationship between larval year class formation and larval survival from 1995 to 2005 is also discussed in Markle and Dunsmoor (2007). A direct relationship between larval abundance and lake elevation from the 1995 through 2005 data is difficult to ascertain since several years with high lake elevation also had low larval sucker abundance (Figure 2-24). The authors indicate that larval sucker survival may be related inversely to fathead minnow abundance (Markle and Dunsmoor 2007). Lower lake elevations may favor fathead minnow abundance and negatively influence larval sucker survival (Figure 2-24; Markle and Dunsmoor 2007).

Also confounding the relationship between larval sucker abundance and lake level management is the prevailing current in UKL that generally flows southerly along the eastern shore of the lake (Markle et al. 2007 Juvenile). The August shoreline abundances of approximately 70% of larvae identified as shortnose and approximately 30% of larvae identified as Lost River suckers are due to location in the lake (Markle et al. 2007 Juvenile). Essentially, the further north in UKL that larval suckers can be retained, the less likely the larvae are to emigrate from the lake through the Link River. The retention of larvae traveling the prevailing currents of UKL can be influenced through two factors: (1) shoreline roughness, such as that provided by nearshore wetlands, and (2) entrance into the internal gyre which has the ability to carry larvae northerly (Markle et al. 2007 Juveniled). These two mechanisms can be influenced by lake level management: increased shoreline roughness (i.e., nearshore wetlands) is available at higher lake elevations, and better larval sucker entrance into the internal gyre of UKL is available at lower lake elevations (Markle et al. 2007 Juvenile). Both shortnose and Lost River sucker larvae likely use both shoreline roughness and entrance into the internal gyre; however, our understanding of the gyre and its ability to transport larvae is only now beginning to develop.

Expected Increases in Wetland Vegetation

Recent activities to restore near-shore wetlands on Upper Klamath and Agency lakes have increased and will continue to increase the amount of available emergent vegetation to larval suckers in the north end of UKL. An estimated 800 to 1000 acres of wetland vegetation is currently established in the Williamson River delta restoration area at an elevation that will remain emergent vegetation with typical lake elevation management following restoration (M. Barry, Williamson River Preserve Director, TNC, and J. Cameron, Physical Scientist, Bureau of Reclamation, June 18, 2007, pers. comm.). This vegetation will become available for fish use in spring 2008 following levee breaches around the Tulana Farms property in fall 2007. Based on surface elevations of the Williamson River delta restoration area, TNC predicts a total of 2196.4 acres of emergent wetland vegetation to establish with lake elevation seasonally fluctuating between 4143.3 and 4137.1 ft (Elseroad 2004). The timeframe for establishment of future emergent vegetation on other parts of the Williamson River delta is uncertain, but efforts to establish wetland vegetation at other locations along the lower Williamson River and Agency Lake indicate a relatively short response time of several years by emergent vegetation (J. Cameron, Physical Scientist, Reclamation and M. Barry, director of Williamson River Delta Preserve, pers. comm.). Both the wetland vegetation available to larvae in spring and summer of 2008 and future wetland vegetation represent substantial increases in available habitat since the surveys conducted in Dunsmoor et al. (2000).

Figure 2-24. Annual estimates of early larval Lost River and shortnose sucker survival in UKL, 1995-2005. The numbers plotted as symbols are the last two digits of the years in question. Panel (A) shows the relationship between sucker survival and the loge-transformed catch per unit effort (CPUE) of fathead minnow the previous year; the solid line is the least-squares regression (y=0.75318 – 0.14053x; P=0.045), and the dashed line is the 0.90-quantile regression (y=1.48164 – 0.26899x; P=0.15). Panel (B) shows the relationship between sucker survival and lake elevation; the solid line is the least-squares regression (y=-406.533 + 0.32209x, where x is in meters (P=0.50), and the dashed line is the 0.90-quantile regression (y=-1510.32128 + 1.19642x; P=0.86).



Source: Figure reproduced with permission from Markle and Dunsmoor (2007).

The reconfiguration of the Williamson River mouth may also provide additional benefit to sucker populations in UKL by providing a direct route for larval suckers to be transported into emergent vegetation wetland areas in the northern portion of UKL. The net inflow to UKL from the Williamson River will not change but the discharge will reach UKL through a series of river mouths to the northwest and northeast of the present river mouth. Small and partial levee breaches along the lower Williamson River will create this series of multiple river mouths. Much of the discharge is projected to exit the river channel through the series of breaches in the dikes upstream of the present day mouth. Reconfiguration of the Williamson River mouth is designed, in part, to transport larval suckers directly into shallow water areas of emergent vegetation.

Additional wetland restoration activities are occurring along the northwest shoreline of Agency Lake. The Barnes and ALR properties, totaling approximately 9,830 acres, have recently been managed as water storage behind the existing dikes, thus some wetland vegetation has become established. In the near future, existing dikes will be breached, allowing for fish access and a more thorough colonization of wetland vegetation on these properties. An increase in emergent vegetation habitat through restored wetlands along northern Upper Klamath and Agency lakes and the potential redirection of larval suckers into wetland habitats should influence the retention time of larval suckers in the northern portion of Upper Klamath and Agency lakes. Recently, few juvenile suckers were encountered during fisheries surveys of the western edge of the marshes at UKL National Wildlife Refuge, Fourmile Creek and Odessa (Mulligan and Mulligan 2007). Suckers may be retained further north in UKL through the re-establishment of additional wetland vegetation on the Barnes and ALR properties and the reconstruction of the Williamson River mouth. Retention of suckers further north may disrupt patterns of sucker emigration from UKL (Markle et al. 2007 Juvenile) and provide the means for larval and juvenile suckers to occupy habitats in and near UKL National Wildlife Refuge.

Juvenile Suckers

Habitat use by juvenile suckers has been characterized in UKL as near-shore and occurring over a variety of substrate compositions (Terwilliger 2006, Hendrixson et al. 2007a, 2007b). The proposed lake elevations provide access to some habitats over the range of lake elevations that juvenile suckers will experience during summer months. Not all habitats are available at all lake elevations, except at the highest lake elevations. Juvenile sucker habitats associated with aquatic vegetation (VanderKooi and Beulow 2003, VanderKooi et al. 2006, Hendrixson et al. 2007a, 2007b) will likely diminish as lake elevation recedes in a manner similar to that described for emergent vegetation in the larval sucker section. The extent that rocky substrate, a juvenile sucker habitat type identified by Simon et al. (1995), extends from the shoreline has not been thoroughly investigated. Simon et al. (1995) indicated that this substrate type likely only extends 10 to 60 feet from the shoreline, and the shallow slopes of UKL, led the authors to postulate that rocky substrates become dewatered at about 4138 ft lake elevation. At higher lake elevations, nearshore vegetation and rocky substrates used by juvenile suckers will be present in UKL. As the lake recedes during delivery of water through the irrigation season, nearshore vegetation will become dewatered to the point that juvenile suckers will no longer have access to this habitat (see discussion in Effects Analysis for larval sucker section). As the lake further recedes, juvenile sucker access to rocky substrates may also become increasingly difficult.

During late summer and early autumn, juvenile suckers appear to leave near-shore areas (Terwilliger 2006). It is assumed that juvenile suckers transition to offshore areas during this time, but there are limited observations to confirm or deny this assumption. The seasonal habitat shift by juvenile suckers may be induced by lake level management (USFWS 2002) or may be a biological response to environmental conditions or changes in physiological demands.

The proposed minimum lake elevations will likely adversely affect juvenile suckers by limiting access to certain habitats at certain lake elevations.

Adult Suckers

Lake elevations may impact sucker populations through adult access to spawning habitats during the spring months and through adult use of relatively deeper water as habitat during the remainder of the year.

Historically, shoreline springs provided spawning areas for Lost River and shortnose suckers. Barkley Springs, Odessa Springs, Harriman Springs, and several others in UKL are not currently used by adult suckers for spawning. Sucker spawning currently occurs at a few shoreline areas including Sucker Springs, Silver Building Springs, Ouxy Springs, Cinder Flat and Boulder Springs along the east side of the lake. Shoreline spawning occurs from late February through early-May with a peak in March or April (Perkins et al. 2000 Water Quality, Hayes et al. 2002 and Barry et al. 2007 UKL). Water depths become one foot or greater over spawning substrate at Sucker Springs, Silver Building Springs, Ouxy Springs and Cinder Flat at elevations of approximately 4140.0, 4139, 4140.5, and 4138 respectively (Reclamation 2002).

The biological lake elevation at the end of February in the proposed action is 4141.5 ft above mean sea level, providing access to over 60% of the shoreline spawning habitat (Table 2-17). However, lake elevations will increase through March to 4143.0 ft before returning to a level of 4142.2 ft by the end of April. These lake elevations will result in an estimated inundation of over 80% of the shoreline spawning areas in UKL during much of the sucker spawning activity greater at these sites (Table 2-17). By the end of spawning at the shoreline spawning areas at the end of May, nearly 60% of the spawning habitat is still inundated.

Table 2-17. Spawning habitat and lake elevation relationship in UKL for endangered suckers at known shoreline spawning areas (average of Cinder Flat, Ouxy Springs, Silver Building Springs and Sucker Springs).

Lake elevation (feet)	Shoreline spawning habitat, percent inundated
4143.3	100.0
4143.0	95.1
4142.5	90.5
4142.0	73.8
4141.5	62.0
4141.0	49.8
4140.5	36.7
4140.0	30.2
4139.5	17.6
4139.0	13.8
4138.5	7.3
4138.0	5.2
4137.5	0.0

Source: Reclamation 2002

Several research efforts have described the apparent depth requirements for adult suckers in the northern portion of UKL. Adult suckers, including older juveniles are found in open water areas of the lake environment typically at depths of greater than 1 m (Peck 2000, USFWS 2001) and prefer water depth greater than the mean depth available in the area (Reiser et al. 2001, Banish et al. 2007). Adult suckers were observed using water depths generally > 3 m for Lost River suckers and > 2 m for shortnose suckers where adequate water quality was above the species' tolerance thresholds and neither species used water depths > 5 m (Banish et al. 2007). The relationship between depth and lake elevation in the northern portion of UKL indicates that end of month minimum biological lake elevations will impact the amount of available habitat in the north end of UKL and, subsequently, will have some impact on adult suckers through the reduction in available habitat
(Table 2-18).

Relative mean depth for all of UKL is approximately 3 meters at full pool lake elevation of 4143.3 feet above mean sea level and diminishes to about 1 m at the proposed minimum elevation of 4137.5 feet. About 50% of the area in the northern portion of UKL provides depths over 3 feet when the minimum proposed lake elevation is reached at the end of September (Table 2-18). The proposed minimum lake elevation for the end of September provides a sufficient mean water depth in UKL in the following months while the lake refills. Adult suckers begin to redistribute throughout the lake after September and demonstrate a wider range of depth requirements (Banish et al. 2007).

Table 2-18. Adult rearing habitat and lake elevation relationship in UKL for endangered suckers in the northern portion of the lake.

Upper Klamath Lake elevation (feet)	**Northern portion of Upper Klamath Lake (percent area > 1 m (~3 ft) deep).**
4143.3 (maximum)	100.0
4143.0	99.9
4142.5	99.8
4142.0	99.7
4141.5	98.9
4141.0	98.1
4140.5	93.9
4140.0	89.7
4139.5	78.6
4139.0	67.4
4138.5	60.2
4138.0	53.2
4137.5 (minimum)	**48.1**

Source: Peck 2000

Lake elevations may be less critical to fish condition from October through February. Most fish, and presumably suckers, become less active during this time of year due to low water temperatures and water quality conditions throughout the Upper Klamath Basin are generally good through winter. However, harmfully low DO levels can occur during ice-cover conditions. Ice-cover conditions can occur on Upper Klamath Lake from December through February, lasting from a few weeks to several months. The depletion rate of DO in the water column increases as the depth of the lake decreases because the lower volume of water holds less oxygen relative to the biological oxygen demand of the sediments. Ice-cover also eliminates wind-induced mixing that adds oxygen to bodies of water and prevents stratification. With ice-cover conditions stratification occurs and near bottom water may become anoxic (no oxygen) leading to release of high levels of ammonia from the sediments into the water column. When ice cover breaks up, the high ammonia mixes throughout the water column, potentially having a negative effect on sucker growth and health. As a result of this process, there is a higher, although unquantified, risk of poor water quality following ice out at lower lake elevations compared to higher lake elevations (Reclamation 2002).

Adult sucker may be affected by the proposed action to store and delivery water in UKL through access to rearing habitat provided by lake depth in the northern end of UKL.

Clear Lake and Gerber Reservoirs

Reclamation proposes to store water in Clear Lake and Gerber reservoirs generally from October though April and deliver from April through September. The Proposed Action is no change from operations of both Clear Lake and Gerber reservoirs under the most recent ESA consultation (Reclamation 2002, USFWS 2002). End-of-month minimum lake elevations resulting from the Proposed Action at Gerber and Clear Lake reservoirs are shown in Table 2-15.

The proposed storage action results in fluctuating volumes and surface areas at both Clear Lake and Gerber reservoirs. This action has potential to benefit suckers through increased habitats for each life stages and reduced risk of potential winter die-off at higher reservoir levels. However, these potential benefits to suckers are diminished as the reservoirs diminish. The following analysis for Clear Lake and Gerber reservoirs acknowledges, as discussed above for UKL, that empirical data since 1990 has not demonstrated a clear association between lake levels and the health of the suckers.

Water delivery from storage during spring through autumn months results in lower lake levels, volumes, and surface area in Clear Lake and Gerber reservoirs. The effect of water delivery from Clear Lake and Gerber reservoirs is a reduction of both shoreline habitat available to larval and juvenile suckers and open water habitat available to juvenile and adult suckers. As water levels drop, suckers likely move to the deeper west lobe where fish become more concentrated and may be adversely affected by increased competition, predation, and disease as a result of concentrating there. This could potentially result in stress and lower survival of endangered suckers. During drought conditions, a Water User Mitigation Plan will be put into effect in years when Project deliveries must be reduced to provide for minimum river flows and lake elevations for listed species.

Clear Lake

During years when the surface elevation of Clear Lake is less than 4524 ft from February through April, access to spawning areas in Willow Creek is blocked. If the proposed biological minimum for Clear Lake of 4520.6 ft were to occur, it will most likely occur during summer or fall months except during periods of extended drought. Fall and winter precipitation is typically able to raise the lake elevation to at least 4524 ft by February in all years except for extreme and extended drought periods. During drought conditions, a Water User Mitigation Plan will be put implemented.

In 1992, when Clear Lake elevation reached a minimum of 4519.4 in October, suckers showed signs of stress including low body weight, poor development of reproductive organs, reduced juvenile growth rates, and high incidence of external parasites and lamprey infestation (Reclamation 1994). Overall fish body conditions were improved with increased body weight and fewer external parasites and lamprey wounds at higher lake levels in 1993-1995 (Scoppettone et. al. 1995). Reclamation proposes to provide a minimum lake elevation of 4520.6 ft at Clear Lake. This elevation is 1.2 ft above the conditions in 1992.

Lower lake levels may also result in degraded water quality, including higher water temperatures and lower DO levels. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (Reclamation 2000 Water Quality). The major concern for harmful and/or lethal water quality conditions is associated with winter ice cover periods. Low lake levels have an increased risk of low DO and potential winter die-off during ice cover conditions. During the winter of 1992-1993, Clear Lake was ice-covered for several months at an elevation of about 4519.5. However, DO concentrations during the ice-cover period that year remained at adequate levels for sucker survival (>4 mg/l; Reclamation 1994).

Because of the relatively low recharge rate in Clear Lake, lake levels may remain relatively low for several years. These conditions may adversely affect sucker through crowding and the associated increases in stress, competition for food and space, predation, and disease. Extended drought may result in complete or nearly complete desiccation of Clear Lake, especially if the lake drops below 4520 feet for extended periods. However, model simulations demonstrate that if the surface elevation of Clear Lake is at least 4521 feet on October 1, it is unlikely that the lake will drop below 4519 feet in the following year. Delivery of water that results in a lake level of less than 4521 feet before October 1 will be curtailed.

In the 2002 BO, USFWS agreed with Reclamation that water operations resulting in a minimum lake elevation at Clear Lake of 4520.6 ft above sea level was permissible (USFWS 2002). In a memorandum from USFWS to Reclamation on 4 March 2003 (memorandum #1-10-03-I-075), USFWS concurred with Reclamation’s effects analysis that a minimum elevation of 4520.6 ft is needed to protect Lost River and shortnose suckers at Clear Lake and that Reclamation’s operation of Clear Lake was permissible (USFWS 2003 Amendment).

Water management action at Clear Lake may affect suckers; however, it is unclear what the effect may be. The proposed water management at Clear Lake is unchanged from the USFWS 2002 BO and its amendment (USFWS 2003 Amendment). Water management at Clear Lake during the last 5 years would have appeared to provide a benefit to the sucker populations there as evidenced through recruitment into the adult populations and the relatively large and stable population of suckers present in Clear Lake (Leeseberg et al. 2007, Barry et al. 2007 Lost).

Reclamation's proposed action may affect suckers at Clear Lake. The effect on suckers may be beneficial or detrimental.

Gerber Reservoir

The proposed water management at Gerber Reservoir is unchanged from the USFWS 2002 BO and its amendment (USFWS 2003 Amendment). The proposed minimum elevation for Gerber Reservoir is 4798.1 feet above mean sea level.

During years when the surface elevation of Gerber Reservoir is less than about 4805 feet above mean sea level from February through April, access to spawning areas in Barnes Valley and Ben Hall creeks is restricted (Reclamation 2001). The seasonal minimum elevation at Gerber Reservoir is likely to occur during summer or fall. Gerber Reservoir is typically able to refill to at least 4805 feet from a minimum of 4798.1 feet during late fall and early winter, so access to spawning tributaries is re-established by the spring months when suckers typically spawn. However, in dry years these streams typically have very low flows that may not provide adequate for the upstream passage of spawning adults regardless of lake elevation (Reclamation 2001).

During dry years when minimum elevations reach 4801.7 feet above mean sea level, the surface area of Gerber Reservoir shrinks to about 750 acres, reducing sucker habitat to less than a third of the full reservoir area. When juvenile and adult rearing habitat shrinks to low amounts, suckers are likely stressed by poor water quality (high temperature and low DO); increased competition; and increased incidence of disease, parasites, and predators. Effects of low lake levels on larval and juvenile suckers are likely to be greater than adults since they have lower food reserves, higher metabolism, and lower mobility, and are more vulnerable to predators.

At a minimum elevation of 4798.1 feet above mean sea level, suckers may become concentrated in the remaining pool and experience stress. Lower lake levels may result in degraded water quality including higher water temperatures, higher pH values and lower DO levels. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were generally adequate for sucker survival except in 1992, when Gerber Reservoir dropped to a minimum elevation of 4796.4 (Reclamation 2000 Water Quality). The proposed minimum elevation is likely to maintain a sufficient pool of water that will likely have less of an effect on the population of shortnose suckers that reside in Gerber Reservoir than in 1992. In the 2002 BO, USFWS agreed that operations resulting in minimum lake elevation at Gerber Reservoir of 4798.1 ft above mean sea level were permissible (USFWS 2002). In a memorandum from USFWS to Reclamation on 4 March 2003 (memorandum #1-10-03-I-075), USFWS concurred with Reclamation's effects analysis that a minimum elevation of 4798.1 foot is needed to protect shortnose suckers at Gerber Reservoir and operations for diverting available water to irrigation was permissible (USFWS 2003 Amendment).

Water management action at Gerber Reservoir may affect suckers, however, it is unclear what the effect may be. The proposed water management at Gerber Reservoir is unchanged from the USFWS 2002 BO and its amendment (USFWS 2003 Amendment). Water management at Clear Lake during the last 5 years would have appeared to provide a benefit to the sucker populations there as evidenced through recruitment into the adult populations and the relatively large and stable population of suckers present in Gerber Reservoir (Leeseberg et al. 2007, Barry et al. 2007 Lost).

Much as with Clear Lake, Reclamation's proposed action may affect suckers at Gerber Reservoir. The effect on suckers may be beneficial or detrimental.

Tule Lake

The Tule Lake National Wildlife Refuge is within the Project. This refuge was established by Executive Order dated 1908. The refuge supports many fish and wildlife species and provides suitable habitat and resources for migratory birds of the Pacific Flyway. Portions of the refuge are also used for agricultural purposes. The refuge receives water indirectly from Project facilities in the form of return flow and drainage. Sump 1A and Sump 1B are refuge facilities that are managed to meet wildlife needs, including the needs of endangered suckers. Reclamation through a contract with Tulelake Irrigation District manages deliveries from the sumps and pumping from D-Plant to aid the Tule Lake National Wildlife Refuge in maintaining the elevations necessary in the sumps to meet wildlife needs and requirements.

The proposed action will limit the amount of water in Tule Lake with acceptable water quality for suckers and other fishes (USFWS 2002). Water depth as cover for suckers and as a buffer against poor water quality events is limiting at Tule Lake. The proposed action may affect sucker populations in Tule Lake.

Conclusions

After reviewing the best scientific and commercial data available, Reclamation has concluded that the various aspects of the proposed action may affect and are likely to adversely affect Upper Klamath Basin endangered suckers. The effects of the proposed action may affect proposed Critical Habitat for endangered suckers in the Upper Klamath Basin. The effects of the proposed action are not contradictory to, and would appear consistent with, the sucker recovery plan (USFWS 1993 Sucker). Reclamation also concludes that suckers are adversely affected by the cumulative effects described in the Environmental Baseline. Although many private, State, tribal, and Federal past, present, and planned future actions would appear to provide benefit to endangered suckers, many of these benefits have not yet been realized through substantial recruitment into the adult populations.

Part 3 COHO SALMON

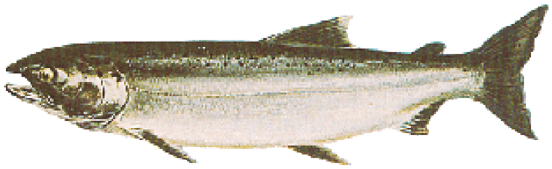
Information about the coho salmon for this BA may be found in this section, including species description, environmental baseline, and effects of the Proposed Action.

Coho Salmon Species Description and Distribution

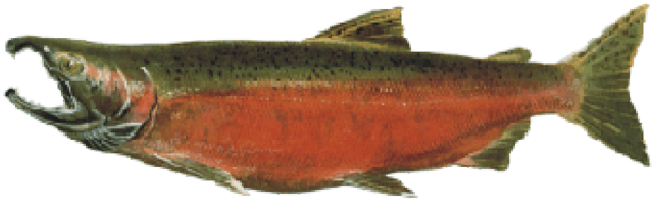
Species Description

Coho salmon (*Oncorhynchus kisutch*) have an anadromous life history in which juveniles are born and rear in freshwater, migrate to the ocean, where they grow to maturity, and adults return to fresh water to spawn. They spawn only once and then die (referred to as semelparity).

In the Klamath River, the majority of the returning spawning coho salmon are three years old. Some precocious males known as "jacks" return as two-year-old spawners. Juveniles typically rear in freshwater for one full year and then migrate to the sea in the spring after their first winter of life.



Adult Female Coho Salmon – Ocean Stage



Adult Male Coho Salmon – Spawning Stage

Distribution

Coho salmon are a widespread species of Pacific salmon, occurring in most major river basins around the Pacific Rim from Monterey Bay in California north to Point Hope, Alaska; through the Aleutians; and from the Anadyr River in Russia south to Korea and northern Hokkaido, Japan (Laufle et al. 1986).

Within the Klamath River Basin, coho salmon may be found throughout the drainage below Iron Gate Dam (IGD). IGD is owned and operated by PacifiCorp and is currently a barrier to anadromous salmonid migrations in the main stem Klamath River. Klamath Project facilities are located upstream of IGD. Table 3-1 shows the approximate river mile for select locations that will be a useful reference for this BA.

Table 3-1. Approximate river mile for select locations from Link River Dam to the mouth of the Klamath River.

Location	*Approximate River Mile*
Link Dam	253.9
East Side	253.1
West Side	252.8
Lake Ewuana Headwaters	252.7
Lost River Diversion Channel	249.2
Miller Island Sampling Point	245.2
New North Canal	243.6
ADY Canal	240.6
Klamath Straights Drain	239.4
Hwy 66 Bridge	234.3
Keno Dam	232.9
JC Boyle Headwaters	227.6
Spencer Creek	227.0
JC Boyle Dam	224.3
Springs	223.8
Springs	223.2
Springs	222.8
JC Boyle Powerhouse	220.0
CA-OR Stateline	209.2
Shovel Creek	206.3
Copco Headwaters	203.6
Copco #1 Dam (A/D Copco to IGD)	198.6
Copco #2 Dam	198.2
Iron Gate Headwaters	197.0
Fall Creek	196.3
Jenny Creek	194.1
Iron Gate Dam	190.5
Bogus Creek	189.6
Willow Creek	185.6
Cottonwood Creek	182.1
Shasta River	177.3
Humbug Creek	171.8
Beaver Creek	161.3
Horse Creek	147.7
Scott River	143.6
Grider Creek	130.5
USGS Gage at Seiad Valley	129.0
Thompson Creek	123.2
Indian Creek	107.4
Elk Creek	105.7
Clear Creek	98.8
Swillup Creek	
Ukonom Creek	89.8
Dillon Creek	84.2
Salmon River	66.4
USGS Gage at Orleans	57.6
Camp Creek	56.5
Red Cap Creek	52.3
Bluff Creek	49.0
Trinity River	43.3
Pine Creek	40.1
Roach Creek	31.5
Pecwan Creek	25.3
Tectah Creek	21.3
Blue Creek	16.4
USGS Gage nr Turwar	5.3
Mouth	0.0

Source: J Hicks, Chief, Planning Division, pers. comm. July 10, 2007.

For the purpose of discussing the impacts on coho salmon within this BA, the Klamath River below IGD is broken into three separate reaches or sections. Since releases at IGD have a diminishing impact on flow within the main stem of the Klamath River as major tributaries enter the Klamath River, these sections are separated by the points of entry for the Scott and Trinity Rivers.

The watershed of the upper section (upstream of the Scott River; river mile 144) is arid and the river channel relatively constrained (p. 29, NMFS 2006). The major tributary of the Klamath River for this reach is the Shasta River (river mile 177). Shasta and Scott River (middle Klamath River) basins differ in terms of their lithology[2], the timing of peak flow, and the influence of springs and snowmelt from other major tributaries of the Klamath River (p. 29, NMFS 2006).

The hydrograph in the middle Klamath River, between the confluences of the Scott River (river mile 144) and the Trinity River (river mile 43), is substantially different from the main stem Klamath River upstream and downstream and in adjacent sub-basins (Salmon River at river mile 66 and the Scott River), particularly in precipitation and flow patterns (p. 29, NMFS 2006).

The reach from the Trinity River confluence to the mouth of the Klamath River will be referred to as the lower Klamath River. The watersheds of this reach are more similar to the smaller adjacent coastal basins, particularly in terms of precipitation patterns and timing of peak flows (p. 29, NMFS 2006).

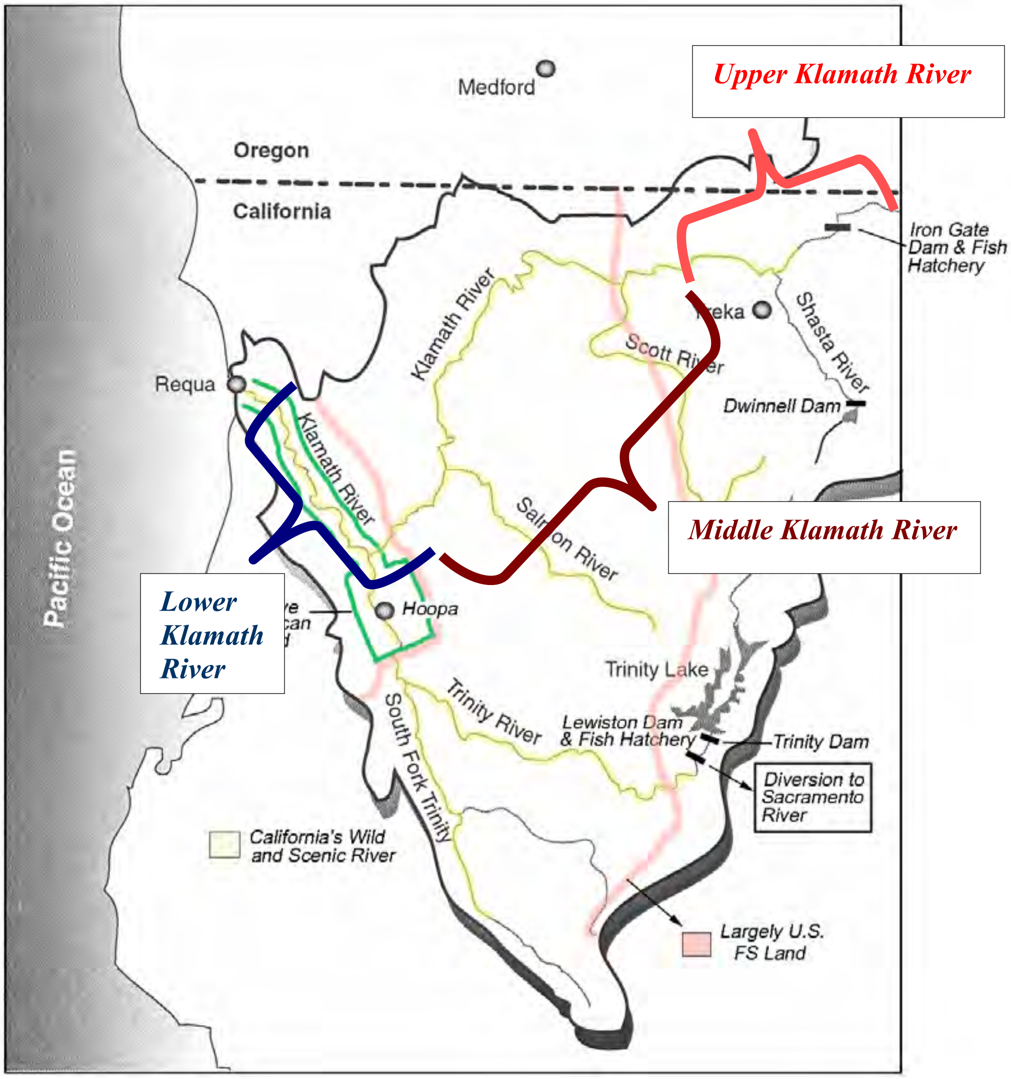
The upper, middle, and lower Klamath River sections combined (from IGD to the mouth) will be referred to as the Lower Klamath River Basin[3] (Figure 3-1). Within the main stem of the Klamath River, in all three sections downstream from IGD to the mouth (middle and lower sections), coho salmon are present at various life stages year round; however, the majority of coho salmon spawn and rear in the tributaries of the Klamath River. IGD is currently an upstream barrier to anadromous fish salmonid migrations in the main stem Klamath River.

---

[2] The study and description of the gross physical characteristics that define a particular rock, including colour, texture, mineral composition, and grain size.

[3] For the purpose of this Biological Assessment, the Klamath River Basin is defined as the entire drainage of the Klamath River.

Figure 3-1. Lower Klamath River Basin includes the Klamath River drainage below the IGD.



Source: U.S. Page. 2, GAO 2005 with alterations by Patricia McClaughry of the Congressional Research Service (CRS), technology office. Alterations to the CRS figure by Keith Schultz, Reclamation, indicate the upper, middle, and lower Klamath River.

Coho Salmon Life History, Abundance, and Trends

The majority of coho salmon within the Klamath River have a three-year life cycle with their time being spent about equally between fresh and salt water. The basic life history begins in natal streams. Spawners mate and deposit eggs into redds dug in the stream substrate. Spawning typically occurs between mid-autumn and early winter from small tributaries to larger rivers, though timing can occur much later for some populations. After spawning, the adults die. Following egg incubation, surviving fry emerge from the substrate in late winter and spring and begin their free swimming life.

The emergent fry move quickly to slow velocity, quiet waters, usually along the stream's edges or into backwaters where water velocities are slower. Juvenile coho salmon typically spend one year rearing in fresh water. Some remain in their natal stream while others migrate within the river basin to find suitable habitat. In the fall, another movement pattern often occurs with juveniles in some areas of the river system, distribution to habitats more favorable for over-winter survival, particularly off-channel habitats (p. xii, Lestelle 2007, also attached as Appendix 3-A).

At approximately 18 months of age, coho salmon juveniles undergo smoltification during spring out-migration and enter the marine environment, where they experience very rapid growth. Across their distribution, adult coho salmon begin arriving at the entrances to their home rivers in late summer, but more typically in early autumn. Fish arrive back to their home river earlier in the northernmost rivers and later in populations further south. This pattern is related to the timing of fall and winter rains and increases in stream flow; flows typically rise later moving from north to south (p. xii, Lestelle 2007).

A central theme in the fresh water life history of juvenile coho salmon is their close association with slow velocity habitats, where body morphology and fin sizes are particularly adapted. Most coho salmon juveniles have a laterally compressed body with long dorsal and anal fins, thought to be adaptations for life in slow water. This build is unlike the sleeker, thinner build of Chinook salmon and steelhead trout (p. xiii, Lestelle 2007).

These minor differences in body shape and fin sizes are consistent with water velocity and depth preferences reported for these three species. Coho salmon prefer much slower velocities than either steelhead or Chinook salmon; Chinook salmon preferences are intermediate between coho salmon and steelhead.

Coho Salmon Fresh Water Habitat Use

The following provides additional information on the freshwater habitats used by coho salmon by their life history stage throughout their distribution. This summary of the fresh water habitat used by coho salmon may be primarily attributed to Lestelle (2007). Lestelle (2007) is attached (Appendix 3-A) and was prepared by Lawrence C. Lestelle for the Klamath Area Office, Reclamation. A further understanding of the freshwater life cycle of coho salmon and its habitat use is important to properly asses the impacts of the Proposed Action.

Adult Migration (October through December)

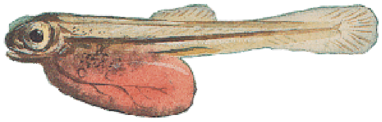
Adult coho salmon primarily use the main channel of the main stem of rivers and tributaries for migrating to spawning sites. They use all habitat types within the main stream and can generally be found holding to rest during the migration in deep water areas, particularly pools. Survival during the fresh water migration is assumed to be high within the Klamath River (Lestelle 2007 and Cramer Fish Sciences 2007; Technical Memorandum 8), although pre-spawning mortality has been observed in some years, such as the 2002 adult salmon fish kill (Guillen 2003).

Spawning (October through December)

Within the Klamath River, coho salmon tend to spawn in small streams or in side channels to the main stem. They sometimes spawn along the river margins (edges) of larger streams but normally not in large numbers. Coho salmon often spawn in relatively high densities in groundwater channels where these habitats exist along the floodplains of rivers.

Egg Incubation and Alevins (November through February)

Survival from egg deposition to fry emergence can vary significantly between streams depending on stream characteristics and local conditions. Changes in stream conditions due to land use can severely reduce survival to the emergence stage (Lestelle 2007).



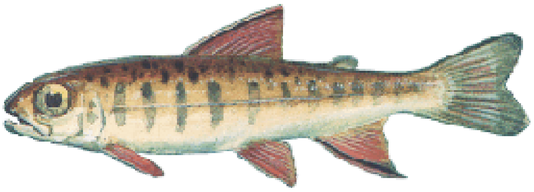
Coho Salmon Alevin

An alevin is a salmon that has hatched and still has a yolk sack.

Two factors most often cited as affecting the survival to emergence of coho salmon are fine sediment loading and bed scour. Following extensive and prolonged land use practices in a watershed that produce these factors, survival to emergence can be reduced by half or more (Lestelle 2007). Survival in spring fed streams with upwelling groundwater is often much higher than in runoff streams where these factors often occur.

Fry Colonization (March through June)

Upon emergence, coho salmon fry move quickly to slow velocity habitats, typically along the channel margin, or they continue to move downstream. They have a strong affinity for very slow velocity water and generally move there as rapidly as possible. Fish that emerge during high flows can be swept downstream, moving them to less suitable habitats, increasing bioenergetics costs, and increasing predation exposure. Survival during the fry colonization stage is mostly density-independent because of their small space requirements.



Coho Salmon Fry

A fry is a young salmon that is free-swimming and feeding. The vertical stripes and bars (parr marks) found on the sides of juvenile salmon assists to camouflage them from predators.

Juvenile Rearing (July through February)

Juvenile coho salmon, referred to as parr, are found residing in a wide variety of stream sizes and types during summer. They are typically found in the highest densities within their natal streams.

Survival of juvenile coho salmon during summer can be strongly density-dependent in smaller streams. Competition for shrinking space, due to declining flows in late summer, as well as limited food, results in reduced survival at higher juvenile abundance. Juvenile coho salmon preference for slow velocity water remains strong during this life stage, where they are most often found in pools. The highest densities are generally found in the pools of the smallest streams.

In large rivers, side channels, off-channel, and channel edge habitats provide important rearing areas for juvenile coho salmon (Beechie et al. 2005). Usually, groundwater channels are used almost exclusively by coho salmon and can be very productive for the species. Rivers and streams with high nutrients and abundant food resources can provide exceptional rearing conditions and increased carrying capacity from an energetic standpoint. Conversely, high water temperatures during the summer can be a limiting factor affecting the distribution, growth, and survival of juvenile coho salmon.

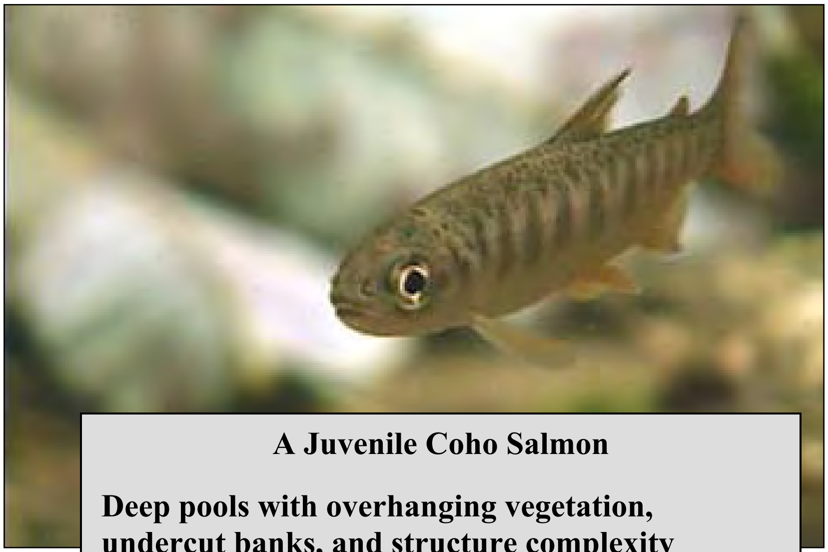
Summer — Thermal Refugia

Animals react not only to immediate changes in their environment but also to cues that signal long-term changes in their environment that prompt adaptation in order to survive. Members of the salmonid family are cold-blooded organisms that can respond to an uncomfortable water temperature by moving from one spot to another to maintain thermal comfort. If the reason they move is because of a discrepancy between the temperature of the surrounding water and a “set point” in their brains that registers thermal comfort, their response is known as behavioral thermoregulation.

High water temperatures can trigger movement of juvenile coho salmon during summer, when little movement typically occurs. Thermal refugia refer to cool water zones that may provide short-term refuge in systems where ambient temperatures during the summer exceed the tolerance of salmonids.

In the Klamath River, the use of thermal refugia by juvenile coho salmon to survive through the summer is well documented (Sutton 2007, Sutton et al.2007). Sutton et al. (2007) stated that most juvenile salmonids were observed moving into the refuge when main stem temperatures exceeded 22 to 23 ºC. However, salmonids in the thermal refuge did not necessarily seek the coolest water, but were generally located in habitats commensurate with species-specific behavioral needs within their thermal tolerance range. Such ranges largely occurred within refuge areas. In his study, thermal regime dynamics indicated that under the hydrological and meteorological conditions observed, higher flows from IGD showed some ability to change the structure of the refuge area, but numbers of fish did not correspond to changes in flows.

Benson and Holt (2005) concluded that higher flows did not negatively impact the thermal refuge at Red Cap Creek in terms of fish use. It appeared that without the thermal refuge, main stem flows alone could not sustain main stem rearing over the summer because high water temperatures usually exceeded their published thermal tolerance limits (Sutton et al. 2007). Observations of non-natal tagged fish and fish in streams with no known spawning populations suggest that use of non-natal tributaries, above their confluences with the Klamath River, provide important over-summer habitat for unknown number of juvenile salmonids, including coho salmon.



A Juvenile Coho Salmon

Deep pools with overhanging vegetation, undercut banks, and structure complexity created by large wood or boulders provide good summer habitat.

The EPA provides water temperature guidance to protect Pacific Northwest salmon and trout. The EPA Quality Criteria for Water considers acute thermal conditions (defined as occurring suddenly or over a short period of time) for coho salmon as 71.6 ºF (22 ºC) and chronic exposures (defined as persisting over a long period of time) to occur at 60.8 ºF (16 ºC). The recommended metric for the above criteria is the maximum 7 day average of the daily maxima (7DADM). This metric is recommended by the EPA because it describes the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over a weeklong period.

Fall Redistribution and Over-wintering (July through February)

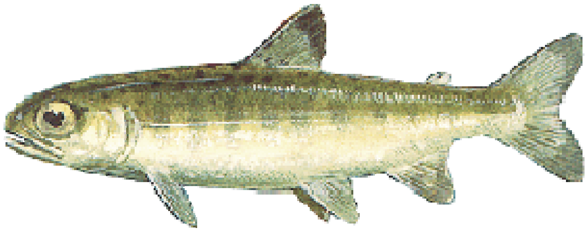
In many streams, some juvenile coho salmon will move from their summer rearing locations in the fall when triggered by increased flows associated with autumn rainfall. Water velocities increase in main stream habitats with rising flow, either dislodging juveniles from their summer rearing sites or stimulating them to move to more favorable slow-water habitats prior to the coming of larger, more frequent winter storms.

Over-winter survival of juvenile coho salmon is approximately two to six times greater in off-channel habitats than within main channel habitats (p. xvi, Lestelle 2007). This difference in survival rates between in- and off-channel habitats is especially important in watersheds that have undergone significant changes due to land use. Coho salmon populations are subject to high over-winter mortality. Populations with poor over-winter habitat show a much reduced life cycle productivity compared to populations with good over-winter habitat. In large rivers, margins of main channels can still provide adequate over-winter habitat depending on case-specific habitat attributes (Beechie et al. 2005).

Smolt Out-Migration (March through June)

In a single watershed, a wide range of smolt out-migration patterns can exist within the overall critical time window. Both migration timing and the rate of migration can be affected by smolt size, location in the watershed at the start of migration, migration distance, temperature, and stream flow.

Larger salmonid smolts generally begin their migration earlier than smaller ones, presumably because smaller ones require additional time to



Coho Salmon Smolt

A smolt is defined as a young salmon undergoing physical changes in preparation for entering salt water. During the smoltification process the parr marks fade.

gain the size necessary for smoltification and for improved marine survival. Early migrants tend to migrate downstream more slowly than late timed fish, a pattern that occurs for salmonid species in general. Flow can also affect migration timing and migration rate.

Factors that can affect the survival rates of migrant smolts in the regulated Columbia and Snake rivers have been extensively studied. While there has been some conflicting discussion on the topic of flow effects on emigration survival, it is generally accepted that survival increases with increased discharge in free flowing river reaches. The effects of flow have also been described in terms of water travel time. Recent research indicates that while migration rate is affected by flow, survival of yearling and older smolts appears to be largely a function of migration distance and exposure time to predators below dams as opposed to travel rate in general (Cramer Fish Sciences 2007; Technical Memorandum 4).

Studies of natural-origin coho salmon smolts show that their migration is not continuous but interspersed by periods of holding. In many cases, it is not rapid once it has been initiated, apparently progressing as if in stages. Smolts generally use slow velocity habitats during periods of holding and resting.

Reclamation and other Federal and State agencies, along with the Tribes[4] have worked cooperatively to determine the extent of IGD flow regimes on the survival of coho salmon smolts during their out-migration. In the first year of the study (spring of 2006), the survival and migration rates of 177 natural-origin and 213 hatchery-origin radio-tagged juvenile coho salmon were estimated within five reaches located between Iron Gate Hatchery (located just downstream of IGD, which is at river mile 190) and the estuary near the mouth of the Klamath River (USFWS 2007 Quarterly Report).

---

[4] Federal agencies and tribes include: USFW, USGS, CDFG, and the Karuk and Yurok Tribes of California.

The study used mark-recapture methods to estimate apparent survival, as well as time-to-event analysis with Cox's proportional hazards regression[5] to compare migration rates of hatchery-origin and natural-origin fish in order to gain insight on factors influencing survival and downstream travel times. Current data and models indicate little support for a survival difference between hatchery-origin and natural-origin coho salmon in 2006, but considerable model uncertainty still exists.

Survival was lower in the reach from Iron Gate Hatchery (river mile 190) to the Scott River (river mile 144) than in reaches located farther downstream. The overall estimate of survival from IGD to river mile 20 (kilometer 33) was 68 percent. Survival was lowest in the uppermost reach closest to IGD. Tagged fish migrated at increased rates as they traveled downstream. Natural-origin coho salmon smolts traveled faster than hatchery-origin smolts downriver from release sites to Indian Creek (river mile 67), but emigration rates of hatchery-origin and natural-origin groups within flow reaches below this point were similar.

Other preliminary results of the project include the observation that tagged coho salmon smolts occupied discrete locations for up to four weeks while migrating downstream. Tagged smolts appeared to be associated with cattails, boulders, undercut banks, submerged willows, and shear zones. The edge habitats used by tagged coho salmon smolts overlapped with habitats used by Chinook salmon fry and is consistent with the observation of edge habitat use by coho salmon in the Skagit River by Beechie et al. (2005) and the importance of cover in the form of submerged vegetation incorporated into Hardy and Addley (2006).

Adult and Juvenile Observations

Adult and juvenile coho salmon are observed in tributaries and the main stem of the Klamath River below IGD; however, these observations often occur incidentally to their main purpose of determining fall Chinook salmon escapement[6]. Thus many of the coho salmon observations available within the Klamath River do not capture the entire population dynamics. However, for both adult and juvenile observations, as discussed below, the data may provide evidence of an increase in abundance in recent years for Trinity River

---

[5] The proportional hazard model is the most general of the regression models because it is not based on any assumptions concerning the nature or shape of the underlying survival distribution. The model assumes that the underlying hazard *rate* (rather than survival time) is a function of the independent variables (covariates); no assumptions are made about the nature or shape of the hazard function.

[6] Escapement is defined as fish that return to their home stream to spawn.

populations, while the Klamath River populations appears to be more stable or slightly decreasing. However, the correlations are not significant ($p > 0.05$).

Adult Observations

Within the Klamath River Basin, most observations of adult coho salmon occur at weir, hatchery, and tribal fishery locations. Once the counting of fall Chinook salmon is terminated, the weirs are removed prior to the high winter flows. salmon spawning is known to extend later into the season than the Chinook salmon spawning. Therefore, counting efforts may not include the later portion of the coho salmon migration. Although, spawning and carcass surveys directed at coho salmon have been conducted both in tributaries and in the main stem of the Klamath River, these surveys have generally been conducted on an inconsistent basis due to the constraints of funding as well as working in high flows.

Current information suggests little main stem spawning is occurring within the lower and middle portion of the Klamath River. From 2003 to 2005, USFWS extended it main stem Klamath River adult salmon surveys into December, as conditions allowed. Although there were logistical and observational challenges, low numbers of adult coho salmon redds were observed in the Klamath River from IGD (river mile 190) to Indian Creek (river mile 107) (Table 3-2). In contrast, Quigley (2005) counted 273 coho salmon redds within four tributaries of the Scott River Basin in 2004. The results indicated to NMFS that “the proportion of main stem spawners may be a relatively small percentage of the annual adult coho salmon spawning population” (see p. 8, NMFS 2007).

Table 3-2. Main stem Klamath River coho salmon redds observed during fall/winter surveys from the IGD (river mile 190) to Indian Creek (river mile 107), 2001 to 2005.

Year of Survey	**Number of Coho Salmon Redds Observed**
2001	21
2002	6
2003	7
2004	6
2005	6

Source: USFWS 2007 as cited on p. 8, NMFS 2007.

Another source of observations within the Klamath River Basin is the annual counts of adult coho salmon returns to the Iron Gate and Trinity River Hatcheries. These annual counts provide information on the abundance of fish returning to these locations (Table 3-3 and depicted graphically in Figure 3-2).

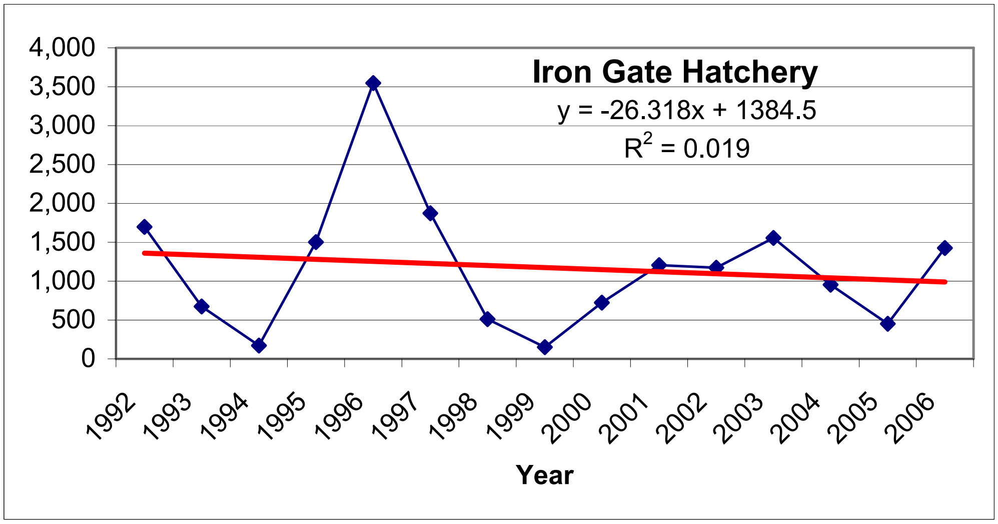
Although there is considerable year-to-year variation among these adult observations, it does appear that there is an increased trend in adult abundance in recent years in the Trinity River with more of a stable trend at Iron Gate Hatchery.

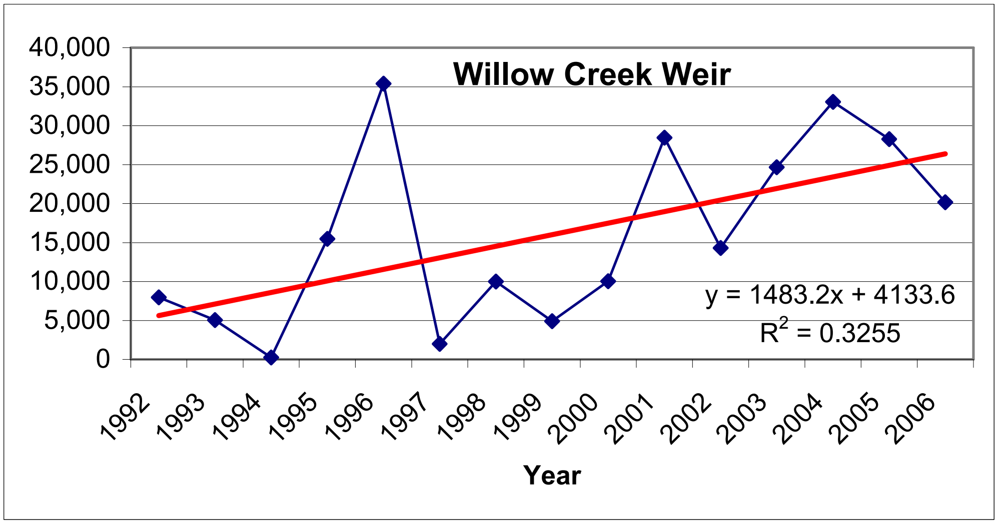
Table 3-3. Adult coho salmon counted at Iron Gate Hatchery and at the Trinity River weir on Willow Creek, 1992 to 2006.

Year	Iron Gate Hatchery	Willow Creek Weir Upstream Abundance Estimate1
1992	1,697	7,961
1993	675	5,048
1994	172	239
1995	1,501	15,477
1996	3,546	35,391
1997	1,872	1,984
1998	511	10,009
1999	151	4,912
2000	723	10,046
2001	1,205	28,470
2002	1,171	14,307
2003	1,555	24,651
2004	954	33,063
2005	451	28,267
2006	1,425	20,162
Average	1,174	15,276
1 Count includes a small number of “grilse.” either a male or female salmon that are less than 20" fork length. 2 Estimate of abundance is extrapolated from weir observations.		

Sources:
1992 to 2001 – NMFS 2002.
2002 to 2006 – Iron Gate Hatchery - CDFG 2007.
2002 to 2003 – Willow Creek Weir - Sinnen et al. 2006.
2005 to 2006 – Willow Creek Weir - NMFS 2007

Figure 3-2. Adult coho salmon counted at Iron Gate Hatchery (top graph) and at the Trinity River weir on Willow Creek (bottom graph), 1992 to 2006. Note the difference y-axis for the two graphs. Although there is considerable year-to-year variation among these adult observations, it does appear that there is an increased trend in adult abundance in recent years in the Trinity River (R square of 0.3255) and a slight decreasing trend at Iron Gate Hatchery. However, the correlation is not significant ($p > 0.05$).





Trinity River historically has been an important producer of natural-origin coho salmon within the Klamath River Basin. In recent years, coho salmon returning to the Trinity River has been dominated by hatchery produced fish. Since 1995, the Trinity River Hatchery has marked 100 percent of hatchery-origin coho salmon released (CDFG 2000). The Willow Creek weir is within the Trinity River drainage but is located below the Trinity River Hatchery and downstream of most natural coho salmon spawning. The Willow Creek weir passes both natural-origin and marked hatchery-origin salmon. Based on the identification of hatchery-origin marks, approximately 90 percent of the adult coho salmon passed through the Willow Creek weir are hatchery-origin fish (NMFS 2002 BO). In 1997 to 2005, the estimated adult coho salmon run ranged between 1,984 and 33,063 fish (see Table 3-3). Naturally-produced coho salmon made up a relatively small portion of the adult run, with estimated abundance ranging from 252 to 8,901. Some naturally-produced fish returned to Trinity River Hatchery, so not all spawn naturally (Table 3-4).

Table 3-4. Adult coho salmon runs by natural and Trinity River Hatchery (TRH) origin to Willow Creek weir (WCW) in the Trinity River.

Return Year	WCW Run Size		Naturally Spawning Fish	
	Natural Origin	TRH	Natural Origin	TRH
1997	252	1,732	232	865
1998	1,001	9,008	886	5,109
1999	555	4,357	440	1,266
2000	342	9,704	288	6,297
2001	3,075	25,395	2,945	15,770
2002	458	13,849	372	7,440
2003	3,930	20,721	3,264	10,991
2004	8,901	24,162	7,830	15,287
2005	2,644	25,623	1,721	9,919

Source: Sinnen et al. 2005, Cramer Fish Sciences 2006; Technical Memorandum 1.

Additional source of observations within the Klamath River Basin are from adult salmon counting weirs. Weirs are currently operated on Bogus Creek [7], Scott

---

[7] Bogus Creek Fish Counting Facility counts: 414 in 2004; 114 in 2005; and, 35 in 2006. However, annual effort was not consistent between years (NMFS 2007).

River[8], and the Shasta River. In the past, a weir was also operated on the Salmon River. However, these weirs are typically removed after the Chinook salmon migration has been completed, but prior to the completion of the coho salmon migration. The usefulness of these projects in estimating the coho salmon abundance is limited.

Since 2001, estimates of naturally produced adult coho salmon at the Shasta River weir have varied from 74 in 2002, to 410 adult fish observed in 2004 (Table 3-5). Adult coho salmon have been observed at the Shasta River weir as early as September 25 (1995), and as late as December 28 (2003). Although the period of operation is inconsistent between years, these observations do confirm that the coho salmon do spawn later than Chinook salmon, with the possibility of limited spawning occurring into January.

Table 3-5. Estimates of naturally produced coho salmon run size based on data collected at the Shasta River Fish Counting Facility (SRFCF), 2001 to 2004.

Year	SRFCF Natural Count Estimate	Last Count Day	Percent Counted[1]	Run Size
2001	207	12/14	94%	220
2002	72	12/17	97%	74
2003	153	12/28	100%	153
2004	373	12/8	91%	410
[1]. Based upon 2003 run timing.				

Juvenile Observations

Juvenile coho salmon sampling occurs in the main stem of the Klamath River and in select tributaries (Table 3-6). The USFWS operates downstream juvenile migrant traps on the main stem of the Klamath River and in the Trinity River. Sampling efficiencies of traps in the main stem Klamath have not been determined adequately to estimate absolute abundance, but the data does indicate migration timing (Figure 3-3), and relative abundance of different life stages at select locations during certain times of the year (NMFS 2002 BO).

Annually, downstream juvenile migrant traps have caught up to 574 natural-origin coho salmon smolts (2002) at the Willow Creek Rotary Screw Trap (Figure 3-4)

---

[8] Scott River live adult coho salmon counts; 17 in 2002; 8 in 2003; and, 1,577 in 2004. Scott River redd counts: 23 in 2005 and 7 in 2006. However, annual effort was not consistent between years (NMFS 2007).

on the Trinity River, and up to 25 natural-origin coho salmon smolts at the Big Bar Rotary Screw Trap (Table 3-6 and Figure 3-5), located at river mile 51 on the main stem of the Klamath River.

Figure 3-3. Passage timing distributions of coho salmon smolts at three main stem Klamath River Trapping locations. Mean passage dates and associated standard deviations for all available years of trapping data (1998 to 2005) were used to derive the normal distributions shown here.

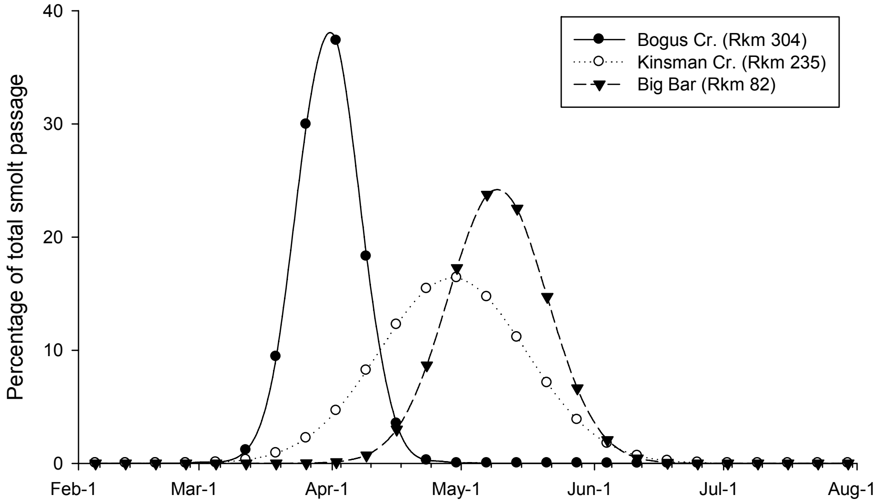


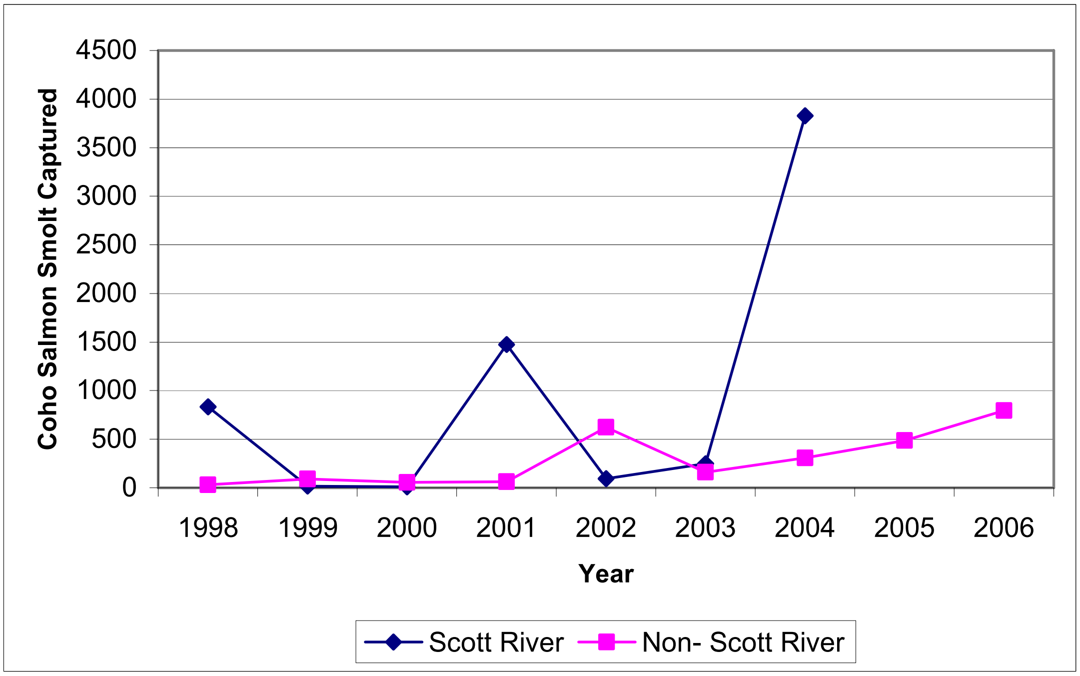
Figure 3-4. The rotary screw trap on Willow Creek, a tributary of Trinity River.

Table 3-6. Natural-origin coho salmon smolt captured in downstream migrant traps in the main stem Klamath River and various tributaries by year 1998 to 2006.

Trap site	Klamath rkm (tributary rkm)	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
Klamath @ Bogus Cr	304.5					1	6	35	6		48
Klamath @ I-5	294.4					15	2	4	4		25
Shasta R	283.2 (0.4)								409	797	1,206
Horse Cr	239.5 (2.6)							88			88
Scott R	232.4 (8.1)			832	19	11	1,473	93	248	3,828	6,504
Klamath @ Kinsman Cr	236.4					8	64	12	35		119
Seiad Cr	211.3 (0.3)							65			65
Klamath @ Happy Camp	172.5							17			17
Elk Cr	172.1 (0.2 & 1.6)							2			2
Klamath @ Persido Bar	137.0							3			3
Salmon @ Somes Bar	105.6 (1.5)					0	2	0			2
Trinity @ Willow Cr	68.8 (34)	32	77	48	54	574	78	65	33		961
Klamath @ Big Bar	82.0	1	3	9	9	25	8	16			71
Total		33	80	889	82	634	1,633	400	735	4,625	9,111

Sources: USFWS data, Klamath Coho Life-Cycle Model Final Report (attached as Appendix 3-B).

Figure 3-5. Natural-origin coho salmon smolt captured in downstream migrant traps in the main stem Klamath River and various tributaries by year 1998 to 2006. Although the traps have had inconsistent periods of operation (days trapped), the data collected do indicate a possible increasing trend in relative abundance, especially for the Scott River.



For tributary origin juvenile coho salmon, the main stem provides a migratory corridor between ocean and tributaries and provides rearing habitat for fry and juveniles. As mentioned earlier, current information suggests that relatively few coho salmon spawn within the main stem of the Klamath River. However, limitations in juvenile trapping data do not allow conclusions of spawning abundance based on this data.

The USFWS described the life history periodicities[9] for anadromous salmonids, including coho salmon, in the Lower Klamath River Basin (USFWS 1997). The USFWS used data from the juvenile out-migrant traps and reviewed relevant literature to conclude that coho salmon fry are present in the main stem Klamath River below IGD from at least April through late July and coho salmon yearlings are present from mid-March through late July.

---

[9] Periodicities may be defined as recurrence at regular intervals. For example, the out-migration of coho salmon typically occurs in March through June in each year.

In 1997, USFWS concluded that juvenile coho salmon likely rear throughout the year in the main stem Klamath River between IGD and Seiad Creek. Consistent with the findings of USFWS are the results of CDFG's 2001 study that indicates the majority of juvenile coho salmon emigrated from the Scott and Shasta Rivers during the period of April 23 through June 24, 2001 (p. 20 NMFS 2002 BO). Both USFWS (1997) and CDFG (1994) indicated that coho salmon fry emigrated from some tributaries to the main stem Klamath River soon after emergence. Further evidence of coho salmon fry emigrating from tributaries to the main stem Klamath River has been observed by the Yurok Tribe (NMFS 2002).

In much of the main stem Klamath River, juvenile coho salmon are forced to seek thermal refugia throughout most of the river during the hottest part of summer (Belchik 2003; Sutton et al. 2007). Summer water temperatures in the Klamath River below Seiad Creek far exceed the preferred range for coho salmon. Thus, rearing capacity in much of the main stem is determined by the availability of thermal refugia, as well as the number of juvenile coho salmon each of these refugia can support. However, summer rearing in non-natal tributaries has the potential to increase the summer carrying capacity of the Klamath River system and the high food abundance in the Klamath River main stem increases the energetic scope of activity of coho salmon that use the main stem on a seasonal basis.

Adult and Juvenile Observation Summary

In summary, adult observations within the Klamath River Basin[10] show considerable year-to-year variation. However, these observations indicate an increasing trend in abundance in recent years for Trinity River populations, while the non Trinity River Klamath River populations appear to be more stable or slightly decreasing; although the correlations are not significant ($p > 0.05$). In regards to juvenile observations, the traps have had inconsistent periods of operation (days trapped); however the data collected do indicate a possible increasing trend in relative abundance, at least for the Scott River.

Coho Salmon Run Size Estimates and Trends

NMFS, in its administration of the ESA, defines anadromous species by Evolutionarily Significant Units (ESUs). An ESU is a population or group of populations of salmon that are substantially reproductively isolated from other populations and contribute substantially to the evolutionary legacy of the biological species. The Southern Oregon/Northern California Coast (SONCC)

---

[10] This is true particularly for the young of the year information at the Willow Creek and Big Bar rotary screw traps.

coho salmon ESU, which includes a portion of the Klamath River Basin, will be discussed in more detail in the next section.

In the 2005 status review of SONCC coho salmon ESU, NMFS found that data on population abundance and trends were limited for the California portion of the SONCC coho salmon ESU, including abundance and trends for populations within the Klamath River Basin (NMFS 2005). NMFS found no regular estimates of natural spawner escapement for coho salmon in the ESU. The historical reviews of population abundance used by NMFS were those by CDFG (1994) and Brown et al. (1994).

These historical estimates on population abundance suggested to NMFS that statewide coho salmon spawning escapement in the 1940s ranged between 200,000 and 500,000 fish. By the early to mid-1960s, statewide escapement was estimated to have declined to just under 100,000 fish (CDFG 1965), with approximately 43,000 fish (44 percent) originating from rivers within the SONCC coho salmon ESU. Wahle and Pearson (1987) estimated that statewide coho salmon escapement had declined to approximately 30,000 fish by the mid-1980s, with about 12,430 (41 percent) originating within the SONCC coho salmon ESU (Table 3-7). For the late 1980s, Brown et al. (1994) estimated natural-origin coho salmon populations at 13,240 for the State of California, and 7,080 (53 percent) for the California portion of the SONCC coho salmon ESU. However, Brown et al. (1994) pointed out that many of the historical estimates were “guesses” that fishery managers and biologists generated using a combination of limited catch statistics, hatchery records, and personal observations. Additionally, Brown et al. (1994) did not include fish returning to the Klamath River Basin.

Table 3-7. Historical estimates of abundance for coho salmon spawners within the Klamath River Basin of the SONCC coho salmon ESU.

Basin, River, or ESU	**Estimated Escapement [1]**		
	CDFG (1965) 1965	**Wahle and Perarson (1987) 1984 to 1985**	**Brown et al. (1994) 1987 to 1991**
Main stem Klamath River and “other” tributaries [2]	8,000	1,000	-
Shasta River	800	300	-
Scott River	800	300	-
Salmon River	800	300	-
Trinity River	5,000	1,500	-
Klamath River Basin Subtotal	**15,400**	**3,400**	**No Estimate**
ESU Total	**43,300**	**12,430**	**7,080 [3]**

[1] Estimates are for natural-origin. Estimates do not include hatchery-origin returns.
[2] Other tributaries do not include the Shasta, Scott, Salmon or Trinity rivers.
[3] ESU total did not include an estimate for the Klamath River Basin.

Source: Table 72, p. 340, NMFS 2005.

In an effort to develop useful tools to assess the operational impacts of Klamath Project operations on coho salmon, Reclamation commissioned Cramer Fish Sciences to conduct a life-cycle analysis of the coho salmon in the Klamath River Basin. The life-cycle model (Klamath Coho Integrated Modeling Framework) objective includes predicting coho salmon production under differing flow regimes in the Klamath River downstream of IGD. The results of the Klamath River coho life-cycle model will be discussed more in a later section. Associated with the model were a series of technical memorandums to support the parameters used in the model. As documented in Cramer Fish Sciences Technical Memorandum 1 (Cramer Fish Sciences 2006 Technical Memorandum 1), Cramer Fish Sciences employed two methods with existing data to derive estimates of returns of natural-origin coho salmon in the Klamath River Basin. Since the available data were limited, it was useful to develop two methods for comparison purposes.

These two methods extrapolated two different data sources within the Klamath River Basin. The comparisons provide a more accurate picture of the returns of natural-origin coho salmon. Reclamation acknowledges that abundance estimates derived by these two methods are, in some instances, highly uncertain. However, these methods attempt to develop reasonable estimates of abundance given the current availability of data within the basin.

The first method Cramer Fish Sciences employed was the "Harvest Sampling Approach," which incorporated data from the Yurok Tribe fishery and estimates of run size above the Willow Creek Weir to estimate annual returns to the Klamath River Basin from 1999 to 2005. The harvest sampling approach is similar to methods employed by the ODFW to estimate returns of natural-origin coho salmon to the Rogue River.

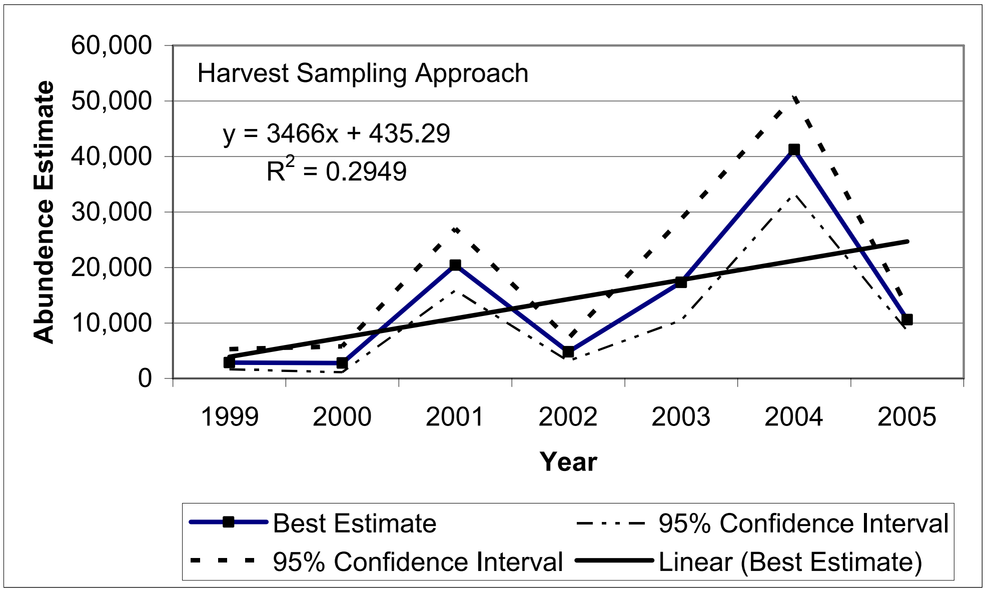
The second method employed, was identified as the "Tributary Approach." It used the best available sampling data in each major tributary to provide a basis for a "professional estimate" of run size in each major tributary from 2001 to 2004. Due to limited data, the Tributary Approach estimates include substantially more uncertainty when compared to the Harvest Sampling Approach. Estimates of the coho salmon returns using these two methods are presented in Table 3-8, and graphically in Figure 3-6. Trends in run sizes across years were similar for each set of estimates. Consistent with the adult and juvenile observations mentioned earlier, run sizes were substantially greater in 2001, 2003, and 2004 than in other recent years.

Table 3-8. Estimated run size of natural-origin coho salmon to the Klamath River using the Harvest Samplings Approach and the Tributary Approach, 1999 to 2005. Due to limited data, the Tributary Approach estimates include substantially more uncertainty when compared to the Harvest Sampling Approach and are based upon professional judgment.

Year	Harvest Sampling Approach		Tributary Approach
	Abundance Best (Estimate)	**95% Confidence Interval**	**Range**
1999	2,872	1,666 – 5,300	-
2000	2,796	1,115 – 5,813	-
2001	20,417	15,862 – 26,973	7,000 – 10,000
2002	4,811	3,133 – 7,223	1,500 – 3,000
2003	17,327	10,487 – 28,742	7,000 – 11,000
2004	41,270	33,326 – 50,750	16,000 – 19,000
2005	10,602	8,599 – 12,922	-

Source: Table 2, p. 9, and Table 10, p. 20 of Cramer Fish Sciences 2006 Technical Memorandum 1.

Figure 3-6. Estimated run size of natural-origin coho salmon to the Klamath River using the Harvest Samplings Approach, 1999 through 2005. The Harvest Samplings Approach indicates an increasing trend. However, the correlation is not significant ($p > 0.05$).



Cramer Fish Sciences also showed that trends between years for abundance of Klamath River coho salmon were similar to those observed in the adjacent Rogue River. NMFS evaluation under existing conditions (p. 341, NMFS 2005), states that "in the Rogue River basin, natural spawner abundance in 1996 was slightly above 1994 and 1995 levels. Abundances in the most recent 3 years were all substantially higher than abundances in 1989–1993 and were comparable to counts at Gold Ray Dam (upper Rogue River) in the 1940s. Estimated return ratios for 1996 were the highest on record...." Reclamation notes that the Rogue and Klamath rivers are similar in that they are the only systems within this ESU that extend inland to the Cascade Mountains.

An interesting result from the Cramer Fish Sciences' Tributary Approach was the ability to partition the first three brood years of coho salmon returns to the Klamath River Basin among the reaches identified within the model (Table 3-9). However, it is noted that the model assumes that spawning failure occurs in the main stem Klamath River every few years due to redd scour at high flows. Cramer Fish Sciences used the reach-by-reach abundance of estimates in 2002 to 2004 to develop the partitioning system that determines how many adult coho salmon go to which reach in each of the three brood years (Cramer Fish Sciences 2007 Report). This information supports the general understanding that little spawning is occurring in the main stem of the Klamath River. Preliminary results suggest that no more then four percent of the brood year return (2002) spawned in the main stem of the Klamath River (Table 11, p. 22, Cramer Fish Sciences 2006 Technical Memorandum 1). However, it is noted that one of the model's assumption is that spawning failure occurs in the main stem Klamath River due to redds being scoured at high flows. Even with this assumption, the contribution of the upper main stem Klamath River is equal or greater in some years to contributions from the Shasta and Scott Rivers, which are critically important populations to spatial distribution and diversity for the SONCC.coho salmon ESU.

Table 3-9. Initial partitioning of the coho salmon Klamath River return to various reaches, Klamath River Basin, 2002 to 2004. This information supports the general understanding that little spawning is occurring in the main stem of the lower and middle Klamath River.

Reach	2002 Brood	2003 Brood	2004 Brood
Upper Main Stem Klamath River	4 %	1 %	1 %
Shasta River	4 %	2 %	2 %
Scott River	2 %	0 %	13 %
Upper Miscellaneous Tributaries	59 %	42 %	21 %
Middle Main Stem Klamath River	0 %	0 %	0 %
Salmon River	2 %	1 %	0 %
Middle Miscellaneous Tributaries	10 %	5 %	7 %
Lower Main Stem Klamath River	0 %	0 %	0 %
Trinity River	20 %	42 %	48 %
Lower Miscellaneous Tributaries	0 %	6 %	8%

Source: Table 11, p. 22, Cramer Fish Sciences 2006 Technical Memorandum 1.

A coarse-scale approach for estimating habitat potential for producing coho salmon, known as Intrinsic Potential[11], has been applied to the Klamath River Basin (Agrawal et al. 2005). The analysis suggests that the greatest availability of high quality coho salmon habitat prior to human development was located in the Scott and Shasta River watersheds. The estimates of coho salmon spawning distribution in Table 3-9 indicate that the Shasta River and Scott River sub-basins are performing far below their pristine potential. Both sub-basins have been substantially altered by human development and water diversions.

---

[11] The Intrinsic Potential (IP) method was developed by Burnette (2001) and Burnette et al. (2003).

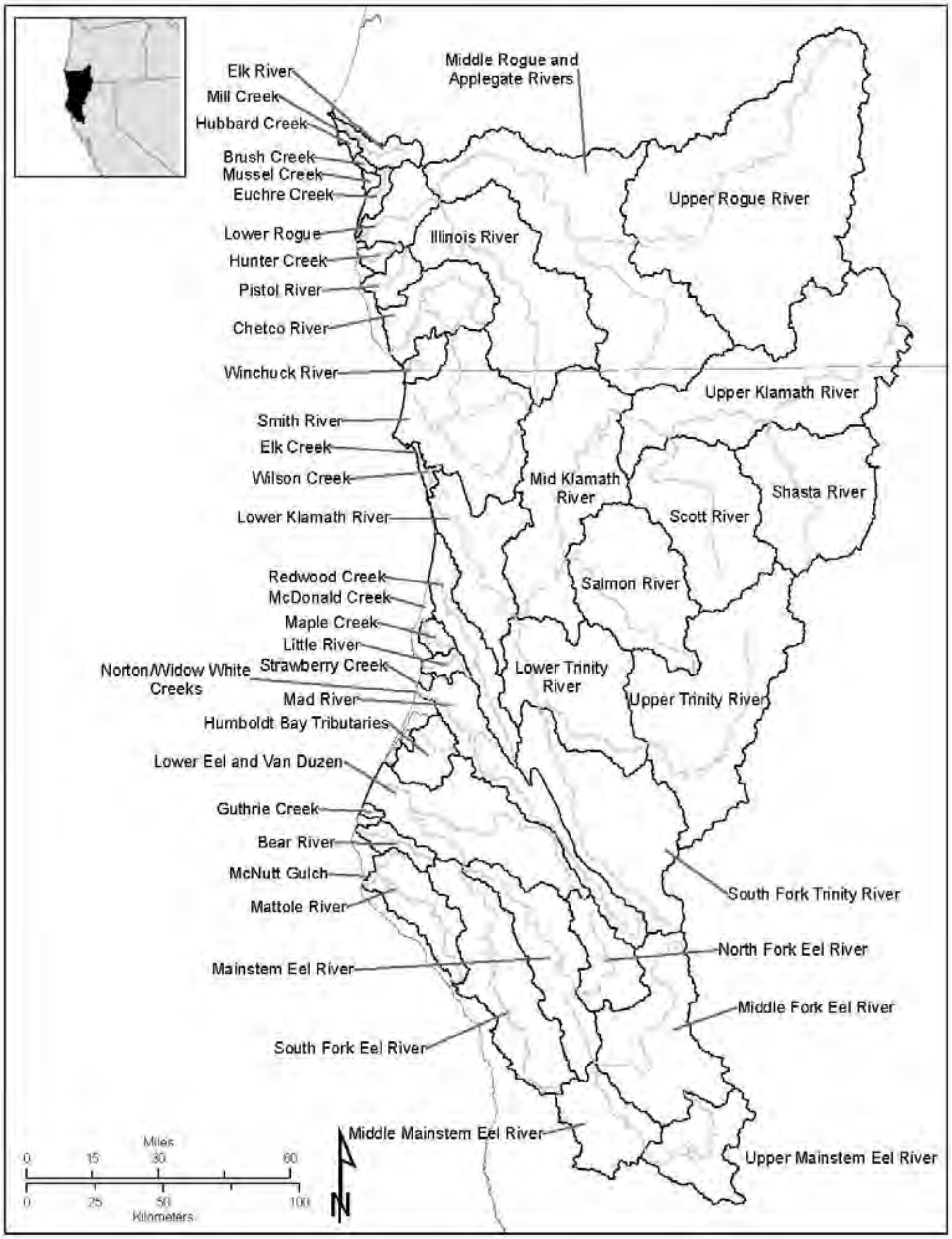
Evolutionarily Significant Unit (ESU)

The SONCC coho salmon ESU was lised as threatened under the ESA in May 6, 1997 (62 FR 24588). The ESA defines threatened as "those animals and plants likely to become endangered within the foreseeable future throughout all or a significant portion of their ranges." Endangered refers to species that are "in danger of extinction within the foreseeable future throughout all or a significant portion of its range."

The SONCC coho salmon ESU includes all natural-origin populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. The SONCC coho salmon ESU includes the Klamath River drainage up to Spencer Creek. Three artificial propagation programs are considered to be part of the ESU: the Cole River Hatchery, Trinity River Hatchery, and Iron Gate Hatchery. The Trinity River and Iron Gate Hatcheries are within the Klamath River Basin. NMFS has determined that these artificially propagated stocks are no more divergent relative to the local natural-origin population(s) than what would be expected between closely related natural-origin populations within the ESU (70 FR 37160; June 28, 2005).

IGD is owned and operated by PacifiCorp and is currently a barrier to anadromous salmonid migrations in the main stem Klamath River. Spencer Creek, the upper boundary of the ESU within the Klamath River Basin, is located immediately upstream of J.C. Boyle Dam and associated reservoir. The confluence of Spencer Creek (river mile 227) and the Klamath River is approximately 37 miles upstream of IGD (river mile 190), thus approximately 37 miles of main stem habitat within the Klamath River is currently not available to anadromous salmon (Figure 3-7). The Klamath Project is upriver of Spencer Creek, thus the Klamath Project is not physically located within the SONCC coho salmon ESU.

Figure 3-7. SONCC coho salmon ESU reflecting independent populations. The SONCC coho salmon ESU includes that portion of Klamath River Basin downstream of and including Spencer Creek. The Klamath Project is upstream of Spencer Creek, thus the Klamath Project is currently not physically located within the SONCC coho salmon ESU.



NMFS Status Reviews

In a technical memorandum, NMFS (2005) summarizes scientific conclusions of the Technical Recovery Teams (TRT)[12] regarding the updated status of 26 ESA-listed ESUs of salmon and steelhead from Washington, Oregon, Idaho, and California. The status review updates were undertaken to allow consideration of new data that accumulated over the various time periods since the last updates and to address issues raised in court cases regarding the ESA status of hatchery fish and resident (non-anadromous) populations. As in the past reviews (1995 and 1997), the Biological Review Team for the SONCC coho salmon ESU concluded that coho salmon in the ESU were not in danger of extinction, but were likely to become so in the foreseeable future if present trends continued. However, in the most recent review (NMFS 2005 Status Review), the Biological Review Team member "votes" on the status of the SONCC coho salmon ESU was not unanimous.

A majority (67 percent) of the Biological Review Team votes fell in the "likely to become endangered" category (Table 3-10). A minority of the Biological Review Team members felt that this ESU is currently not likely to become endangered (received 14 votes; at the other end of the spectrum, in danger of extinction, received 29 votes). These votes reflect the uncertainty that NMFS was operating under in designating the status of the ESU. In a data-poor environment, experts in the field may come to different conclusions.

---

[12] As part of the recovery planning process, the NMFS brought together a group of scientists to serve as a Technical Recovery Teams (TRT) with a goal of providing a scientific context for identifying necessary actions to help the ESU recover. The TRT tasks were to: (1) identify biological viability criteria for populations and the ESU that would lead to recovery and delisting of the ESU; (2) characterize associations between coho salmon abundance and habitat; (3) identify factors of population declines within the ESU; and (4) identify research, evaluation, and monitoring needs.

Table 3-10. Vote distribution of the Biological Review Team regarding the status of the SONCC Coho Salmon ESU. Each of the 13 Biological Review Team members were allocated 10 points (votes) to be placed among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Southern Oregon/ Northern California Coast (SONCC) Coho Salmon	29	87	14

Source: Table 92, p. 401, NMFS 2005

Population Structure

A population is defined as a group of fish of the same species that spawn in a particular locality in a particular season and does not interbreed substantially with fish from any other group (p. 6, NMFS 2006). Because a low level of natural straying is expected to occur, some exchange of fish between adjacent rivers (within-ESU exchanges) probably occurs (Weitkamp et al.1995).

An understanding of the biological organization of populations within an ESU and the temporal and spatial scales relevant to this organization is critical to developing meaningful biological viability criteria. For salmonids, the organization of populations can range from dependent populations, to independent populations, to population groups, and finally to the ESU. NMFS (p. 8, NMFS 2006) defines these population categories as:

(1) *Functionally Independent Populations* are populations with a high likelihood of persisting over 100-year time scales. McElhany et al. (2000) states an independent population is one "whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations."

(2) *Potentially Independent Populations* are populations with a high likelihood of persisting in isolation over 100-year time scales, but are too strongly influenced by immigration from other populations to exhibit independent dynamics.

(3) *Dependent Populations* are populations that do not have a high likelihood of sustaining themselves over a 100-year time period in isolation, yet receive sufficient immigration to alter their dynamics and extinction risk.

(4) *Ephemeral Populations* are populations that do not have a high likelihood of sustaining themselves over a 100-year time period in isolation, and do not receive sufficient immigration to affect this likelihood. Habitats that support such populations are expected to be occupied only rarely.

NMFS stated that few of the biological characteristics examined provide information useful for developing and understanding the historical population structure of SONCC coho salmon ESU populations (p. 17 and p. 18, NMFS 2006). The genetic data provide support for an isolation-by-distance view of population structure, although finer resolution of the population structure from genetic data was not available (NMFS 2006). Information on dispersal rates, life history and phenotypic traits, and population dynamics are also not generally available for the SONCC coho salmon ESU. Where this information is available, NMFS concluded that often it is not collected at a large enough spatial scale useful for distinguishing populations. In addition, the lack of time series and the tendency of many of the characteristics to be highly variable (e.g., run timing, jacking rate[13], etc.) and often attributable to environmental variation limit their use for distinguishing populations (NMFS 2006).

Population size, dispersal rates, life-stage specific survival rates, and fecundity data are not available for populations in the SONCC coho salmon ESU (p. 10, NMFS 2006). NMFS therefore focused on measures of historical habitat carrying capacity, as a metric of population viability. However, as noted earlier, Brown et al. (1994) pointed out that all of these historical estimates are “guesses” that fishery managers and biologists have generated using a combination of limited catch statistics, hatchery records, and personal observations. NMFS acknowledged that the analysis of population structure was strongly constrained by the lack of available data (p. 42, NMFS 2006).

Identified Populations within the SONCC Coho Salmon ESU

NMFS has recognized that our understanding of the current status of coho salmon in this region is imprecise and that available data is sparse and provides a poor foundation for rigorous analysis of the processes that influence these populations. In place of detailed, local information, NMFS drew on data and analyses developed elsewhere and applied what has been learned to similar situations in the SONCC coho salmon ESU (p. 43, NMFS 2006).

The geographic setting of the SONCC coho salmon ESU includes three large basins and numerous smaller basins across a diverse landscape. The Rogue River and Klamath River extend beyond the Coast Range and include the Cascade Mountains. For the Rogue River, Klamath River, and Eel River basins of the SONCC coho salmon ESU, the approach NMFS used to determine populations

---

[13] Jacking rate is defined as the proportion of adult coho salmon from a brood that return as jacks. Jack is defined as a coho salmon that matures at age 2 and returns from the ocean to spawn a year earlier than normal. Jacks are all male fish.

was essentially to divide these large basins into major sub-basins. NMFS subsequently determined that the populations in these larger sub-basins were acting as Functionally Independent Populations and the populations in the smaller sub-basins acted as Potentially Independent Populations.

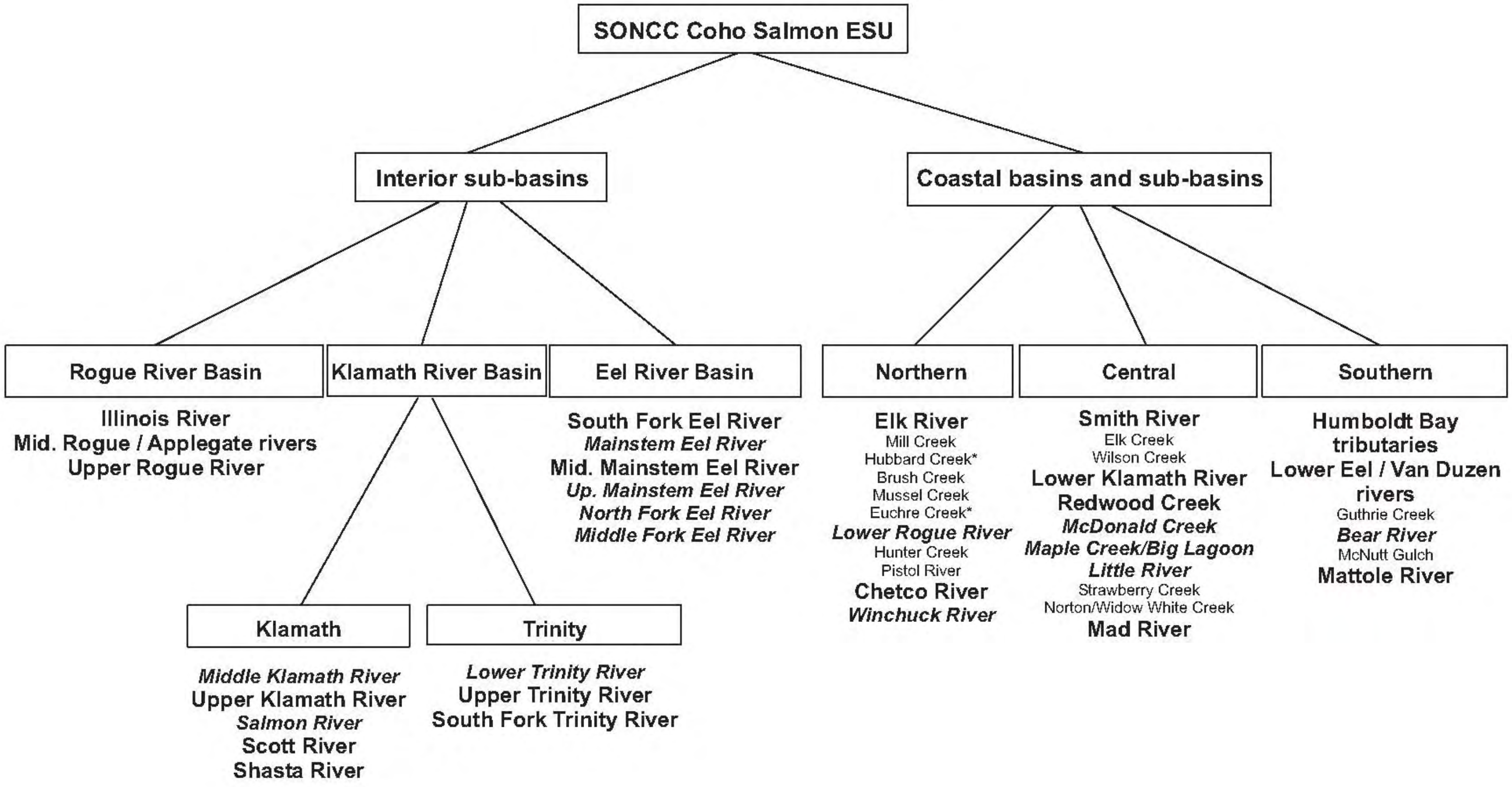
NMFS further divided these larger basins into interior and coastal sub-basins (p. 23, NMFS 2006).

- *Interior sub-basins:* This group includes the middle and upper portions of the Rogue River, Klamath River, and Eel River basins. Within the interior sub-basins, the upper portions are characterized by higher mean elevations, stream flows heavily influenced by snowmelt, wide seasonal fluctuations in air temperature, and cooler minimum air temperatures compared to coastal basins. The middle portions of these large river systems have sub-basins that are characterized by warmer maximum air temperatures, less seasonal fluctuations in air temperature than upper sub-basins, warmer minimum air temperatures, and little influence of snowmelt.

- *Coastal basins*: These areas are characterized by warmer winter air temperatures, low elevations, warmer mean air temperatures, less seasonal fluctuations in air temperature, and located within the coastal ecoregion. Included in this group are the lower portions of the Rogue River, Klamath River, and Eel River, as well as the Van Duzen River which are similar based on the environmental variables in the analysis.

With these qualifiers, the NMFS Technical Recovery Team has preliminarily identified 62 historical populations within the SONCC coho salmon ESU, of which 27 are considered functionally independent and potentially independent, with all other coho salmon populations dependent on others within the ESU (Figure 3-8).

Figure 3-8. Arrangement of the historical populations within the SONCC coho salmon ESU. The Lower Klamath River population is considered part of the Central Coastal Sub-basin. Functionally independent populations are listed in bold font, potentially independent populations are listed in bold italic font, and all other listed populations are dependent and ephemeral population.



Source: Figure 9, p. 46, NMFS 2006.

Identified Populations within the Klamath River Basin

NMFS (2006 Historical Populations) analysis suggested substantial environmental variability within the Klamath River Basin results in nine populations: lower Klamath River; middle Klamath River; Salmon River; Scott River; Shasta River; lower Trinity River; upper Trinity River; South Fork Trinity River; and the upper Klamath River (Table 3-11).

Table 3-11. Klamath River Basin historical populations, as determined by NMFS, and boundaries for those populations, SONCC coho salmon ESU.

Basin	Population	Boundary
Klamath River	Lower Klamath River Population	**River mile 0 to river mile 43.** Mouth of Klamath River upstream to confluence with Trinity River.
	Middle Klamath River Population	**River mile 43 to river mile 128.** Confluence of Trinity River upstream to and including Portuguese Creek (inclusive); and includes the Seiad and Grider Creek drainages, which are upstream of the confluence of Portuguese Creek.
	Upper Klamath River Population	**River mile 128 to river mile 227.** Portuguese Creek (non-inclusive) upstream to Spencer Creek (inclusive), excluding Seiad and Grider Creeks, which are considered part of the Middle Klamath River population.
	Salmon River Population	**Mouth at river mile 66.** Confluence of Klamath River is lower boundary.
	Scott River Population	**Mouth at river mile 144.** Confluence of Klamath River is lower boundary.
	Shasta River Population	**Mouth at river mile 177.** Confluence of Klamath River is lower boundary.
	South Fork Trinity River Population	**Mouth of Trinity River at river mile 44.** Confluence of Trinity River is lower boundary.
	Lower Trinity River Population	**Mouth of Trinity River at river mile 44.** Confluence of Klamath River upstream to confluence with North Fork Trinity River (non-exclusive).
	Upper Trinity River Population	**Mouth of Trinity River at river mile 44.** Confluence of North Fork Trinity River (inclusive) upstream to Ramshorn Creek (inclusive).

It is noted that the boundaries for the Upper Klamath River Population is from the confluence of Portuguese Creek (river mile 128) and extends upstream to and includes Spencer Creek (river mile 227). Spencer Creek is upstream of the IGD (river mile 190). The IGD is currently an upstream barrier to anadromous salmonid migrations in the main stem of the Klamath River. Thus, that portion of the boundaries for the Upper Klamath River Population between IGD and Spencer Creek (approximately 37 miles) is currently unavailable to this population.

Viable Salmonid Populations (VSP) Guidance

The VSP document (McElhany et al. 2000) describes four key parameters for evaluating the status of salmonid populations: population size (abundance); population growth rate (productivity); spatial structure; and, diversity.

(1) *Population Size:* Generic guidance from the VSP paper suggests that effective population sizes of less than 500 to 5,000 fish per generation are at increased risk (McElhany et al. 2000)). The population size range per generation was converted to an annual spawner abundance range of 175 to 1,750 fish by dividing by three, which is the generation length for the majority of the Klamath River coho salmon.

(2) *Productivity:* Productivity is generally understood to be the ratio of the abundance of juveniles or adults produced in one generation to the abundance of their parent spawners. Productivity is primarily driven by habitat quantity, quality, and reproductive fitness.

(3) *Spatial Structure:* The spatial structure of a population results from a complex interaction of the genetic and life history characteristics of a population, the geographic and temporal distribution and quality of habitat; and the disturbance level of the habitat. Although the understanding of these interactions is limited, the ability of individuals to successfully colonize and move through habitat at each subsequent life stage is essential for population viability.

(4) *Diversity:* The transfer from parents to offspring (heritability) of certain biological traits such as age at maturity, growth rate, and the effect of these traits on each other has been researched and described. As an example, under certain circumstances, fishing may influence the biological traits of salmon that return to spawn, and potentially the traits that are conveyed to their offspring. Diversity in biological traits is important so that populations can successfully respond to changing environmental conditions.

2005 ESU Risk Assessment by Criteria

In a recent NMFS (2005) status review, NMFS used the four VSP criteria (abundance, productivity, spatial structure, and diversity) to assess the ESU. Reclamation understands that these criteria will also be used as a framework for approaching formal ESA recovery planning for salmon. The Biological Review Team that reviewed the SONCC coho salmon ESU found moderately high risks for abundance and growth rate/production (productivity), with mean matrix scores of 3.5 to 3.8, respectively, for these two categories. The Biological Review Team considered risks to spatial structure (mean score = 3.1) and diversity (mean score = 2.8) to be moderate (Table 3-12).

Table 3-12. Summary of risk scores (1 = low to 5 = high) for four VSPs Criteria. Data presented are the mean followed by the (range). The Biological Review Team found moderately high risks for abundance and growth rate/production (productivity).

ESU	**VSPs Criteria**			
	Abundance	**Productivity**	**Spatial Structure**	**Diversity**
SONCC Coho Salmon	3.8 (2 to 5)	3.5 (2 to 5)	3.1 (2 to 4)	2.8 (2 to 4)

Source: Table 93, p. 401, NMFS 2005.

As documented by NMFS (2005), the Biological Review Team remained concerned about low population abundance throughout the SONCC coho salmon ESU relative to historical numbers and long-term downward trends in abundance. However, the scarcity of data on escapement of natural-origin spawners in most basins continued to hinder risk assessment. A reliable time series of adult abundance is available only for the Rogue River. The Rogue River is not within the Klamath River Basin but is within the ESU. Reclamation notes that the Rogue and Klamath Rivers are similar in that they are the only systems within this ESU that extend inland to the Cascade Mountains.

Data for the Rogue River indicate that long-term (22-year) and short-term (10-year) trends in mean spawner abundance are on the rise in the Rogue River. Less-reliable indices of spawner abundance in several California populations reveal no apparent trends in some populations and suggest possible continued declines in others. Additionally, the Biological Review Team considered the relatively low occupancy rates of historical coho salmon streams (between 37 and 61 percent from brood years 1986 to 2000) as an indication of continued low abundance in the California portion of this ESU (NMFS 2005).

The moderate risk matrix scores for spatial structure reflected a balancing of several factors. The modest percentage of historical streams still occupied by coho salmon is suggestive of local extirpations or depressed populations. The Biological Review Team also remains concerned about the possibility that losses of local populations have been masked in basins with high hatchery output. The

Biological Review Team's concern for the large number of hatchery fish in the Rogue River, Klamath River, and the Trinity River systems was also evident in the risk rating of moderate for diversity.

The extent to which the strays from hatcheries in these systems are contributing to natural-origin production remains uncertain. However, NMFS (2005) generally believes that hatchery-origin fish and progeny of hatchery fish constitute most of the production in the Trinity River and may be a significant concern in parts of the Klamath River and Rogue River systems as well. On the positive side, the Biological Review Team determined that populations can still be found in all major river basins within the ESU. Although extant populations reside in all major river basins within the ESU, there is concern about the loss of local populations in the Trinity River, Klamath River, and Rogue River systems. Additionally, the relatively high occupancy rate of historical streams observed in brood year 2001 suggests that much habitat remains accessible to coho salmon. However, the high hatchery-origin production in these systems may mask trends in ESU population structure and pose risks to ESU diversity.

Both the presence-absence and trend data presented by NMFS (2005) suggest that many coho salmon populations in this ESU are continuing to decline. Presence-absence information from the past twelve years indicates fish have been extirpated or at least reduced in numbers sufficiently to reduce the probability of detection in conventional surveys. Population trend data were lacking in this ESU, nevertheless, for those sites that did have trend information, NMFS (2005) concluded that evidence suggests declines in abundance.

Critical Habitat

On May 5, 1999, critical habitat was designated for the SONCC coho salmon ESU (64 FR 24049). Critical habitat includes all waterways, substrate, and adjacent riparian zones below longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). NMFS has identified twelve dams in the range of these ESUs that currently block access to habitats historically occupied by coho salmon, including the IGD. However, NMFS has not proposed these inaccessible areas as critical habitat because areas downstream are believed to be sufficient for the conservation of the ESUs. A Recovery Team will be convened by NMFS to address whether additional habitat is necessary to recover coho salmon.

Environmental Baseline

Environmental baseline is a pivotal concept in section 7 consultations as it provides the foundation for the effects analysis. As stated in 50 CFR 402.02, "*The Environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process…*" The regulations also define "*effects of the action*" as "*the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interdependent[[14]] and interrelated[[15]] with that action, that will be added to the environmental baseline*" (50 CFR 402.02).

Assessing the effects on the environmental baseline for ongoing projects, such as the 100 year old Klamath Project, is complicated by the fact that many preexisting aspects of the project are part of the environmental baseline, while other aspects associated with the project's Proposed Action are the subject of the consultation.

Past and Present Impacts on Coho Salmon

Coho salmon on the west coast of the United States have experienced significant declines in abundance during the past several decades as a result of both human-induced and natural factors. Multiple factors are responsible for this decline.

Within the SONCC coho salmon ESU, dam construction has blocked access to coho salmon habitat in portions of the Eel River, Mad River, Trinity River, Rogue River and the Klamath River basins. Within the Klamath River Basin, an estimated 20 percent of historical coho salmon habitat is no longer available (62 FR 62741; November 25, 1997).

Past coho salmon harvests by ocean salmon fisheries have also contributed to the decline of SONCC coho salmon ESU. Currently, only incidental "hook-and-release" of natural-origin coho salmon continues in ocean salmon fisheries. For a certain percentage of the coho salmon caught in a "hook-and-release" fishery, the stress of being caught and released causes direct or delayed mortality. However,

---

[14] Interrelated actions are part of a larger action and depend on the larger action for their justification (50 CFR, Section 402-02). Interrelated actions are typically "associated with" the Proposed Action.

[15] Interdependent actions have no independent utility apart from the Proposed Action (50 CFR Section 402-02). Interdependent actions are typically "because of" the Proposed Action.

capture rates for coho salmon have been reduced from a high of 80 percent to a low of 5 percent in recent years in non-tribal fisheries now directed at Chinook salmon (NMFS 2002 BO). Poor and uncertain hatchery practices in the past also continue to have lingering adverse effects on natural-origin populations in the ESU. For example, stock transfers from outside of the Klamath River Basin, which did occur in the past, might change the genetic bases or phenotypic[16] expression of life-history characteristics in a natural population in such a way that the population might seem either less or more distinctive than it was historically.

Timber harvest activities, associated road construction, grazing, and mining activities have degraded adjacent aquatic habitat conditions. This was acknowledged in the Northwest Forest Plan (USDA and USDI 1994 as cited in NMFS 2002 BO), which guides present and future Federal land management activities in the Klamath River Basin.

Water was diverted and pumped for use in sluicing and hydraulic mining operations have also contributed to the decline in coho salmon. Mining operations can result in dramatic increases in turbidity levels and physical alterations of the streambed altering stream morphology. The negative impacts of stream sedimentation on fish abundance from mining were observed as early as the 1930s.

Water management throughout the Klamath River Basin has altered the historical hydrology. The magnitude and timing of water flows has significantly changed in the Trinity, Shasta, and Scott Rivers and in the main stem of the Klamath River. Agricultural activities, including return flows from irrigation, are also known to increase nutrient loading through runoff into adjacent streams. These activities have likely resulted in adverse effects to coho salmon as well as other fish species, including other salmonids.

Climate variability also plays a large role in driving the fluctuations in salmon abundance by influencing their physical environment, the availability of food, the competitors for that food, and the predators that prey on salmon.

Harvest, hatchery practices, land use, water management, and climate variability, including ocean conditions, have all contributed to declines in coho salmon abundance throughout the West Coast. These components will be discussed in more detail below.

---

[16] Phenotype may be defined as the characteristics shown in an individual of the genetic traits it inherited.

Harvest

Excess fishing is believed to have been a factor in the decline of coho salmon until the mid-1990s when harvest was substantially curtailed (62 FR 24588; May 6, 1997). Since 1994, the retention of natural-origin coho salmon has been prohibited in marine fisheries south of Cape Falcon, Oregon. Retention of marked hatchery-origin fish has been allowed off the coast of Oregon in recent years. Impacts to natural-origin coho salmon occur as a result of hook-and-release mortality in directed fisheries for either Chinook or hatchery-origin coho salmon.

Coho salmon originating from the Klamath River Basin are contacted by ocean fisheries primarily off the coast of California. Coded wire tagged coho salmon released from hatcheries south of Cape Blanco have a southerly migration pattern, primarily to California (65 to 92 percent), with some recoveries in Oregon (7 to 34 percent), and (1 percent) in Washington or British Columbia (Weitkamp et al. 1995). The above percentage data represents the range of recoveries for five hatcheries.

In recent years, the Pacific Fishery Management Council (PFMC) has recommended regulations that do not allow directed coho salmon fisheries or the retention of coho salmon south of Humbug Mountain in Oregon. In establishing recommendations for ocean salmon fisheries, the PFMC was guided by the reasonable and prudent alternatives of NMFS 1999 Supplemental BO and Incidental Take Statement reasonable and prudent measures and terms and conditions for SONCC coho salmon ESU. This required marine exploitation rates less than or equal to 13 percent, as indicated by Rogue River and Klamath River hatchery-origin salmon stocks.

Table 3-13 provides the projected exploitation rate on Rogue and Klamath River hatchery-origin salmon for the last five years (2002 to 2006). The extent to which coded-wire tagged recovery patterns of these hatchery-origin salmon coincide with the distribution patterns of natural-origin coho salmon is not known.

Table 3-13. Projected exploitation rate on Rogue and Klamath River Hatchery-origin coho salmon, 2002 to 2006.

Year	Projected Exploitation Rate on Rogue and Klamath River Hatchery-origin Coho Salmon	Source
2002	7.7 percent	p. III-13, PFMC 2003
2003	7.7 percent	p. 66, PFMC 2004
2004	7.7 percent	p. 67, PFMC 2005
2005	7.7 percent	p. 70, PFMC 2006
2006	5.2 percent	p. 67, PFMC 2007
Average	7.2 percent	

Direct harvest of coho salmon within the Klamath River Basin was terminated in 1994, with the exception of a limited harvest for subsistence and ceremonial purposes of the Yurok, Hoopa Valley, and Karuk tribes. Recent harvests of coho salmon in the Yurok Tribe fishery include[17]: 486 in 2002; 343 in 2003; and, 1,540 in 2004 (NMFS 2007). This harvest includes both hatchery-origin and natural-origin coho salmon. NMFS (2002 BO) estimated the annual tribal harvest of coho salmon to average less than 100 natural-origin coho salmon and less than 1 percent of the annual return of natural-origin coho salmon to the SONCC coho salmon ESU.

Restrictions on recreational and commercial harvest of coho salmon since 1994 within the Klamath River Basin has undoubtedly had a beneficial effect on coho salmon adult returns to SONCC coho salmon ESU streams (p. 363, NMFS 2005). Mortality associated with incidental or illegal catch of natural-origin populations within the SONCC coho salmon ESU is uncertain, but is believed to be low (CDFG 2002).

Artificial Propagation

There are concerns that hatchery-origin fish may harm natural-origin populations. Specifically, some fishery biologists are concerned that a preponderance of hatchery-origin fish in a population could weaken that population's ability to respond to a diversity of environmental stresses and conditions. In addition, there have been concerns that hatchery-origin fish could carry disease to the natural-origin population and reduce genetic variation.

---

[17] Annual effort was not consistent between years.

Weitkamp et al. (1995) identified four hatcheries that were producing and releasing coho salmon within the SONCC coho salmon ESU during the mid-1990s: Mad River Hatchery, Trinity River Hatchery, Iron Gate Hatchery, and Cole River Hatchery. Prairie Creek Hatchery produced coho salmon for many years but closed in 1992 (CDFG 2002). Rowdy Creek Hatchery is a privately owned hatchery that has produced coho salmon in the past. However, the facility did not produce coho salmon in 1999 and 2000 due to lack of adult spawners (CDFG 2002), and no further production of coho salmon at this facility is planned. A more detail discussion of the Iron Gate Hatchery and the Trinity River Hatchery follows.

Iron Gate Hatchery

Iron Gate Hatchery, located on the Klamath River near Hornbrook, California, approximately 190 river miles (306 km) from the ocean, was founded in 1965 and is operated by the CDFG. The Iron Gate Hatchery was built by Pacific Power and Light Company to mitigate the effects of both habitat loss from Copco 2 to IGD and the effects associated with IGD operations on natural-origin salmonids, including coho salmon that naturally occurred in the upper Klamath River (CDFG 2002 and Salmon and Steelhead Hatchery Assessment Group [SSHAG] 2003).

The coho salmon stock at the Iron Gate Hatchery was initially developed from eggs taken from the Klaskanine Hatchery in Oregon in 1966. Klaskanine Hatchery is located along the North Fork Klaskanine River (Columbia River Basin) approximately 12 miles southeast of Astoria, Oregon. In an effort to increase returns to Iron Gate Hatchery, coho salmon from Cascade Hatchery (Columbia River Basin) were released in 1966, 1967, 1969, and 1970 (CDFG 2002 and CDFG 2003 Preliminary Conclusions). Since 1977, only the offspring of coho salmon returning to the Klamath River Basin have been released from Iron Gate Hatchery (CDFG 2003 Preliminary Conclusions).

Annual releases of coho salmon from the Iron Gate Hatchery have decreased from an average of approximately 147,000 fish from 1987 to 1991, to 93,206 fish from 2003 to 2007 (Table 3-14). CDFG reduced these releases to more closely adhere to the Iron Gate Hatchery mitigation goal of 75,000 coho salmon yearlings per year. Adult returns averaged 1,120 annually between 1991 and 2000, and 161 females on average have been spawned annually for broodstock during this period. The adult coho salmon return averaged 1,355 from 2001 to 2006 (K. Rushton, Fish Hatchery Manager II, CDFG, August 1, 2007 pers. comm.).

Table 3-14. Iron Gate Hatchery coho salmon releases as yearlings, 1964 to 2007.

Brood Year	Release Year	Number of Fish	Brood Year	Release Year	Number of Fish
1964	1966	82,854	1986	1988	135,000
1965	1967	19,502	1987	1889	143,400
1966	1968	31,507	1988	1990	122,962
1967	1969	68,848	1989	1991	130,000
1968	1970	100,080	1990	1992	84,999
1969	1971	519,835	1991	1993	144,998
1970	1972	47,700	1992	1994	76,999
1971	1973	10,000	1993	1995	79,506
1972	1974	80,000	1994	1996	74,250
1973	1975	185,000	1995	1997	81,498
1974	1976	0	1996	1998	79,607
1975	1977	125,000	1997	1999	75,156
1976	1978	151,326	1998	2000	77,147
1977	1979	87,000	1999	2001	46,254
1978	1980	51,000	2000	2002	67,933
1979	1981	99,812	2001	2003	74,271
1980	1982	121,856	2002	2004	109,374
1981	1983	120,672	2003	2005	74,716
1982	1984	78,042	2004	2006	89,482
1983	1985	22,059	2005	2007	118,187
1984	1986	179,760			
1985	1987	205,000			

Source: K. Rushton, Fish Hatchery Manager II CDFG, August 1, 2007 pers.comm.

With the possible exception of the Trinity River, the CDFG and NMFS Southwest Region Joint Hatchery Review Committee (2001) noted that no accurate estimates of the relative contribution of natural-origin versus hatchery-origin fish are available for the Klamath River Basin. Beginning in 1995 and continuing up to the present, a portion of the coho salmon released annually from the Iron Gate Hatchery has been marked with left maxillary clips. In previous status reviews, NMFS's Biological Review Team was uncertain whether the use of nonnative stocks to start the Iron Gate Hatchery population was sufficient to have lasting effects on the present population. However, since out-of-basin and out-of-ESU transfers ceased by 1977, NMFS concluded that coho salmon from the artificial coho salmon propagation program at the Iron Gate Hatchery is now part of the SONCC coho salmon ESU.

Trinity River Hatchery

Trinity River Hatchery is below Lewiston Dam, approximately 154 river miles (248 km) from the ocean. The hatchery first began releasing coho salmon in 1960. The Trinity River Hatchery facility originally used Trinity River fish for broodstock, though coho salmon from Eel River (1965), Cascade Hatchery (1966, 1967, and 1969), Alsea River (1970), and Noyo River (1970) have also been reared and released at the hatchery.

Trinity River Hatchery produces the largest number of coho salmon of any production facility in California. The Trinity River Hatchery target annual production is 500,000 yearlings. Actual production averaged 496,813 from 1987 to 1991, decreased to 385,369 from 1992 to 1996, then increased again to 527,715 fish from 1997 to 2002. Coho salmon releases for the years 2003 to 2007 averaged 50,384. During the period 1991 to 2001, an annual average of 3,814 adult coho salmon returned to the hatchery, and an average 562 females were spawned at the Trinity River Hatchery. For the years 2002 to 2006, an average of 798 coho salmon females were spawned. Returning coho salmon from 2002 to 2006 averaged 11,738 fish, (L. Marshall Jr., CDFG, August 2, 2007, pers. comm.)

Currently, it is assumed that there is little natural production of coho salmon in the Trinity River system and available data generally support this assumption. All of the Trinity Hatchery fish are marked. Between 1997 and 2002, hatchery fish constituted between 89 and 97 percent of the fish (adults plus grilse) returning to the Willow Creek weir in the lower Trinity River (Sinnen 2002). Out-migrant trapping conducted on the lower Trinity River indicated that marked Trinity River Hatchery fish comprised 91 percent, 97 percent, and 65 percent of the catch in 1998, 1999, and 2000, respectively (Yurok Tribal Fisheries Program 2002).

NMFS (2005 Status Review) concluded that coho salmon from the Trinity River Hatchery should be considered part of the SONCC coho salmon ESU. NMFS made this determination because out-of-basin and out-of-ESU transfers ceased by 1970 and production since 1970 has been exclusively from fish within the basin.

Land Use

Industrious land management began in the late 1880s. During the "Great Depression[18]," many new roads were built in the Klamath River Basin and new territory was opened up for logging. Many of these roads featured stream crossings that were not designed to allow for fish passage. After World War II, technological improvements such as power saws, bulldozers, rafts, tugs, trucks and trailers allowed for an increased rate of timber harvest in the Klamath River Basin.

The effects of land management activities on streams and fish habitat are well documented (Sullivan et al. 1987; Hartman and Scrivener 1990; Meehan 1991). Forest management activities that influence the quantity, quality, or timing of stream flows affect fish habitat primarily through changes in the normal levels of peak flows or low flows (Sullivan et al. 1987; Chamberlin et al. 1991). Water outflows from hillsides to streams are affected through changes in evapotranspiration[19], soil water content, and soil structure.

Timber Harvest

Roads associated with timber harvest account for a large portion of the erosion that occurs in logged areas. Poor road design, location, construction and maintenance cause erosion of all types: mass soil movement, surface, gullies, and stream bank. Harvest has expanded from established roads into more inaccessible terrain and areas of greater environmental risk.

A logging truck prepares to head down the Mount Ashland access road.

In general, timber management activities allow more water to reach the ground, and may alter water infiltration into forest soils such that less water is absorbed or the soil may become saturated faster, thereby increasing surface

---

[18] The "Great Depression" was a decade of unemployment, low profits, low prices, high poverty and stagnant trade that affected the entire world in the 1930s.

[19] Evapotranspiration is defined as the vaporization of water through direct evaporation from wet surfaces plus the release of water vapor by vegetation.

flow. Road systems, skid trails, and landings where the soils become compacted may also accelerate runoff. Ditches concentrate surface runoff and intercept subsurface flow bringing it to the surface (Chamberlin et al. 1991; Furniss et al. 1991). Significant increases in the magnitude of peak flows or the frequency of channel forming flows can increase channel scouring or accelerate bank erosion.

Increases in sediment contributions to streams are generally attributable to changes in rates of erosion on hill slopes through such processes as increased landslide activity, sheet wash erosion associated with road management activities (construction and maintenance), yarding operations, and fires (both wildfires and controlled burns). The largest contributions of sediment are typically from road construction activities (Furniss et al. 1991). Significant increases in the sediment supplied to streams can cause channel aggradations, pool filling, additional bank erosion, and losses of channel structures and habitat diversity. Stable large woody debris structures within the stream channel may be lost through direct removal, channel aggradations, debris torrents, or gradual attrition through lack of recruitment. These losses result in a reduction in sediment storage capacity, fewer and shallower scour pools, and a reduction of in-stream cover for fish (Chamberlin et al. 1991).

Changes in peak flows and sediment yield directly related to removing vegetation will typically persist for only a few years and tend to decrease over time as the watershed recovers and new vegetation grows. Changes associated with roads may persist indefinitely as roads are maintained or abandoned without treatment. Stream channel responses may take decades or centuries to recover (Chamberlin et al. 1991; Furniss et al. 1991).

Mining

Mining activities within the Klamath River Basin began prior to 1900. Many of the communities in the Klamath River Basin originated with the gold mining boom of the 1800s. Water was diverted and pumped for use in sluicing and hydraulic mining operations. This resulted in dramatic increases in turbidity levels altering stream morphology. The negative impacts of stream sedimentation on fish abundance were observed as early as the 1930s. Several streams impacted by mining operations and containing large volumes of silt seldom had large populations of salmon or trout (Smith 1939).

A past gold mine operation within the Klamath River Basin showing hydraulic mining. Unknown date.

Since the 1970s, large-scale commercial mining operations have been eliminated due to stricter environmental regulations. Mining operations can adversely affect spawning gravels; result in increased poaching activity, decreased survival of fish eggs and juveniles, decreased benthic invertebrate abundance, adversely affect water quality; and impact stream banks and channels.

Agriculture

Crop cultivation and livestock grazing in the upper Klamath River Basin began in the mid-1850s. Since then, valleys have been cleared of brush and trees to provide more farm land. By the late 1800s, native perennial grasses were replaced by various species of annual grasses and forbs[20]. This, combined with soil compaction, resulted in higher surface erosion and greater peak water flows in streams. Other annual and perennial crops cultivated included grains, alfalfa hay, potatoes and corn.

Besides irrigation associated with the Klamath Project, other non-Klamath Project irrigators operate within the Klamath River Basin. The Project supplies water annually to approximately 200,000 to 220,000 acres of the 240,000 acres within the Project boundaries. Current agricultural development in the Shasta River Valley consists of approximately 51,600 acres of irrigated land. Estimated consumptive use of irrigation water by the crops is approximately 100,000 AF per year. Current agricultural development in the Scott River Valley consists of approximately 33,000 acres of irrigated land with an estimated consumptive use by the crops of approximately 71,000 AF per year. Actual diversions would exceed the consumptive use of the crops due to irrigation application efficiency, conveyance losses in the system and surface evaporation.

Center Pivot Irrigation System, Northern California, Mount Shasta is in the background. In the past, return flows from irrigation has resulted in elevated nutrient levels (referred to as nutrient loading) in the Klamath River and in some tributaries.

It is also noted that in response to the NMFS 2002 BO, Reclamation conducted a Pilot Water Bank program to augment Klamath River flows. With no unused

---

[20] A broad-leaved herb other than a grass, especially one growing in a field, prairie, or meadow

storage space available in which to bank water, the Pilot Water Bank consisted of compensating land owners to forego the use of Klamath Project water through land idling or the pumping of groundwater. These methods are unsustainable.

A series of diversion dams on the Trinity River, a tributary of the Klamath River, transfers water from the Klamath River Basin to the Sacramento River Basin. The difference in elevation between the Trinity River and the Sacramento River facilitates generation of hydroelectric power. Starting in 1964 and continuing until 1995, an average of 1.2 million AF per year, or 88 percent of the Trinity River flow, was diverted into the Central Valley Project within the Sacramento River Basin. This diversion contributed to the decline of coho salmon populations within the Klamath River Basin.

There are two other diversion systems within the Klamath River Basin. Fourmile Creek and Jenny Creek diversions transfer water from the Klamath River Basin into the Rogue River Basin. Estimated annual (1960 to 1996) out of basin diversions from the Fourmile Creek drainage of the Klamath River basin to the Rogue River Basin was approximately 4,845 AF. Net out of basin diversions from the Jenny Creek drainage of the Klamath River Basin to the Rogue River Basin were approximately 22,128 AF (38,620 AF exported, 16,492 AF imported). Thus the total average annual (1960 to 1996) diversions from the Klamath River Basin to the Rogue River Basin was 26,973 AF (La Marche 2001). These diversions are part of the FERC Settlement discussions.

As the value of farm lands increased throughout the Klamath River Basin, flood control measures were implemented. During the 1930s, the U.S. Army Corps of Engineers implemented flood control measures in the Scott River Valley by removing riparian vegetation and building dikes to constrain the stream channel. As a result of building these dykes (banking), the river became more channeled, water velocities increased, and the rate of bank erosion accelerated. To minimize damage, the Siskiyou Soil Conservation Service planted willows along the stream-bank and recommended channel modifications take place which re-shaped the stream channel into a series of gentle curves.

Water Management

Dams impounding water for mining and farming operations were first built in the Klamath River Basin during the 1850s. Some of these dams blocked fish passage in a number of tributary streams. The first hydroelectric dams were built in the Shasta River and in the Upper Klamath River Basin just prior to the turn of the century.

Starting in the early 1900s, construction and operation of facilities associated with the Klamath Project, as well as other facilities began. These facilities include Link River Dam, A-Canal, and the Lost River Diversion Dam and Channel, which are part of the Klamath Project. Non-Klamath Project facilities within the Upper Klamath River Basin include PacifiCorp's Copco Nos. 1 and 2 Dams, J.C. Boyle

Hydroelectric Dam, IGD, and Keno Dam. Since the majority of the irrigation of agriculture lands occurs in the spring and summer, changes in the natural flow regime caused by irrigation in the Upper Klamath River Basin would primarily reduced late spring and summer monthly flows.

IGD was completed in the early 1960s. Minimum stream flows and ramping rate regimes were subsequently established in the Federal Energy Regulatory Commission (FERC) license covering operations at IGD[21]. Approximately 37 miles to 46 miles[22] of habitat for the threatened coho salmon are blocked above IGD (CDFG 2002). As a mitigation measure for the loss of fish habitat between Iron Gate and Copco No. 2 Dams, Iron Gate Fish Hatchery was established.

Keno Dam (River Mile 230) is a non-hydroelectric facility and is not part of Reclamation's Klamath Project. The fish ladder facility is visible on the right and is located on the left bank of the Klamath River (looking downstream).

Hecht and Kamman (1996) viewed the hydrologic records (pre- and post-Klamath Project). The authors concluded that there was much less variability between mean, minimum, and maximum flows in the Klamath River at Keno prior to construction of the Klamath Project. They also concluded that the timing of peak and low flows changed significantly after construction of the Klamath Project, and that decreased flows in the late spring and summer were observed during post-Klamath Project operations, as measured at Keno. Their report also noted that water diversions occurred in areas outside the boundaries of the Klamath Project, but within the Klamath River Basin.

Around the 1920s, water resources in the Lower Klamath River Basin were developed for agriculture irrigation. For example, Dwinell Dam in the Shasta

---

[21] The Federal Energy Regulatory Commission (FERC) is the United States Federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, and oil pipeline rates. FERC also reviews and authorizes liquefied natural gas terminals, interstate natural gas pipelines and non-federal hydropower projects.

[22] USFWS website accessed on August 26, 2007: <http: //www.fws.gov/news/NewsReleases/showNews.cfm?newsId=74351AE0-AFB6-B5ED-282B0355EA8DEC55>.

River Basin was constructed in 1928 to impound irrigation water for the Montague Water Conservation District. No minimum flow regimes were established in the Shasta River. In the 1960s, the Trinity and Lewiston Dams were completed in the Trinity River Basin. The initial operation plan diverted at least 80 percent of the Trinity River flow into the Sacramento River Basin.

Indian Tribes in the Klamath River Basin have an interest in water management. Although they have yet to be quantified, the Klamath Tribes may have water rights that predate those of irrigators (p. CRS-7, Powers et al. 2005). A court has held that the rights of the Klamath Tribes have a priority date of "time immemorial[23]" and are not restricted by the date of the Tribes' 1864 Treaty with the U.S. Government[24]. The Federal district court for Oregon held that the Klamath Tribes have reserved gathering rights along with their hunting, fishing, and trapping rights, and that all of these rights have accompanying water rights[25]. The decision stipulated that these rights are to be quantified at a level that will sustain productive habitat so that there will be game to hunt, and fish to catch, as well as edible plants to gather. How these and other recent court rulings will affect Klamath River Basin water allocations under the ongoing water rights adjudication is not yet clear.

Climate Variability

Climate variability plays a large role in driving the fluctuations in salmon abundance by influencing their physical environment, the availability of food, the competitors for that food, and the predators that prey on salmon. The complexity of influences on salmon, both climate and otherwise, combined with the scarcity of observations of factors important to salmon in estuaries and the ocean, make it challenging to identify the links between salmon and climate. However, ocean conditions unfavorable for coho salmon are believed to be partially responsible for the depressed status on naturally produced coho salmon stocks in California (p. 10, NMFS 2007).

---

[23] *United States v. Adair*, 723 F. 2d 1394 (9th Cir. 1983); *Parravano v. Babbitt*, 70 F. 3d 539 (9th Cir. 1995); *Klamath Water Users Association v. Patterson*, 204 F. 3d 1206 (9th Cir. 2000).

[24] *United States v. Adair*, *supra,* at 1414.

[25] *United States v. Adair*, 187 F. Supp. 2nd 1273 (D. Or. 2002).

Mantua et al. (1997) demonstrated a connection between salmon abundance and a North Pacific climate variation, named the PDO. Warm phase PDO is generally associated with reduced abundance of coho and Chinook salmon in the Pacific Northwest, while cool phase PDO is linked to above average abundance of these fish.

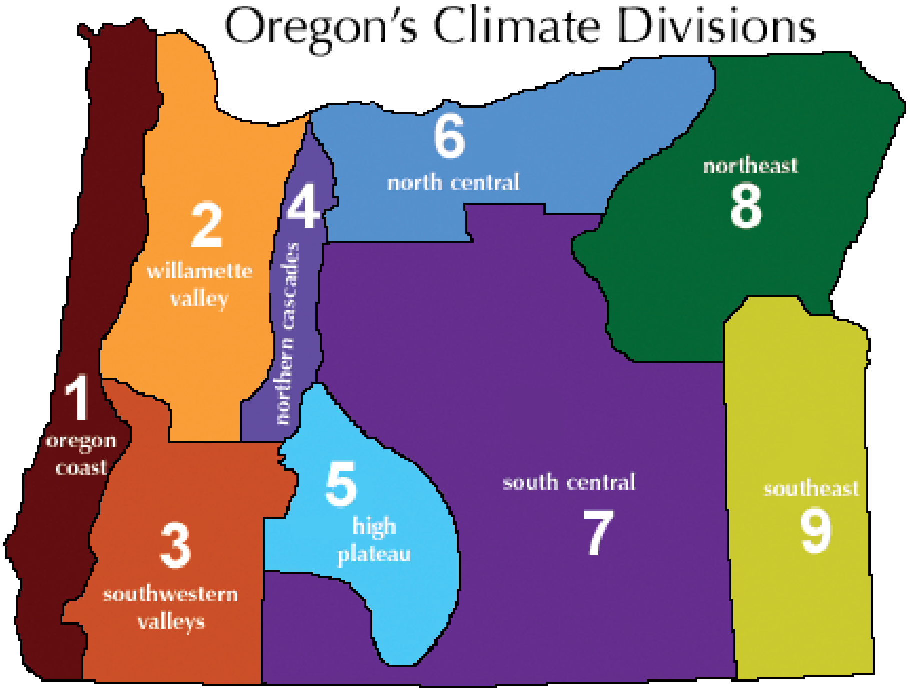
The Upper Klamath River Basin is an arid region. To best illustrate this, Appendix Table 3-D-3 reflects IGD flows as the total quantity of water available at IGD if all net inflows into UKL are passed directly through Keno Dam and all accretions from Keno Dam to IGD are added to those flows. This reflects no Klamath Project diversions and no refilling of UKL or meeting ESA requirements for listed suckers. Under this scenario, the 1961 to 2006 historical median monthly IGD flows would range from a low of 819 cfs in August to a high of 3,490 cfs in March.

Climate divisions for the entire United States have been established by the National Climatic Data Center. Monthly division values are obtained by averaging values for all NOAA Cooperative stations available for a given month. Division 5, High Plateau[26] of the Oregon Climatic Divisions includes a portion of the drainage (input) for the UKL (Figure 3-9). It is noted that the UKL is located within Division 7, the South Central zone. However, since Division 7 represented such a large area, Division 5 was used to better illustrate potential UKL inputs.

---

[26] <http: //www.ocs.orst.edu/page_links/climate_data_zones/allzone5.html>

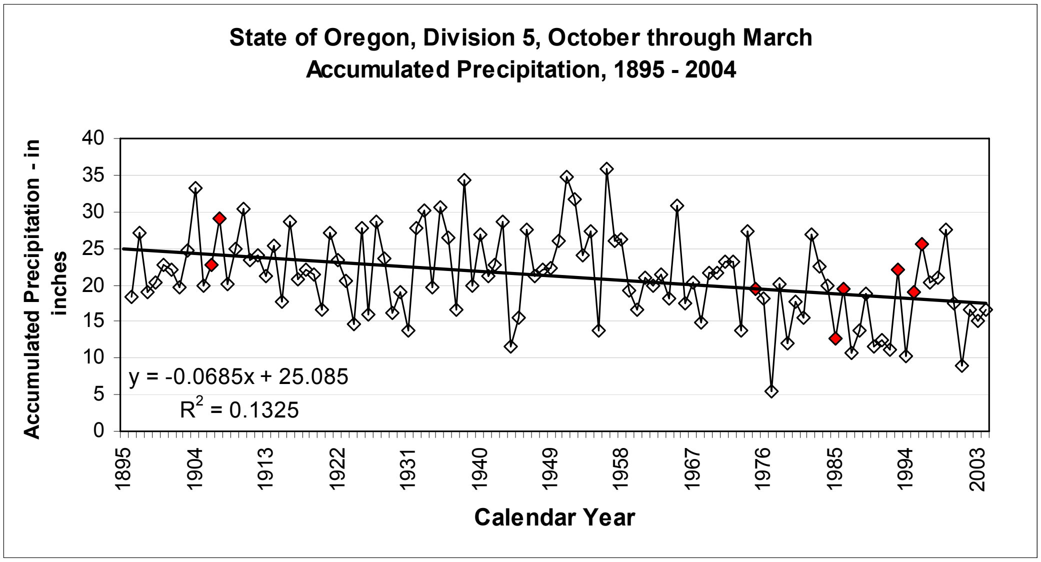
Figure 3-9. Division 5, High Plateau of the Oregon Climatic Divisions, includes drainages of the UKL.



in reviewing data from Division 5, High Plateau of the Oregon Climatic Divisions, the Upper Klamath River Basin has been receiving less precipitation since the early 1900s (Figure 3-10), while the mean annual temperature has been getting warmer (Figure 3-11). While a long term trend of less precipitation and warmer temperatures appears to be taking place, the year-to-year variation in precipitation and temperature make it difficult to predict on a yearly basis. The Klamath River has probably always been a relatively warm river (Hecht and Kamman 1996 and p. 28, NMFS 2002 BO). In the Pacific Northwest, warm years tend to be relatively dry with low summer stream flow and light snow pack. Conversely, cool years tend to be relatively wet with high summer stream flow and heavy snow pack (Scientific Consensus Statement [SCS] 2004).

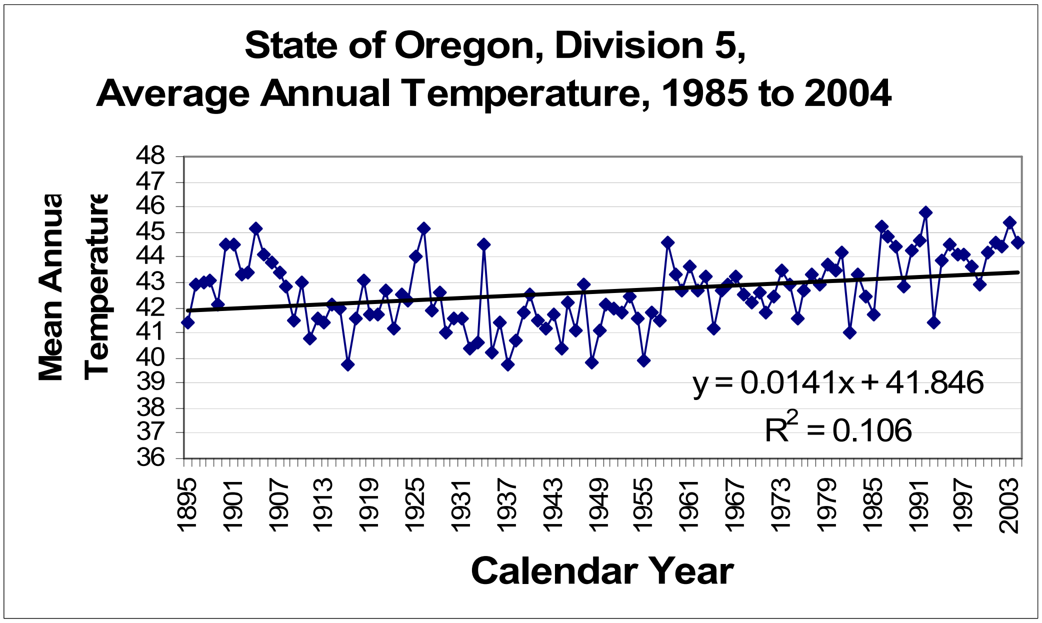
Given these trends in climate, irrigation requirements, including those for the Klamath Project, may increase into the future. In an already relatively warm water system such as the Klamath River (Figure 3-12), less precipitation and warming trends will also present long term challenges and are expected to place additional stress on the coho salmon's ability to survive and recover, as well as on the water resources.

Figure 3-10. State of Oregon, Division 5, October through March, accumulated precipitation, 1895 to 2004. The correlation is not significant (p > 0.05).



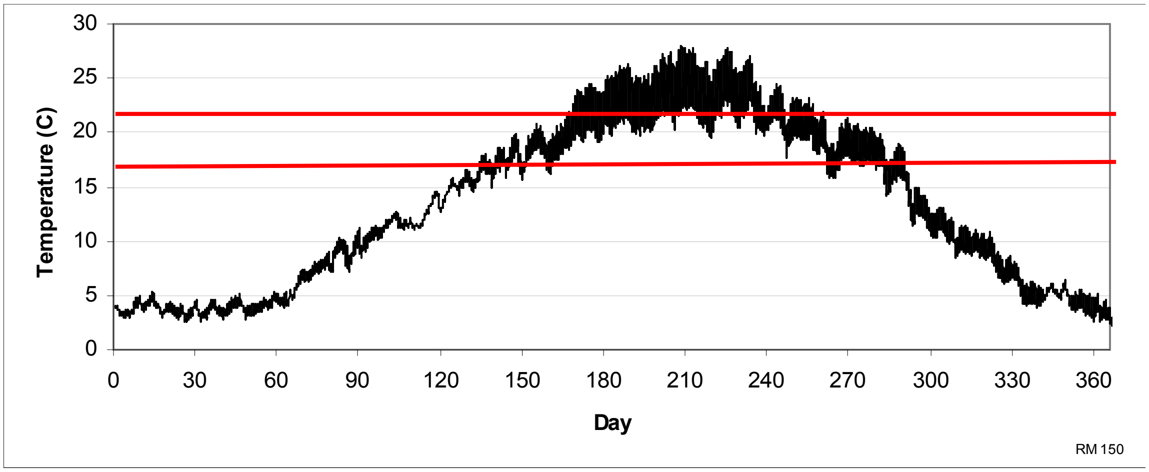
Source: J. Hicks, Chief, Planning Division, Reclamation, June 2007, pers comm. and <http: //www.ocs.orst.edu/page_links/climate_data_zones/allzone5.html>

Figure 3-11. State of Oregon, Division 5, average annual temperature, 1985 to 2004. The correlation is not significant (p > 0.05).



Source: J. Hicks, Chief, Planning Division, Reclamation, June 2007, pers comm and <http: //www.ocs.orst.edu/page_links/climate_data_zones/allzone5.html>

Figure 3-12. Hourly water temperature at river mile 150 of the Klamath River. Klamath River is currently considered a relatively warm water system. The EPA Quality Criteria for Water considers acute thermal conditions (defined as occurring suddenly or over a short period of time) for coho salmon as 71.6 ºF (22 ºC) and chronic exposures (defined as persisting over a long period of time) to occur at 60.8 ºF (16 ºC).



Source: Figure 4, p. 11, Cramer Fish Sciences 2007 Technical Memorandum 7.

Habitat Restoration

There are several broad conservation efforts currently occurring to restore coho salmon habitat throughout the Klamath River Basin. The following are the larger programs. Discussions on smaller, more spatially focused efforts may be found in Section VI, pages 11 through 17, NMFS 2007.

Klamath River Basin Conservation Area Restoration Program

The U.S. Congress authorized 1 million dollars annually from 1986 through 2006 to implement the Klamath River Basin Conservation Area Restoration Program. In 1991, the Klamath River Basin Fisheries Task Force (Task Force) adopted a Long Range Plan to assist in directing restoration programs and projects throughout the Klamath River. The Task Force also encouraged local watershed groups to develop restoration plans for five sub-basins: Shasta River sub-basin; Scott River sub-basin; Salmon River sub-basin, mid-Klamath River sub-basin, and the lower-Klamath River sub-basin.

Since 1991, over 1.3 million dollars have been distributed to these watershed groups to develop sub-basin restoration planning and restoration activities (p. 12, NMFS 2007). While the Klamath River Basin Conservation Area Restoration Program ended in 2006, funds were authorized for the 2007 fiscal year. The USFWS administered the funds consistent with the goals of the original program. A description of the restoration planning and restoration activities by sub-basin is available on pages 12 and 13 of NMFS 2007.

Trinity River Restoration Program

The Trinity River Basin Fish and Wildlife Management Act of 1984 authorized the Secretary of Interior to develop and implement a program to restore fish and wildlife populations in the Trinity River. Historically, the upper Trinity River functioned as dynamic system that effectively created and maintained quality spawning and rearing habitat for coho salmon. However, since the completion of Lewiston Dam in 1964, flows have been insufficient to maintain the dynamic nature of the river. Consequently, the river became confined within a narrow channel bordered by a dense riparian corridor. The Trinity River Restoration Program began a program to mechanically remove the entrenched riparian corridors and gently slope the stream banks. To maximize the effectiveness, the Trinity River Restoration Program incorporates a scientific evaluation and modeling program to investigate fish population responses to altered flow regime and physical habitat manipulations. In coordination with the habitat restoration effort, since 2001higher spring flows from Lewiston Dam have occurred on an annual basis.

California State Recovery Strategy for Coho Salmon

In August 2004, the California State Fish and Game Commission listed coho salmon north of San Francisco Bay under the CESA. The CESA (Fish and Game Code Sections 2050 to 2097) is administered by the CDFG and prohibits the take of plant and animal species designated by the Fish and Game Commission as either threatened or endangered in the State of California. “Take” in the context of the CESA means to hunt, pursue, kill, or capture a listed species, as well as any other actions that may result in adverse impacts when attempting to take individuals of a listed species.

Similar to the ESA, the CESA allows exceptions to the take prohibition. Sections 2091 and 2081 of the CESA allow the CDFG to authorize exceptions to the State’s prohibition against take of a listed species. Section 2091 allows State lead agencies that have formally consulted with the CDFG to take a listed species, if the take is incidental to carrying out an otherwise lawful project that has been approved under the California Environmental Quality Act (CEQA). Section 2081 allows the Department to authorize take of a listed species for educational, scientific, or management purposes. Private developers whose projects do not involve a State lead agency under CEQA may not take a listed species without formally consulting with the CDFG and agreeing to strict measures and standards for managing the listed species.

Prior to the final listing of coho salmon under CESA, the California State Fish and Game Commission directed the CDFG to develop a recovery strategy for restoring native California coho salmon. The primary objective of the recovery strategy is to return coho salmon to a level of sustained viability so that they can be de-listed and regulations or other protections under the CESA will not be necessary. Appendix II of NMFS 2007 presents the prioritized coho salmon recovery actions for the Klamath River Basin as found in the CDFG's recovery strategy.

Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan

NMFS recently announced (72 FR 37512; July 10, 2007) the completion of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act Klamath River Coho Salmon Recovery Plan (NMFS 2007). This MSRA Recovery Plan, dated July 10, 2007, was prepared by the Southwest Fisheries Science Center. This document fulfilled the requirement that a recovery plan for Klamath River coho salmon be completed and made available to the public by the Secretary of Commerce within six months of the enactment of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of January 12, 2007.

To develop the MSRA Recovery Plan, NMFS relied "heavily on the existing recovery strategy developed by CDFG (2004)" (as cited on p. 38, NMFS 2007). The MSRA Recovery Plan presents long-range guidance for various agencies, organizations and individuals to use as they consider taking actions or pursuing projects that may affect Klamath River coho salmon.

ESA Recovery Planning for the SONCC Coho Salmon ESU

No recovery plan has been completed for the SONCC coho salmon ESU, but recovery planning is under way (NMFS 2007). As part of the recovery planning process, NMFS brought together a group of scientists to serve as a Technical Recovery Team to provide a scientific context for identifying necessary actions to help the ESU recover. The Technical Recovery Team was tasked to identify biological viability criteria for populations and the ESU that would lead to recovery and delisting of the ESU; characterize associations between coho salmon abundance and habitat; identify factors of population declines within the ESU; and, identify research, evaluation, and monitoring needs (NMFS 2006).

As mentioned earlier, the first phase of the Southwest Region's recovery planning efforts has been carried out by the Technical Recovery Team by identifying historical populations within the SONCC coho salmon ESU. In June 2006, the Technical Recovery Team released its historic population structure report for the SONCC coho salmon ESU (NMFS 2006). The final phase of recovery planning for the SONCC coho salmon ESU is underway (71 FR 53421; September 11, 2006). This will consist of: a description of management actions to achieve the recovery plan's goals for conservation and survival of the species; objective, measurable criteria which, when met, would result in the species being de-listed; and, estimates of time and costs required to achieve the recovery plan's goal and intermediate steps toward that goal.

Conservation Implementation Program (CIP) and ESA Recovery Implementation

Through the CIP, Reclamation has annually funded projects since 2004 throughout the Klamath River drainage system that included enhancement and restoration of habitat conditions, improved water quality conditions, removed fish passage barriers, reduced entrainment through the installation of fish screens, monitoring, research, and increased water conservation efficiencies.

Over $10 million has been expended on major items funded by the CIP and for ESA Recovery Implementation from 2004 to 2007 which include, but are not limited to:

- Funding of five Chadwick Meetings
- Funding of contract to hire an organizational specialist
- Funding of 50 percent of Water Master Salary for Shasta/Scott for two years
- Funding of continuation of the Salmon River gauge
- Funding of spring run Chinook salmon genetic study
- Funding of radio telemetry, Chinook salmon
- Funding of Shasta/Scott groundwater study completion
- Funding of Oregon Water Resources support
- Funding support for Hardy study due to natural flow study
- Funding of NAS Study of Hardy/natural flow
- Contributed to five-year sucker review
- Funding of collection of electronic and/or existing restoration plans throughout the basin to aid in avoiding duplication and to ensure coordination with existing groups
- Funding of conducting 6 Public meetings to receive public input on the draft CIP document
- Funding of Upper Klamath Basin Working Group Science Panel (involving sucker review, etc)
- Funding of purchase and installation of Weirs used to monitor sucker movement
- Funding of Radio Telemetry, Juvenile Coho Salmon
- Funding of Thermal Refugia Study in Klamath River
- Partial Funding of a Data Portal being developed by the Trinity Restoration Office with potential to be expanded for the entire Klamath River; IIMS Partnership
- Funding of training course on the data collection for the 2-D modeling for the Trinity River

- Funding of Natural Flow Study
- Funding of Oregon State University (OSU) Public Outreach meetings
- Funding of Temperature Control Device Investigation for PacifiCorp Reservoirs
- Funding of Karuk Tribes Fisheries Monitoring Efforts;
- Funding of Indian Creek Gauge
- Funding of Yurok Tribes Fisheries Monitoring Efforts
- Funding of Escapement data upon sun setting of Task Force
- Funding of Green Sturgeon Monitoring
- Funding of Lamprey Monitoring
- Funding for Inter-Tribal Fish and Water Commission
- Funding of TMDL Model Review for Lost River
- Funding for Collier Map Model.

Additionally, in a May 18, 2007 new release, Reclamation's KBAO, in partnership with other Federal and State agencies (California and Oregon), participated in a basin-wide technical review process to evaluate and rank a total of 16 proposals submitted under the Fiscal Year 2007 solicitation. Reclamation was able to increase the available funding from the original solicitation total of $650,000 to a total of over $1.6 million and, therefore, was able to award grants to fund 13 proposals in FY 2007

The proposals were sought to:

(1) Restore the Klamath River ecosystem

(2) Help enhance populations of threatened coho salmon and endangered shortnose and Lost River suckers

(3) Further the fulfillment of the Federal Government's tribal trust responsibilities as they relate to the natural resources in the Klamath River watershed

The projects funded in FY 2007 represent a variety of restoration, scientific research, and planning approaches, with project grants varying from $48K to $366K. The projects funded in FY 2007 were:

- Shackleford Creek Diversion Improvement (Siskiyou County RCD)
- Bluff Creek Habitat Protection – Road Decommission (Karuk Tribe)
- Lower Klamath River – Upslope Erosion Control (Yurok Tribe Watershed Restoration Dept.); Keno Reservoir Treatment Wetlands Feasibility, Phase II (Rabe Consulting)
- Whites Gulch Migration Barrier Removal Project (Trinity County Planning Dept.)

- Plan, Coordinate, Manage Restoration Projects in the Shasta Valley (Shasta Valley RCD
- Baseline Habitat and Habitat Usage: Salmonids of the Shasta River (Center for Watershed Sciences - University of California at Davis)
- Cotton Creek Fish Passage Improvement (Resource Management)
- Water Quality Sampling/Monitoring below IGD (Yurok Tribe Environmental ProgramHotelling Gulch Stream Modification Feasibility (Salmon River Restoration Council)
- Red Cap/Camp Creek Fisheries Monitoring (Mid-Klamath Watershed Council)
- Fluvial Geomorphology and Vegetation Monitoring – Sprague River (Klamath Tribes)
- Salmon River Temperature Dynamics (Salmon River Restoration Council)

In Fiscal Years 2007 and 2008, Reclamation budgeted $4.8 million for CIP and Endangered Species recovery activities to be expended within the CIP.

NMFS and CDFG

NMFS administers several grant programs to further restoration efforts in the Klamath River Basin. From 2000 through 2005, NMFS issued grants of nearly 13.9 million dollars to the State of California and 6.2 million dollars to Klamath River Basin Tribes that funded restoration projects within the Klamath River Basin. In 2006, the State of California dedicated 10 million dollars toward restoration actions specifically identified within the Klamath River Basin (p. 17, NMFS 2007). Projects funded by these two agencies include a wide range of activities including: establishing conservation easements; conducting road inventories and restorations; improving fish passage; fostering public out reach and watershed planning; fencing off riparian habitat; and species and habitat monitoring.

Additional Efforts

Regulations (50 CFR §402.02) implementing section 7 of the ESA define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that:

(1) Can be implemented in a manner consistent with the intended purpose of the action

(2) Can be implemented consistent with the scope of the action agency's legal authority and jurisdiction

(3) Are economically and technologically feasible

(4) Would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat

Table 3-15 describes actions taken by Reclamation through these regulations.

Table 3-15. Reclamation Actions taken in response to NMFS 2002 BO's Reasonable and Prudent Alternatives (RPAs), Reasonable and Prudent Measures (RPMs), Terms & Conditions (T&C), and Conservation Measures (CMs).

Reasonable and Prudent Alternative (RPA):		
Number	**Recommendation/Requirement**	**Status**
RPA 1	Specific water management measures over the next 10 yrs (2002-2012)	In coordination with NMFS, Reclamation has developed water management measures to increase flows and augment spring releases. Implemented flow requirements in the 2002 BO; changed to Phase III flows per court order on April 1, 2006.
RPA 2	A water bank and water supply enhancement program to provide flows to the Klamath River below IGD to improve coho salmon habitat	Reclamation developed a water bank to aid in flow augmentation in 2002; With Judge Armstrong's order, this requirement was eliminated with the implementation of Phase III flows in April 2006.
RPA 3	An agreed upon long-term flow target to be achieved by 2010 (see table 8)	Phase III flows implemented. With Judge Armstrong's order, this requirement was implemented in April 2006 directing implementation of Phase III flows.
RPA 4	An inter-governmental task force to develop, procure, and manage water resources in the Klamath River Basin	Reclamation has been working on this through FERC Settlement discussions.
RPA 5	An inter-governmental science panel to develop and implement a research program to identify and fill gaps in existing knowledge regarding coho salmon and their habitat requirements during various life history stages and water year types	Reclamation has been working on this through the CIP process, and FERC Settlement discussions.

<table>
<tr><th colspan="3">Reasonable and Prudent Measures:</th></tr>
<tr><th>Number</th><th>Recommendation/Requirement</th><th>Status</th></tr>
<tr><td>RPM 1</td><td>Arrange for the ongoing collection and analysis of information to further understand the relationship between IGD water releases and suitable downstream salmon habitat in the Klamath River.</td><td>Reclamation has funded a number of research studies independently and through the CIP process.</td></tr>
<tr><td>RPM 2</td><td>Continue efforts to identify additional water supplies in the Klamath Basin.</td><td>The Klamath Basin Water Supply Initiative is an ongoing program to identify and develop additional water supplies in the Upper Klamath Basin. Reclamation has conducted several feasibility studies, including Swan and Long Lake Valley. Long Lake Valley is still under consideration for development.</td></tr>
<tr><th colspan="3">Terms & Conditions</th></tr>
<tr><th>Element</th><th>Recommendation/Requirement</th><th>Status</th></tr>
<tr><td>T&C 1</td><td>Provide a summary report outlining the status of the water supply initiative, identified opportunities with regard to water supplies, and current scoping of implementation strategies. Provide report to NMFS by Feb 1 of each year covered by this BO.</td><td>Reclamation has provided annual reports which included information on the water supply initiative including annual demand reduction to NMFS and USFWS.</td></tr>
<tr><td>T&C 2</td><td>Study methods to treat and/or recycle agricultural return flows from the Klamath Project service area before release into the Klamath River within the next 3 years. Once effective methods are identified, seek funding to develop and operate such systems in the Klamath Project service area.</td><td>Reclamation conducted an efficiency study in 1998 of the Project and determined it is 93% efficient (Reclamation 1998 Water Use). Through the Water Conservation Program, Reclamation has provided 18 miles of pipe to Irrigation Districts to replace open canals between 2002 and 2007. An additional 2 miles is scheduled to be installed in 2008.</td></tr>
<tr><td>T&C 3</td><td>Conduct a feasibility study to develop off-stream storage in the Lower Klamath Lake area to store additional water for fish and wildlife enhancement purposes. Seek funding to develop such storage areas for these purposes.</td><td>Reclamation has conducted several studies, including Swan and Long Lake Valley. Long Lake Valley is still under consideration for development. Studies in the Lower Klamath Lake area were discontinued due to economic and water quality issues.</td></tr>
<tr><td>T&C 4</td><td>Fund a study on the feasibility of developing groundwater resources to replace surface water use or by discharging groundwater directly into Shasta and/or Scott Rivers.</td><td>This action is not within the Klamath Project’s authorization or jurisdiction. The CIP process is examining this possibility.</td></tr>
</table>

T&C 5	Fund instream flows studies on both the Shasta River (from Dwinell Dam to Parks Creek) and Scott Rivers to assist in the development of minimum stream flows.	The CIP process is examining this possibility.
T&C 6	Provide funding to support installation of screened diversions on unscreened diversions and gaging devices on diversion in the Scott River and Shasta River to facilitate better State enforcement of appropriated water rights and reduce fish entrainment.	This action is not within the Klamath Project's authorization or jurisdiction. Reclamation is working with the Shasta RCD to assist with design of fish screens in 2006 and 2007 through the CIP..
T&C 7	Work with non-governmental organizations and the State of California to develop a management plan on the Scott River and Shasta River that coordinates simultaneous diversion of instream flows to minimize dramatic reductions in flow, and the stranding of fish, at the beginning of the irrigation season in March and April.	Reclamation was working with the Shasta and Scott RCDs through the CIP..
T&C 8	Investigate the feasibility of discontinuing the inter-basin transfer of water from the Klamath River to the Rogue River Basin and reserving that water for instream flow in the Klamath River below IGD.	Reclamation investigated the options, discontinuation of this water transfer is now part of FERC Settlement discussions.
Conservation Measure		
Number	**Measure**	**Status**
CM 1	Ensure the environmental documentation necessary to implement increased flow in the Trinity River consistent with the Trinity River Restoration Program and the existing court order limiting implementation of the Record of Decision is completed as quickly as possible.	Reclamation's Northern California Area Office continues to implement the ROD as quickly as possible.
CM 2	Assist the State of Oregon in revitalizing and completing the Alternative Dispute Resolution process established to resolve water right adjudication disputes in the Upper Klamath Basin.	This is part of the FERC Settlement discussions.

Historical Flows

Hydrologic Conditions

The Klamath River Basin experiences a variety of annual hydrologic conditions ranging from drought to flood. Hydrologic conditions can change significantly seasonally, monthly, and even weekly. Within the Klamath River Basin, there are periods of extreme variation and periods of little variation. For example, rainfall and snow melt may dominate portions of the basin at different times of year. Snowmelt drives the hydrology of the upper Klamath River Basin, while rain and snowmelt drive the hydrology of the Lower Klamath River Basin.

The Klamath Project began operations in the early 1900s and reached its present operating configuration in the 1960s. For the purpose of this BA, the impacts of the Proposed Action to coho salmon through flow will be measured at IGD. Appendix Table 3-D-1 depicts the historical monthly average IGD Discharge from 1961 to 2006. Appendix 3-D-2 depicts the exceedences for this period at 10 percent intervals. These historical exceedences will be considered the historical flows for the purpose of this BA.

Average Monthly Changes in IGD Flow due to the Klamath Project

Reclamation developed water accounting spreadsheet model (KPOPsim and WRIMS) that simulates Project operations to help evaluate the impacts of varying water deliveries to overall Project operations[27]. It defines the available water supply including monthly runoff into UKL and water demands at various locations. In addition, the model provides estimates of flow accretions downstream of project facilities.

Present Klamath Project

The Klamath Project consists of an extensive system of canals, pumps, diversion structures, and dams capable of routing water to approximately 240,000 acres of irrigated farmlands in the Upper Klamath River Basin. However, the Project usually only supplies water to approximately 200,000 to 220,000 acres annually. Since the early 1960s, the net diversion to the Klamath Project (including diversions to two National Wildlife Refuges) has fluctuated between years. Table 3-16 below contains the annual UKL Project diversions and the resultant reductions to the Klamath River at IGD. The Annual Net Reduction to Klamath River is calculated by subtracting the annual LRDC and Klamath Straits Drain additions to the Klamath River (i.e., Project additions/returns) from the Gross Annual Project Diversions.

---

[27] Detailed description of the model components, inputs, and assumptions are found in CH2M Hill (1997).

Table 3-16. Annual Project Diversions (Gross & Net) and resultant reduction to Klamath River at IGD.

	From Klamath Project		**Thousands of Acre Feet**	
Year	**Gross Annual Project Diversions**	**LRDC Inflows to Klamath River**	**Straits Drain Inflows to Klamath River**	**Annual Net Reduction to Klamath River Flows from the Project**
1961	433.47	121.53	112.49	199.45
1962	429.81	133.75	89.86	206.20
1963	367.76	170.64	116.78	80.34
1964	377.28	143.16	105.25	128.87
1965	360.86	287.34	157.53	-84.01
1966	447.48	137.29	95.90	214.29
1967	397.14	159.62	113.38	124.14
1968	477.34	130.21	122.15	224.98
1969	432.08	213.36	140.89	77.83
1970	436.52	245.02	158.15	33.35
1971	394.29	324.83	131.16	-61.70
1972	424.52	298.73	139.89	-14.10
1973	498.39	153.17	115.09	230.13
1974	464.58	224.73	125.30	114.55
1975	455.34	189.76	136.16	129.42
1976	448.29	157.72	120.12	170.45
1977	468.78	111.87	123.13	233.78
1978	386.32	186.26	87.30	112.76
1979	478.48	97.28	99.67	281.53
1980	442.42	133.53	126.84	182.05
1981	475.15	75.76	78.36	321.03
1982	394.80	252.59	145.75	-3.54
1983	401.74	282.88	132.44	-13.58
1984	434.79	281.95	160.33	-7.49

	From Klamath Project		**Thousands of Acre Feet**	
Year	**Gross Annual Project Diversions**	**LRDC Inflows to Klamath River**	**Straits Drain Inflows to Klamath River**	**Annual Net Reduction to Klamath River Flows from the Project**
1985	460.05	166.24	109.86	183.95
1986	499.02	175.25	126.09	197.68
1987	513.43	90.92	100.82	321.69
1988	512.95	84.55	100.20	328.20
1989	480.14	128.49	112.21	239.44
1990	500.22	92.80	102.79	304.63
1991	509.14	43.66	84.09	381.39
1992	479.17	22.79	6.12	450.26
1993	419.47	110.74	91.37	217.36
1994	503.81	37.82	63.08	402.91
1995	398.43	131.67	79.35	187.41
1996	460.12	212.76	125.19	122.17
1997	475.37	181.02	98.74	195.62
1998	405.66	319.61	119.99	-33.94
1999	483.29	341.13	129.13	13.03
2000	506.07	184.14	80.52	241.41
2001	150.72	57.48	21.09	72.16
2002	512.23	101.28	75.15	335.80
2003	401.25	108.31	65.66	227.28
2004	451.04	118.61	66.53	265.90
2005	382.29	72.10	71.52	238.67
2006	422.11	279.36	123.72	19.03

Flows from Keno Dam, as measured at IGD, are currently adjusted throughout the year for the benefit of ESA listed coho salmon under NMFS's 2002 BO. These minimum flows at IGD are listed in Table 9 of the NMFS 2002 BO. During spring and early summer, the minimum level of those flows currently varies by year type, based upon an estimated amount of water inflow into UKL. Higher flows are generally required in the spring to support out-migration of juvenile salmon.

Minimum Flow Requirements

As discussed in the History of Consultation section in Part I of this document, the court has upheld the long-term Phase III flow levels of the NMFS 2002 BO. The court stated that "the flow schedule in Phase III is the only portion of the [NMFS 2002] BO that remains valid, and the Ninth Circuit [Court] contemplated the Phase III flows as the starting point for any supportable in stream flow regime" (p. 13 of Judge Armstrong's Ruling, Case 4: 02-cv-02006, Document 452, filed March 27, 2006). As discussed below, Reclamation is proposing to modify the flows of Phase III during the March through June period. The minimum flows of the NMFS 2002 for Phase III, during July through February, will remain the same under the Proposed Action.

On page 56 of the 2002 BO, NMFS states that coho salmon are primarily tributary spawners and that main stem spawning and rearing habitat is likely not limiting at the current population size. It also recognizes the importance of the main-stem as a migratory corridor for adult and down-stream migrating smolts. Additionally, as cited in the NMFS 2002 BO, "[c]oho salmon typically rear in fresh water for up to 15 months, then migrate to the sea as smolts between March and June (Weitkamp et al. 1995)", as cited on page 12, NMFS 2002 BO.

On pages 63 and 64 of the 2002 BO, NMFS further states that in "developing long-term flow targets [Phase III flows] NMFS thinks focusing on conditions that provide adequate migration flows and daytime refuge habitat to optimize coho [salmon] smolt survival is appropriate. Given that coho [salmon] smolts have survived often difficult conditions for at least 15 months, and that all smolts must migrate to the sea through the main stem Klamath River, NMFS thinks that the smolt life stage is an important life stage to protect and for which suitable conditions in the main stem Klamath [River] should be provided."

Hardy and Addley (2001) provide habitat-discharge relations in the form of graphs depicting the relationship between flow and available weighted useable area. The flow that maximizes habitat is that which produces the greatest weighted useable area. NMFS used the Hardy and Addley (2001) habitat-discharge relations and estimates of monthly unimpaired flow to estimate available habitat (i.e., weighted useable area) for unimpaired flows during alternative water year types. The estimated unimpaired flows used in this analysis were based upon the elimination of all water diversions in the entire Upper Klamath River Basin and not just the diversion to Klamath Project. This analysis reflected an underlying assumption by NMFS that rearing habitat in the Klamath River main stem was limiting coho salmon production. NMFS stated in its (p. 32, NMFS 2002) that "NMFS is unaware of specific; quantitative estimates of coho salmon habitat requirements in the main stem Klamath River necessary to maintain the species. Therefore, we do not have a specific "target" that must be met to determine the precise point at which jeopardy to the species occurs".

Hardy and Addley (2006) stated that sufficient data were lacking to develop site-specific Habitat Suitability Curves (HSC) for coho salmon juveniles within the Klamath River (p. 115, Hardy and Addley 2006). Therefore, Hardy and Addley (2006) used data for juvenile Chinook salmon to define escape cover and distance to escape cover (p. 117, Hardy and Addley 2006).

In particular, there is a lack of empirical observations of coho salmon smolt habitat use in the main stem Klamath River. However, in McMahon and Holtby (1992), a coho salmon smolt behavior study cited by NMFS in the 2002 BO, coho salmon smolts were generally found in the same habitats and areas as coho salmon fry. With the lack of coho salmon smolt habitat use data in the 2002 BO, NMFS used "coho [salmon] fry habitat as a surrogate for coho [salmon] smolt habitat and flow conditions appropriate to optimize smolt survival during their downstream outmigration to the ocean" (p. 65, NMFS 2002 BO). However, the NRC (2004) concluded that given the absolute scarcity of coho salmon, it seemed unlikely to the committee that the coho salmon is saturating its available main stem habitat, even without augmentation of main stem flows.

Current July through September Minimum Flows

In the 2002 BO, NMFS recommended maintaining 1,000 cfs as a long-term minimum flow for releases from IGD during the July through September period in all water year types (p. 68, NMFS 2002 BO). NMFS acknowledged that there was substantial uncertainty in the expected affects to coho salmon summer rearing habitat in the main stem. NMFS recommendation was based, in part, on Hardly and Addley's (2001) suggestion that that flows in the vicinity of 1,000 cfs are not expected to increase temperatures within this reach and would have the benefit of dampening the magnitude of diurnal fluctuations in water temperature. Observed diurnal fluctuations in water temperature within the Klamath River main stem are increases in temperature during daylight hours and declines in temperature during the night. Cloudy days and nights make for smaller daytime increases and smaller nighttime decreases. Likewise, clear days and nights with increased make for greater daytime temperature increases and greater nighttime temperature decreases. Thus, river temperatures are highly dependent on ambient air temperatures and solar heating.

Current October through February Minimum Flows

The minimum flow regime for this time period (1,300 cfs), for all NMFS year types, was based on limited measurements and observations “that fall Chinook [salmon] spawning habitat would be adequate in the IGD to Shasta River reach under this IGD discharge” (p. 68, NMFS 2002 BO). NMFS further assumed that main stem passage, tributary access, and spawning habitat for coho salmon will also be adequate under this IGD flow regime.

Hardy and Addley (2006) stated that sufficient data were lacking to develop site-specific Habitat Suitability Curves for coho salmon juveniles within the Klamath River (p. 115, Hardy and Addley 2006). Therefore, Hardy and Addley (2006) used data for juvenile Chinook salmon to define escape cover and distance to escape cover (p. 117, Hardy and Addley 2006).

NMFS also stated in its (p. 42, NMFS 2002 BO) that “Model results presented in the draft Phase II report (Hardy and Addley 2001) for Chinook salmon spawning habitat indicate that spawning habitat is maximized at approximately 1,300 cfs in the Iron Gate to Shasta River reach” and “At potential flows under the proposed action during drier years, when resultant flows may be less than 900 cfs, Chinook spawning habitat availability is reduced and salmon passage conditions may deteriorate.”

The Proposed Action includes NMFS 2002 BO long term recommended flows for the months of October through February. Hardy and Addley’s (2006) Maximum Habitat Appendix Tables I-8, I-9, I-10 and I-11, show only minor reductions in the maximum available coho salmon habitat in the IGD to Seiad reach between IGD releases of 1,300 cfs and 1,000 cfs. A potential change in minimum flows, in conjunction with these relatively minor reductions in the maximum available coho salmon habitat, may present increased opportunities to store, spill, or release up to 90,000 AF of additional water later in the year. The results of this change would significantly increase the likelihood of higher spring flows during the months of March through May.

Current March through June Minimum Flows

For March through June of each year, for each NMFS water year type (dry, below average, average, above average, and wet), using coho salmon fry habitat suitability curves as a surrogate for coho salmon smolts, NMFS determined in the NMFS 2002 BO the long-term IGD flow release minimum flows by first estimating the amount of habitat that would be available in the Shasta River (river mile 177) to Scott River (river mile 144) reach under estimated unimpaired flows from entire the Upper Klamath River watershed and not just the Klamath Project, using the one-dimensional habitat discharge curve for coho salmon fry. This determination reflects an assumption that main stem rearing habitat in the spring limits coho salmon smolt production.

NMFS chose to use the one-dimensional curves in the NMFS 2002 BO because, in NMFS's opinion, the two-dimensional coho salmon fry habitat discharge curves provided in Hardy and Addley's Phase II report provided questionable results (more available habitat) at lower modeled flows. NMFS also chose the Shasta River to Scott River reach habitat-discharge curve to determine required flows because IGD releases are the dominant contributor of flow to this reach, and it is the first main stem reach encountered by relatively high numbers of smolts emigrating from the Shasta River.

NMFS then subtracted 20 percent of available habitat, depending on the water year type, to arrive at the flow that would provide the corresponding level of available habitat. Using this technique, NMFS calculated the long-term minimum requirement flows, by water year type, as outlined in the NMFS 2002 BO.

Adaptive Management Approach of the NMFS 2002 BO

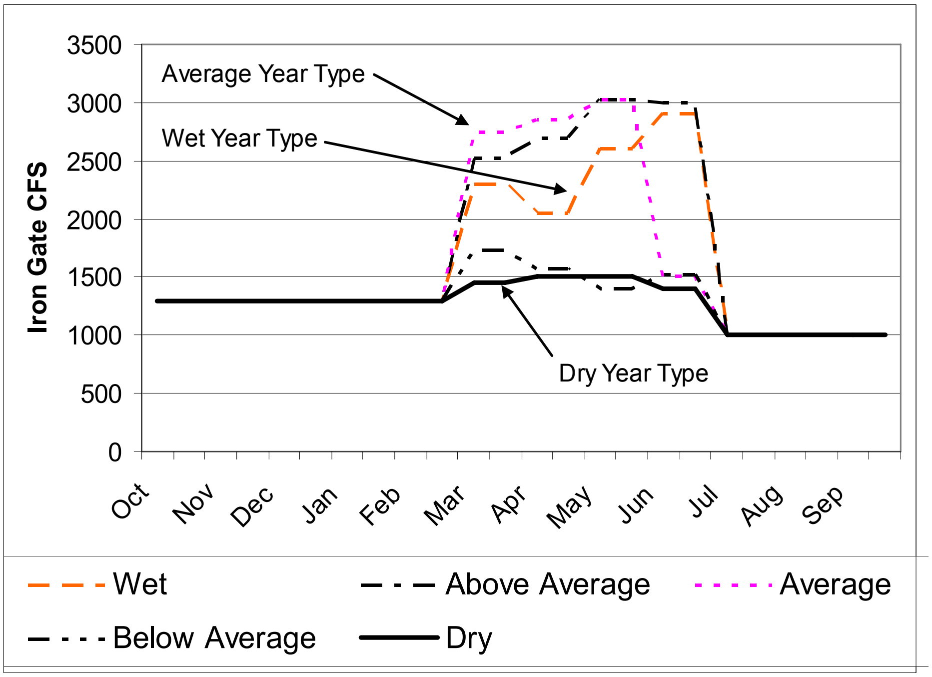
The NMFS 2002 BO minimum flows, as discussed above, are identified in Table 3-17 and graphed in Figure 3-13. Reclamation notes that there are some unusual aspects of the NMFS 2002 BO minimum flow requirements when viewed by year type. As an example, the minimum flow requirement in May during a dry year type (1,500 cfs) is higher then in a below average year type (1,400 cfs). Likewise, during the months of March, April, and May, the minimum flow required in an above average and average year types are higher than in the wet year type. Thus, the minimum flow requirements do not necessarily correspond with the available water for the given year type.

Table 3-17. The 2002 to 2012 NMFS BO recommended long-term minimum flows IGD discharge by month, by water year type.

Month	Water Year Type (values in minimum daily cfs)				
	Dry	Below Average	Average	Above Average	Wet
October to February	1,300	1,300	1,300	1,300	1,300
March	1,450	1,725	2,750	2,525	2,300
April	1,500	1,575	2,850	2,700	2,050
May	1,500	1,400	3,025	3,025	2,600
June	1,400	1,525	1,500	3,000	2,900
July to September	1,000	1,000	1,000	1,000	1,000

Source: Table 9, p. 71, NMFS 2002.

Figure 3-13. The 2002 to 2012 NMFS BO recommended long-term IGD discharge by water year type, by month.



In the NMFS 2002 BO, NMFS expressed that if the scientific findings from additional studies and reports warrant modifying these IGD minimum flows, they would consider those findings and make appropriate adjustments. NMFS (2002 BO) further expressed that adjustments could include dividing certain months (e.g., March through June) into weekly flow recommendations to better mimic the natural hydrograph. If NMFS finds that the long-term minimum flows should be modified based on the findings from these additional studies and reports, they will amend the long-term minimum flows accordingly (Section 11.4.5, p. 70, NMFS 2002 BO). The NMFS 2002 BO provides for the incorporation of new knowledge to amend the long-term minimum flows, which may be defined as adaptive management[28].

Proposed Action

A more thorough description of the Proposed Action is available in Part I of this BA. A summary of the Proposed Action as it relates to impact on coho salmon is provided below.

Under the Proposed Action, Reclamation will retain the NMFS 2002's recommended long-term minimum flows for releases from IGD during the October through February period. Under the NMFS 2002 BO, the minimum flow regime for this time period (1,300 cfs) was based on limited measurements and observations "that fall [C]hinook spawning habitat would be adequate in the IGD to Shasta River reach under this IGD discharge" (p. 68, NMFS 2002 BO). NMFS further assumed that main stem passage, tributary access, and spawning habitat for coho salmon will be adequate under this IGD flow regime (see Section 11.4.4 – Rationale for long-term flow targets: October through February, pages to 68 to 69, NMFS 2002 BO). At this time, Reclamation proposes no changes to the recommended long-term minimum flows as outlined in the NMFS 2002 BO for the October through February period.

Under the Proposed Action, Reclamation will also retain the NMFS 2002 BO's recommended 1,000 cfs as a long-term minimum flow for releases from IGD during the July through September period (p. 68, NMFS 2002 BO). This recommendation was based, in part; on Hardly and Addley's (2001) recommend minimum dry summer flows of 1,000 cfs (see Section 11.4.3 – Rationale for long-

---

[28] Adaptive may be defined as a type of natural resource management in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices.

term flow targets: July through September, pages 67 to 68, NMFS 2002 BO). Additionally, NMFS concluded that flows in the vicinity of 1000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature (as discussed in next sub-section – Temperature). At this time, Reclamation proposes no changes to the recommended long-term minimum flows as outlined in NMFS 2002 BO for the July through September period.

On page 56 of the 2002 BO, NMFS states "[g]iven that coho [salmon] are primarily tributary spawners, that main stem spawning and rearing habitat is likely not limiting at the current population size, and recognizing the importance of the main stem as a migratory corridor for adult and down-stream migrating smolts, NMFS thinks that the approach contained in this [2002 BO] sufficiently addresses the adverse effects of the Klamath Project to SONC coho salmon [ESU]...". Further, the 2002 BO states that "[c]oho salmon typically rear in fresh water for up to 15 months, then migrate to the sea as smolts between March and June" (p. 12, NMFS 2002 BO). Similar to the conclusion in the NMFS 2002 BO, Reclamation recognizes the importance of the March through June period in the coho salmon life cycle within the main stem of the upper Klamath River.

In regards to the time period of March through June, under the Proposed Action, Reclamation will retain the NMFS 2002 BO's recommended long-term minimum flows for a dry year water type for releases from IGD[29]. However, unlike the NMFS 2002 BO, Reclamation proposes to not go below these minimum monthly flow levels for all water year types. This would be a deviation from the NMFS 2002 BO, which established minimum flows by year type.

The rationale for these minimums and their impact on ESA-listed coho salmon will be discussed below. The long-term minimum flows for a dry year type were established in NMFS 2002 and were based on salmon fry habitat suitability curves utilizing estimated unimpaired flows (see Section 11.4.2 – Rationale for long-term flow targets: March through June, pages 63 to 67, NMFS 2002 BO).

In most years, Reclamation anticipates operating above the cumulative monthly minimum flows. The following exceedence table reflects the estimated frequency of IGD flows that might be realized under the Proposed Action (Table 3-17).

---

[29] Dry year water type releases: March 1,450 cfs; April 1,500 cfs; May 1,500 cfs; and June 1,400 cfs.

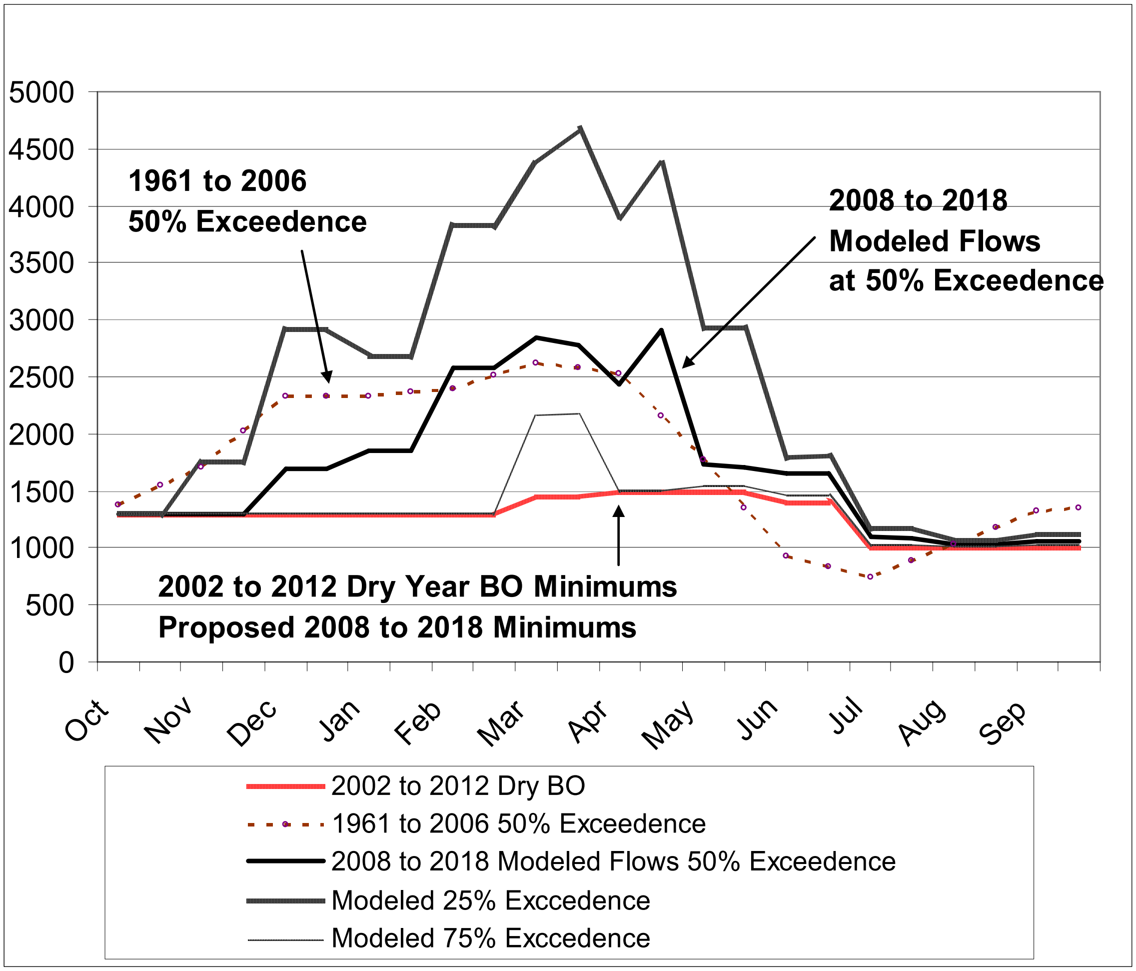
Table 3-18. Modeled IGD flow exceedences (2008 to 2018) under the Proposed Action in cubic feet per second (cfs) in 5 percent increments.

	Oct	Nov	Dec	Jan	Feb	Mar I	Mar II	Apr I	Apr II	May I	May II	Jun I	Jun II	July I	July II	Aug	Sept
95%	1,300	1,300	1,300	1,300	1,300	1,450	1,450	1,500	1,500	1,500	1,500	1,400	1,400	1,000	1,000	1,000	1,000
90%	1,300	1,300	1,300	1,300	1,300	1,450	1,450	1,500	1,500	1,504	1,504	1,405	1,405	1,000	1,001	1,000	1,000
85%	1,300	1,300	1,300	1,300	1,300	1,450	1,450	1,500	1,500	1,509	1,509	1,412	1,412	1,003	1,004	1,002	1,002
80%	1,300	1,300	1,300	1,300	1,300	1,717	1,815	1,500	1,500	1,524	1,523	1,432	1,432	1,009	1,009	1,004	1,007
75%	1,300	1,300	1,300	1,300	1,300	2,159	2,172	1,500	1,500	1,540	1,537	1,453	1,453	1,020	1,019	1,006	1,013
70%	1,300	1,300	1,300	1,300	1,300	2,285	2,445	1,500	1,500	1,572	1,567	1,496	1,496	1,036	1,034	1,012	1,024
65%	1,300	1,300	1,300	1,300	1,593	2,439	2,489	1,500	1,677	1,589	1,583	1,518	1,518	1,044	1,042	1,014	1,030
60%	1,300	1,300	1,300	1,309	1,880	2,571	2,559	1,624	2,159	1,605	1,599	1,545	1,563	1,062	1,059	1,020	1,041
55%	1,300	1,300	1,374	1,656	2,473	2,675	2,739	2,035	2,505	1,641	1,632	1,587	1,587	1,073	1,068	1,023	1,048
50%	1,300	1,300	1,695	1,855	2,577	2,850	2,777	2,434	2,904	1,727	1,712	1,658	1,658	1,095	1,087	1,030	1,062
45%	1,300	1,300	1,834	2,109	2,728	2,883	2,836	2,645	3,115	1,909	1,909	1,689	1,696	1,107	1,097	1,032	1,070
40%	1,300	1,300	1,986	2,251	3,097	2,953	2,994	2,747	3,217	2,067	2,067	1,706	1,731	1,122	1,114	1,038	1,082
35%	1,300	1,345	2,064	2,556	3,505	3,236	3,147	2,977	3,447	2,485	2,486	1,736	1,744	1,135	1,129	1,044	1,086
30%	1,300	1,629	2,471	2,581	3,632	3,670	3,771	3,478	3,948	2,775	2,775	1,738	1,769	1,141	1,145	1,049	1,089
25%	1,300	1,747	2,908	2,678	3,822	4,371	4,671	3,901	4,371	2,919	2,919	1,786	1,803	1,168	1,159	1,056	1,113
20%	1,300	1,966	3,018	2,908	3,960	4,868	4,972	4,286	4,757	3,111	3,111	1,942	1,943	1,196	1,190	1,066	1,145
15%	1,300	2,262	3,185	3,491	4,762	5,370	5,285	5,004	5,474	3,592	3,591	2,426	2,322	1,301	1,283	1,095	1,183
10%	1,300	2,911	3,337	3,948	5,663	6,006	5,898	5,309	5,779	3,884	3,885	2,576	2,549	1,395	1,365	1,120	1,239
5%	1,300	3,348	4,907	6,307	7,172	6,681	6,573	5,704	6,174	4,247	4,247	2,748	2,653	1,438	1,420	1,142	1,267

Mar I - March 1 through March 15; Mar II - March 16 through 31; Apr I - April 1 through April 15; Apr II - April 16 through April 30;
May I - May 1 through May 15; May II - May 16 through May 31; Jun I - June 1 through June 15; Jun II - June 16 through June 30.

In most years, Reclamation anticipates operating within the 25 to 75 percent exceedence levels. Figure 3-14 reflects the minimum flows of the Proposed Action, the modeled 25, 50, and 75 percent exceedence flows under the Proposed Action (2008 to 2018), the (1961 to 2006) historical 50 percent exceedence, which includes past Klamath Project operations.

Figure 3-14. The proposed minimum flows, the 1961 to 2006 50 percent exceedence, and the model (2008 to 2018) 25, 50, and 75 percent exceedences. The modeled (2008 to 2018) exceedence flows do not reflect possible modification of flows by the Technical Team.



Source of modeled exceedence: J. Hicks, Chief, Planning Division, Reclamation, October 10, 2007, pers. comm.

The modeled 50 percent exceedence flows are based on Water Resources Integrated Modeling System (WRIMS)[30] modeling using the proposed lake elevations and refill curves identified in the Proposed Action as described in Part I of this document. However, modeled flows do not reflect potential recommendations for modifications of flows or lake elevations from the Interactive Management approach of the Proposed Action, through the Technical Team. The modeled flows at 50 percent exceedences reflect meeting UKL level refill rates and potential spills that would occur above those elevations. The "probability of exceedence" curve gives the forecast probability that a flow will be exceeded at the location in question. In other words, at a 50 percent exceedence level it is estimated that 50 percent of the time flows could be above this level and 50 percent of the time flows could be below this level.

The total annual flows modeled under the Proposed Action utilized the historical data (1961 to 2006). However, the Proposed Action will modify the flow patterns by slightly lowering the flows from October through February and increasing the flows in April through July (see Figure 3-14). This will be accomplished by the Klamath Project operations storing more water earlier in the year so that it can be released during the March through June critical time period of coho salmon smolt out-migration. The additional flows will be beneficial to out-migrating smolt and provide for additional coho salmon juvenile and fry rearing habitat during this time period.

Factors Affecting Species Environment

Klamath River Coho Salmon Envirogram

To determine the factors affecting ESA-listed coho salmon and its environment, Reclamation constructed an envirogram (Table 3-19), a concept introduced by Andrewartha and Birch (1984). Andrewartha and Birch define an envirogram as "a dendrogram whose branches trace pathways from distal causes in the web to proximate causes in the centrum." The centra are traditionally divided into four categories: resources, mates, malentities[31], and predators (carnivores, parasites, and pathogens). Within each of these categories, the relationship between the target organism and each of the most distal influences in its environment is outlined in a linear fashion. To simplify explanation and interpretation of each linear relationship, symbolic equations are used to

---

[30] Water Resources Integrated Modeling System, or WRIMS (a.k.a CALSIM), is a comprehensive and powerful modeling tool for water resources systems simulation. The model is a product of joint development between State of California, Department of Water Resources (DWR) and Bureau of Reclamation.

[31] Malentities are considered “unfortunate accidents” – unintentional harm to the primary species, such as an animal that eats the primary species incidentally or infrequently (Sharks are a malentity for humans, fishing gear may incidentally capture species other than the target species.)

describe each component of the diagram from the most distal to the most proximate (central) causes.

In reviewing the envirogram, Reclamation identified three factors to be considered in assessing the impacts of the Proposed Action on coho salmon: water quantity (including timing); water quality (DO, nutrient loading, and temperature), and disease.

The biology of coho salmon is multi-dimensional, and communicating such complexity schematically on two-dimensional paper is a daunting task. However, the linear design of an envirogram greatly facilitates assessment of individual components and their relation to the organism's biology as a whole. Because the relationship between components is simplified to one-way interactions, the resulting diagrammatic representation simplifies visual assimilation of a great deal of information. Thus, the envirogram, by design, is synthetic and holistic. On the other hand, the simplicity of a linear design is not without drawbacks. For instance, the linearity does not represent the cyclic nature implicit in many elements in the environment.

Table 3-19. Klamath River coho salmon envirogram, Klamath Project, 2007.

					Coho salmon Life Stage						
4	**3**	**2**	**1**	**Centrum**	**Adult Migration**	**Spawning**	**Egg and Alevin**	**Early Fry**	**Overwintering**	**Smolt Migration**	**Ocean**
Resources:											
	Basin Climate →	Annual Precipitation ↘									
			Stream Flow ↘								
	Human Modifications →	Water Management ↗		**Water Quantity and Timing**	●	●	●	●	●	●	
		Human Modifications →	Inter-basin Water Transfer ↗								
Human Modifications →	Water Management →	Flow Regime ↘									
Human Modifications →	Dams →	Water Temperature →	Dissolved Oxygen ↘								
Human Modifications →	Land Use →	Nutrient Loading ↗		**Water Quality**	●	●	●	●	●	●	
			Pollutants ↗								
	Human Modifications →	Land Use ↗									
Broad Climatic Changes →	Contiential Shelf Fertility →	Prey: Small Fishes →	Marine Growth ↘								
				Food	●			●	●	●	●
Basin Water Fertility →	Algae Production →	Prey: Invertebrates →	Freshwater Growth ↗								
Malentities:											
Climate →	Annual Precipitation ↘										
		Flow Regime →	Water Temperature ↘								
Human Modifications →	Water Management ↗										
Human Modifications →	Dams →	Reservoirs ↘									
			Water Temperature →	**Heat Stressors**	●	●		●			
Human Modifications →	Land Use →	Removal of Riparian Vegetation ↗									
			↗								
Basin Climate →	Multi-year Drought →	Ground Water Level →	Thermal Refugia								
		↗									
	Basin Climate →	Annual Precipitation ↘									
			Stream Flow ↘								
	Human Modifications →	Water Management ↗		**Connectivity**	●			●	●	●	
		↗	Barriers to Upstream Migration ↗								
	Human Modifications →	Dams									
		↘	Suppression of Flushing ↘								
		↗	Large Wood Debris ↘								
				Habitat Quality	●	●	●	●	●	●	
	Human Modifications →	Land Use →	Increase Sedimentation →								
		↘	Over Stream Cover ↗								
Human Modifications →	Land Use →	Increase Sedimentation →	Suffocation →	**Egg Hatching Success**			●				
		↗	Artificial Propagation →	**Competitors**				●	●	●	●
	Human Modifications →	Hatcheries									
		↘	Past Hatchery Practices →	**Fitness**	●	●	●	●	●	●	●
Predators:											
		Water Temperature ↘	Exposure to Pathogens ↘								
		Stream Flow ↗	↗	**Disease**	●			●	●	●	
	Human Modifications →	Hatcheries →	Artificial Propagation ↘								
		Human Modifications →	Introduced Species →	**Piscivorous Fishes, Birds, Mammals**	●	●	●	●	●	●	●
			Suitable Habitat →								
			Alternate Prey ↗								
		Human Modifications →	Fisheries →	**Physical Removal**	●						●

Factors to be Considered

An envirogram is simply a tool that sharpens our understanding of the most important ecological factors that affect a population or group of populations of a particular species. Envirograms are not intended to be stand-alone documents but should be used in conjunction with species profiles and maps showing the distribution of populations and suitable habitat. They are considered to be "works in progress" and always can be modified by new and better information. Comparing envirograms for different species facilitates the recognition of resource overlaps and commonalities, conflicts, and biological interactions.

Using the envirogram (see Table 3-19), Reclamation identified three primary factors to be considered in assessing the impacts of the Proposed Action on coho salmon: water quantity (including timing); water quality (DO, nutrient loading, and temperature), and disease. Although other factors such as food, connectivity, predation, and physical removal do have impacts on the populations, these factors are considered to be of less importance. The qualitative impacts of the Proposed Action on coho salmon through water quantity and timing; water quality, and disease will follow. A quantitative discussion of these impacts will be discussed in later sections.

Water Quantity and Timing

The impacts of water quantity and timing on salmon include: reduced potential rearing habitat; inhibition of upstream and downstream passage; and increased water temperatures. Based on the estimated fresh water habitat use pattern for coho salmon, the water quantity and timing of flows within the main stem Klamath River could impact the coho salmon at various life stages.

Integrated Flow and Habitat Based Flow Recommendations

Hardy and Addley (Table 27, p. 182, Hardy and Addley 2006) provides a natural flow paradigm based on physical habitat for a given annual exceedence level for a given month. Hardy and Addley (2006) maintained that this integrated approach combined the underlying characteristic of the flow and habitat regime based on the ranges of expected variability for a given exceedence range meets the objectives of using Hardy and Addley's (2006) estimated natural flow paradigm to guide the process to recommend flows. However, this analysis did not evaluate whether these flows were physically possible to attain or what effect they may have on other species within the ecosystem above IGD, such as the two listed species of suckers.

However, Reclamation notes that Hardy and Addley (2006) recommended flows were developed for considerations of Chinook salmon, steelhead trout, and coho salmon, not just for ESA-listed coho salmon, which is the focus of this BA.

Subsistence Flow

Hardy and Addley (2006) defined subsistence flows as minimum stream flows needed to maintain tolerable water quality conditions, provide minimal aquatic habitat, and typically result in the accumulation of fine particulate matter in lower velocity areas.

Hardy considered subsistence flows to represent flows between approximately the 80 and 95 percent exceedence ranges. Hardy and Addley (2006) concluded that at the subsistence flow exceedence ranges, 80 to 95 percent; water temperature affects in terms of increased risk associated with thermal stress, disease, and migration inhibition become a concern. However, Hardy and Addley (2006) believed that these conditions naturally occurred within the main stem Klamath River below IGD and they, in fact, represent an important environmental stressor for long-term population genetics. Therefore Hardy and Addley (2006) attempted to balance their recommendations between allowing the full range of natural flow and temperature conditions to exist and the objective to reduce these risks to acceptable levels (pages 182 and 183, Hardy and Addley 2006). Again, Reclamation notes that Hardy and Addley's (2006) recommended subsistence flows were developed primarily for Chinook salmon, steelhead trout, and coho salmon, not just for ESA-listed coho salmon, which is the focus of this BA.

Water Quality

While there has been much focus on water quantity and timing, water quality is also an important issue in the Klamath River Basin. The impacts of water quality on salmon include degradation of spawning and rearing habitat and exceedence of parameters that may contribute to direct or delayed mortality. Although elevated pH is of some concern, three aspects of water quality, DO, nutrient loads and temperature are of primary interest due to their direct effect on fish survival and the interactions between them. The excessive nutrient loading originating in the Upper Klamath River Basin drives the primary production of phytoplankton and attached aquatic vegetation, which causes the elevated pH values observed in the Klamath River (Kann and Smith 1993; Campbell 1995). See the discussion on algal productivity and associated poor water quality and nutrient loading in Section II of this BA and the nutrient loading discussion below for a summary of nutrient loading sources and the effects of algal productivity on pH and other aspects of water quality.

The Klamath River, from the headwaters to the mouth, is listed as water quality impaired under Section 303(d) of the Federal Clean Water Act. In 1992, the California State Water Resources Control Board proposed that the Klamath River be listed for both temperature and nutrients, requiring the development of Total Maximum Daily Load (TMDL)[32] limits and implementation plans. The EPA and North Coast Regional Water Quality Control Board (NCRWQCB) accepted this action in 1993. The basis for listing the Klamath River as impaired was aquatic habitat degradation due to excessively warm water temperatures and algae blooms associated with high nutrient loads, water impoundments, and agricultural water diversions (EPA 1993).

---

[32] Total Maximum Daily Load (TMDL) is the amount of a particular pollutant that a particular stream, lake, estuary or other water body can 'handle' without violating state water quality standards.

In 1997, the NCRWQCB updated the 303(d) list and added DOn as an additional limiting factor for aquatic habitat in the Klamath River (NCRWQCB 1998)[33]. The impairment listing regarding DO was prompted by a 1997 USFWS report (NMFS 2002 BO). The USFWS' concerns included: the current status of salmonid populations in the Klamath River; the effects of past and current land use on water quality; annual fish and temperature monitoring data; and documented fish die-offs.

The fact that the Klamath River is listed for temperature, nutrients, and DO is especially important due to the relationship between these three water quality parameters. As described by Campbell (1995), increased water temperatures and lower saturated oxygen concentrations typically occur in the Klamath River during summer months, the same time of year that the growth and respiration cycles of aquatic plants affect DO concentration. These three parameters interact synergistically, and can have a much greater impact on water quality and salmonids than either temperature or DO alone (Campbell 1995).

Dissolved Oxygen

As water temperatures rise and plants and algae decompose, the level of DO decreases. Dissolved oxygen levels in the Klamath River often fall below the State of California's water quality objective of 7.0 mg/l. Dissolved oxygen is also discussed in more detail in the sucker portion of this BA.

Nutrient Loading

Excessive nutrient loading leads to increased growth of aquatic plants and algae in the Klamath River. This growth fosters sediment accumulation which decreases the quality of salmonid spawning and rearing habitat and leads to decreased DO concentration and high pH values on a daily cycle (Campbell 1995). The increased growth of aquatic plants and algae can also retard water velocity at low stream flows, contributing to higher stream temperatures in the Klamath River (Trihey and Associates 1996). Again, reflecting the close relationship between these three water quality parameters.

The vast majority of nutrient input to the Klamath River is due to background nutrient sources. Particulate organic matter that originates or is a result of nutrients released from UKL is overwhelmingly the largest source of nutrients relative to other nutrient sources, including agricultural, municipal, and industrial inputs in the Klamath Falls area (Reclamation, 2007, unpublished data). Table 3-20 summarizes nutrient concentrations observed at the UKL and Klamath Straits Drain outlets.

---

[33] The mission of the North Coast Regional Water Quality Control Board is to preserve, enhance, and restore the quality of California's water resources, and to ensure their proper allocation and efficient use for the benefit of present and future generations

Table 3-20. Summary of 2002 UKL and KSD Nutrient Concentrations.

Location	**Ammonia**	**TKN**	**NO_2+NO_3**	**Total P**	**Ortho P**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Median Observed Concentrations					
UKL at Link Dam	0.13	2.45	0.07	0.20	0.08
KSD at Hwy 97	0.31	2.60	0.15	0.43	0.38
Minimum Observed Concentrations					
UKL at Link Dam	0.06	0.40	0.03	0.11	0.03
KSD at Hwy 97	0.07	1.90	0.06	0.22	0.03
Maximum Observed Concentrations					
UKL at Link Dam	0.97	3.50	0.25	0.42	0.46
KSD at Hwy 97	0.80	3.60	1.40	0.85	0.68
All nutrient loads, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite (NO_2+NO_3) loads are for the period of mid-April through mid-August.					

Nutrient loads diverted into the Klamath Project and discharged back into the Klamath River, from UKL and the Klamath Project, were estimated for the period of April to October 2002, except for nitrate plus nitrite, which is estimated for the period of April to August 2002. The nutrient loading estimates show that the Klamath Project is a net "sink" for nutrients and provides substantial nutrient reduction of diverted waters. The nutrient load reduction is estimated at 83 percent for ammonia, 69 percent for nitrate plus nitrite, 85 percent for total Kjeldahl nitrogen, 62 percent for orthophosphate, and 73 percent for total phosphorous. Table 3-21 summarizes 2002 nutrient loading to the Upper Klamath River and the Klamath Project (Reclamation, 2007, unpublished data).

Table 3-21. Upper Klamath River Basin Nutrient Loading, 2002.

Location	Ammonia	NO_2+NO_3	TKN	Ortho P	Total P
	Metric Tons	Metric Tons	Metric Tons	Metric Tons	Metric Tons
Nutrient Load from Upper Klamath Lake to the Klamath River					
UKL at Link Dam	107.0	26.3	778.4	41.4	81.6
Nutrient Load diverted to the Klamath Project from Upper Klamath Lake and the Klamath River					
A-Canal	87.7	24.3	678.6	39.6	70.6
LRDC	16.3	4.7	131.0	5.8	14.2
North Canal	11.9	0.8	55.7	4.2	6.9
Ady Canal	17.4	2.2	113.7	8.0	14.2
Total Load to KP	133.2	32.1	978.9	57.6	105.9
Nutrient Load Returned to the Klamath River from the Klamath Project					
KSD at Hwy 97	22.3	10.0	147.3	21.8	28.2
Nutrient Load Reduction Within the Klamath Project					
Net Reduction	-110.9	-22.1	-831.6	-35.8	-77.7
All nutrient loads, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite (NO2+NO3) loads are for the period of mid-April through mid-August.					

In addition to Klamath Project net reductions of nutrients, much of the nutrients originating from the Upper Klamath River Basin are trapped by a system of reservoirs between UKL and IGD, which settle out particulate organic matter and reduce the overall nutrient load to the reaches below IGD. All of the reservoirs are "productive," and nutrient concentrations are elevated in all of them.

However, UKL is in general, several times as "productive" as IGD and Copco reservoirs (KWUA, 2003). Further, UKL is a much larger body of water with a larger surface area and shallow depth can produce appreciable nutrient inputs to the Klamath River. Comparatively, the IGD and Copco reservoirs have much smaller surface areas and, although productive, do not yield the same loading potential as UKL. These reservoirs thus have a considerably smaller impact on releases of nutrients to the Klamath River than UKL (KWUA 2003).

Upper Klamath River Basin nutrient loading and cycling processes are discussed in more detail in the sucker portion of the BA. However, Reclamation agrees with Hardy and Addley (2006) that it is most likely that DO and other water quality parameters are of secondary importance when compared to that of temperature (p. 47 and p. 48, Hardy and Addley 2006).

Temperature

Temperatures periodically reach levels that are lethal to coho salmon within the Klamath River Basin. Table 3-22 provides a summary of temperature considerations for salmon and trout life stages from EPA guidance (EPA 2003). The EPA Quality Criteria for Water considers acute thermal conditions for coho and Chinook salmon as 71.6 ºF (22 ºC) and chronic exposures to occur at 60.8 ºF (16 ºC). High water temperature, combined with elevated nutrient levels, results in stimulation of aquatic plant and algae growth. As water temperatures rise and plants and algae decompose, the level of DO decreases. Dissolved oxygen levels throughout the Lower Klamath River Basin often fall below the State of California's water quality objective of 7.0 mg/l.

Table 3-22. Summary of temperature considerations for salmon and trout life stages from EPA Region 10, Guidance for Pacific Northwest State and Tribal temperature water standards.

Life Stage	Temperature Consideration	Unit and Temperature[1]
Spawning and egg incubation	Temperature range at which spawning is most frequently observed in the field.	Daily Average: 4 to 14 °C
	Results in good survival in egg incubation studies.	Constant: 4 to 12 °C
	Reduced viability of gametes in holding adults	Constant: >13 °C

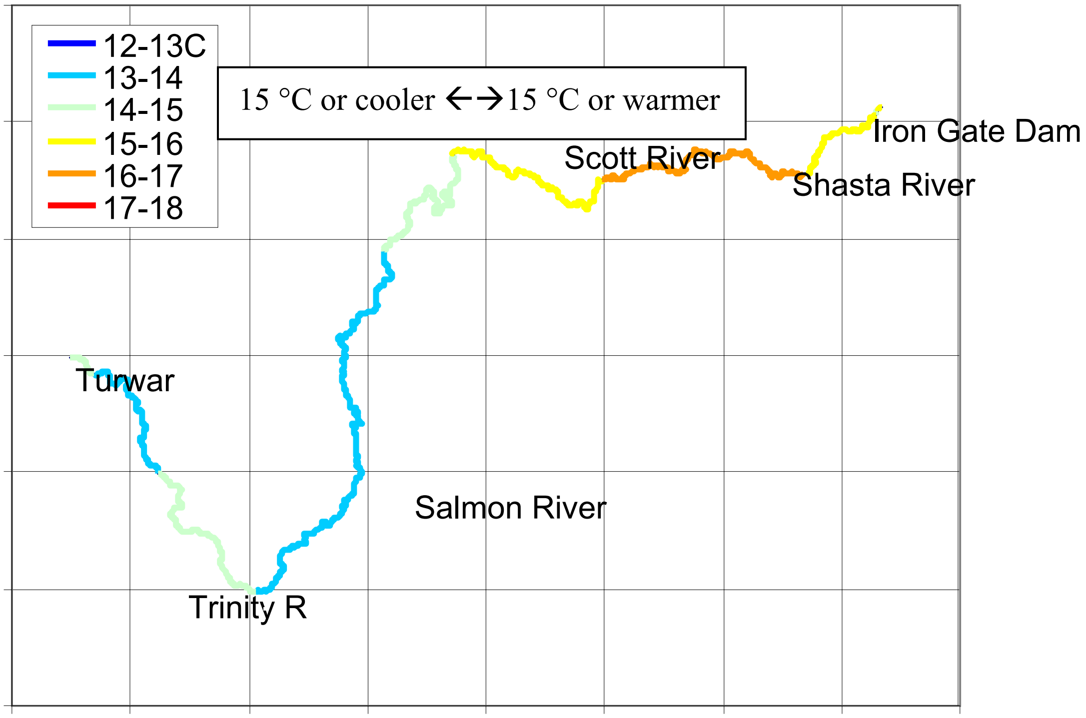
Life Stage	Temperature Consideration	Unit and Temperature[1]
Juvenile Rearing	Lethal temperature with one week exposure.	Constant: 23 to 26 °C
	Optimal Growth with unlimited food,	Constant: 13 to 20 °C
	Optimal Growth with limited food,	Constant: 10 to 26 °C
	Impairment to smoltification.	Constant: 12 to 15 °C
	High disease risk in lab. Studies.	Constant: 18 to 20 °C
	Elevated disease risk in lab. Studies.	Constant: 14 to 17 °C
	Minimized disease risk in lab. Studies.	Constant: 12 to 13 °C
Adult Migration	Lethal temperature with one week exposure.	Constant: 21 to 22 °C
	High disease risk in lab. Studies.	Constant: 18 to 20 °C
	Elevated disease risk in lab. Studies.	Constant: 14 to 17 °C
	Minimized disease risk in lab. Studies.	Constant: 12 to 13 °C
	Migrations blockage and migration delay.	Average: 21 to 22 °C
	Reduced adult swimming performance.	Constant: > 20 °C
	Optimal adult swimming performance.	Constant: 15 to 19 °C
	Overall reduction in migration fitness due to cumulative stresses.	Prolong Exposure: > 17 to 18 °C

[1] All temperatures in ºC, for a reference: 15 ºC = 59 ºF, 20 ºC = 68 ºF, 23 ºC = 73.4 ºF.

High water temperatures during the late spring and summer months can be an important factor affecting the distribution, growth, and survival of juvenile coho salmon. Figure 3-15 is a longitudinal view of daily mean water temperatures from IGD to Turwar, on June 1 in a typical year. Water temperatures above 60.8 ºF (16 ºC) can trigger movement of juvenile coho salmon during these months. Movement occurs as fish seek refuge from high temperatures. The National Academy of Science concluded that any juvenile coho salmon living in the main stem of the Klamath River probably tolerate the temperature only by staying in pockets of cool water created by ground-water seepage or small tributary flows. The NAS also hypothesized that adding substantial amounts of warm water could reduce the size of these thermal shelters, although that hypothesis was not supported by research at the Red Cap Creek thermal refuge (Benson and Holt 2005)[34].

Generally, during late spring and early summer, flows from Iron Gate Reservoir tend to be below equilibrium temperature on the order of 2 to 4 ºC. However, the effect is diminished with increased distance from the dam. The cooler water temperature is attributed to the source of the water, the IGD reservoir. Note that the warmest reach of the Klamath River is between Scott River and Shasta River.

Figure 3-15. Longitudinal view of daily mean water temperatures from IGD to Turwar, on June 1 in a typical year.



Source: Figure 5, p. 9, Cramer Fish Sciences 2007 Technical Memorandum 7.

---

[34] National Academy of Science news release dated February 6, 2002. News release obtained on July 5, 2007 at http: //www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=10296

Findings from recent studies on main stem Klamath River water temperatures, including PacifiCorp (2006) and Dunsmoor and Huntington (2006), are:

(1) Higher flows in the spring from reservoir releases tend to be cooler than would be expected under a natural flow regime due to the thermal mass in the reservoirs.

(2) Thermal mass of the reservoirs is responsible for an increase in fall water temperature over what would be expected under a natural flow regime.

(3) The reservoirs generally dampen the expected day-to-day and diurnal thermal cycle although releases below IGD imprints the flow and thermal signal downstream and reflects both operational changes in flow constrained by a limit on maximum turbine releases of 1735 cfs.

(4) The operational zone of impact on the thermal regime is pragmatically confined from IGD downstream to the vicinity of Seiad Valley (river mile 129) and dependant of flow release magnitudes at IGD.

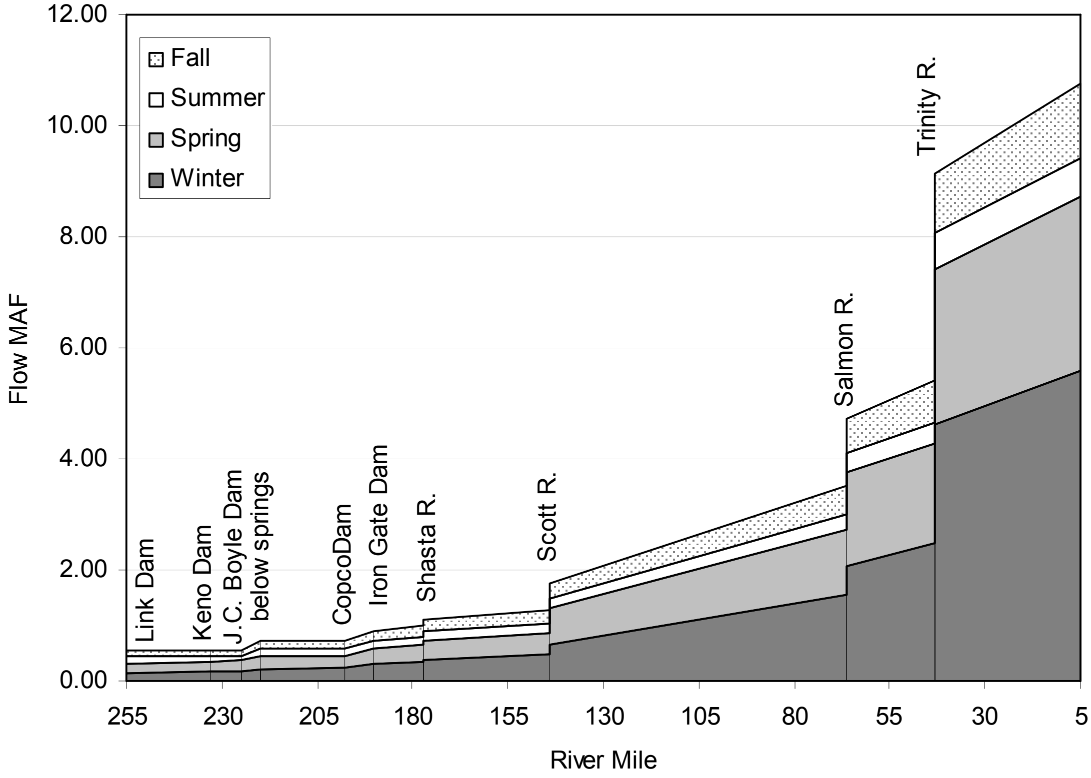
Various flow rates from IGD can influence water temperature by altering the impact of tributary contribution and changing transit time, depth, and width of the Klamath River (Watercourse 2003). Generally, during late spring and early summer, discharges from Iron Gate Reservoir tend to be below equilibrium temperature (Deas and Orlob 1999, Watercourse 2003; Cramer Fish Sciences 2007 Report). However, the cooling effect to the Klamath River is diminished with increased distance from the dam (Deas and Orlob 1999; Campbell et al. 2001; Cramer Fish Sciences 2007 Report). The cooler water temperature is attributed to the temperature dynamics of Iron Gate Reservoir. Water behind IGD is also the source of cold water for Iron Gate Hatchery. During fall, Iron Gate Reservoir will periodically release water above the river's equilibrium temperature, acting as a heat source for the river (Deas and Orlob 1999).

To further understand the relationship of flow to temperature, Reclamation commissioned Cramer Fish Sciences and Watercourse Engineering to develop a flow and temperature components for the coho salmon life-cycle model for the main stem Klamath River below IGD. More detailed information on the model may be found in a following section, Cramer Fish Science, Technical Memorandum 7 and in Appendix 3-B.

Similar to the findings of Hardy and Addley (p. 47, 2006), Cramer Fish Sciences, in addition to several other modeling efforts, concluded that releases from IGD in most years would have a limited ability to regulate temperature in the middle Klamath River downstream of the confluence with the Scott River (river mile 144) and increased discharges do not provide appreciable thermal benefits beyond reduced diel temperature fluctuation in the vicinity of the dam (Deas and Orlob 1999; Campbell et al. 2001; Watercourse 2003; Cramer Fish Sciences 2007 Report). However, in years with low fall tributary flows, modeling suggests that increased IGD discharge could actually increase water temperature in the main stem of the lower Klamath River (Cramer Fish Sciences 2007 Report). This may be possible because the higher warmer flows within the main stem could dilute the cooler tributary inputs. See Appendix 3-C for more detail on the relationship between water temperature, distance from IGD, and flow.

In general, the diurnal range in water temperature is greatest in the summer and smallest in winter. Flow considerations likewise include seasonal and longitudinal variability between IGD and the ocean. Accretions in winter and spring can increase the river flows by an order of magnitude, while summer flows, although doubling between IGD and Turwar, do not increase to the same extent. The IGD (river mile 190) to Turwar (river mile 5) reach extends approximately 185 miles. Several main tributaries flow into the reach: Shasta River, Scott River, Salmon River, and Trinity River (Figure 3-16).

Figure 3-16. Simulated seasonal flows in the Klamath River from Link River to Turwar in 2000. Flows from IGD comprise a progressively smaller proportion of the average annual and seasonal main stem flows at points further downriver.



Source: Figure 14, p. 88, Cramer Fish Sciences 2007 Technical Memorandum 7.

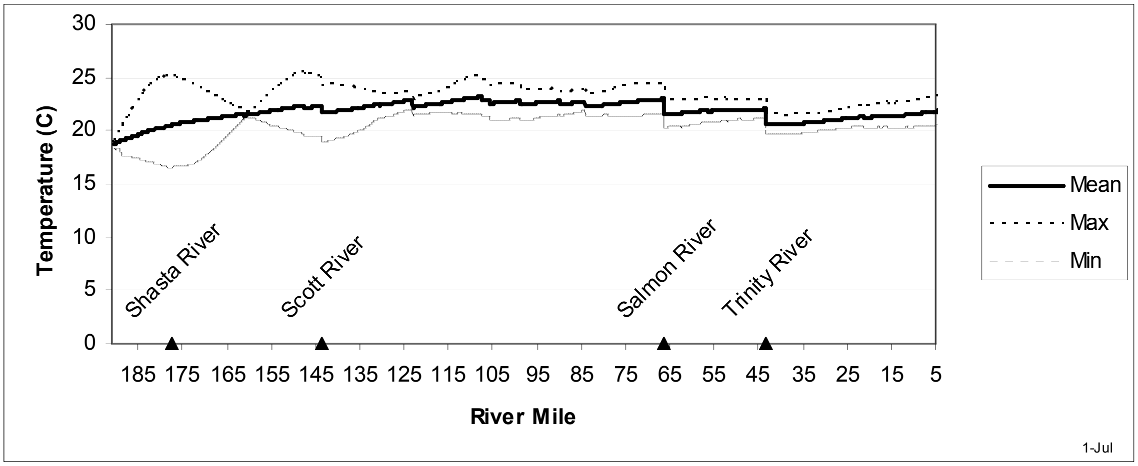
During winter, the water released from the IGD reservoir has its least effect on downstream temperatures, and the river warms slightly with progressive distance downstream. In spring, conditions may vary considerably, but the reservoir generally reduces main stem temperatures down to the Scott River. During late spring and early summer the reservoir tends to release waters that are on the order of 2 to 4 ºC below temperatures that would be experienced if IGD was not in place. The cooler water has a diminishing effect further downstream. From later summer into fall, the large thermal mass of the reservoir tends to create a thermal lag, where temperatures leaving the dam may be warmer than equilibrium temperature. The effects of this thermal lag diminish with distance downstream.

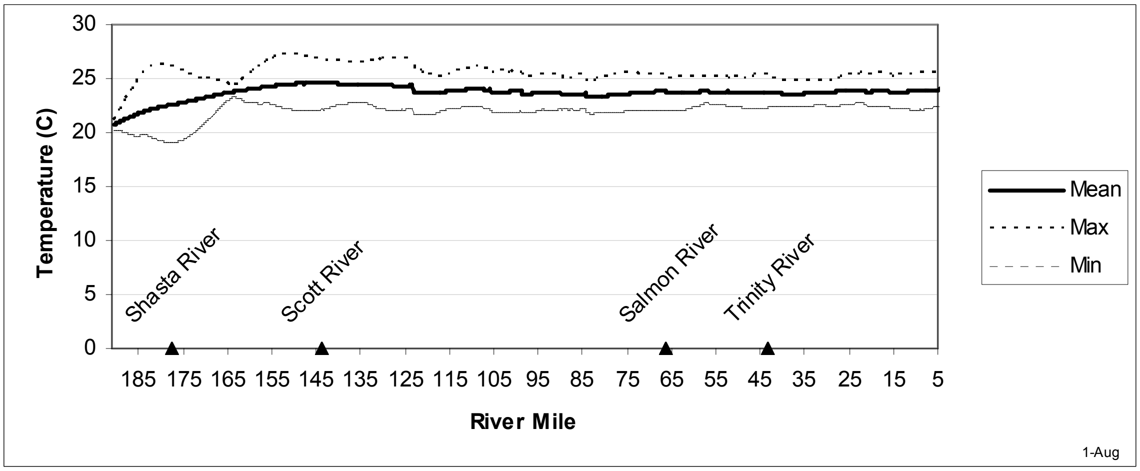
The temperature modeling indicated that tributary inputs and meteorological conditions are the primary temperature drivers throughout the year downstream from the Scott River. Thus, the ability to control temperature in the lower Klamath River through flow management at IGD is limited because ambient temperatures and tributary flows downstream are much larger than those from IGD, depending on season and annual variability (see earlier Figure 3-16).

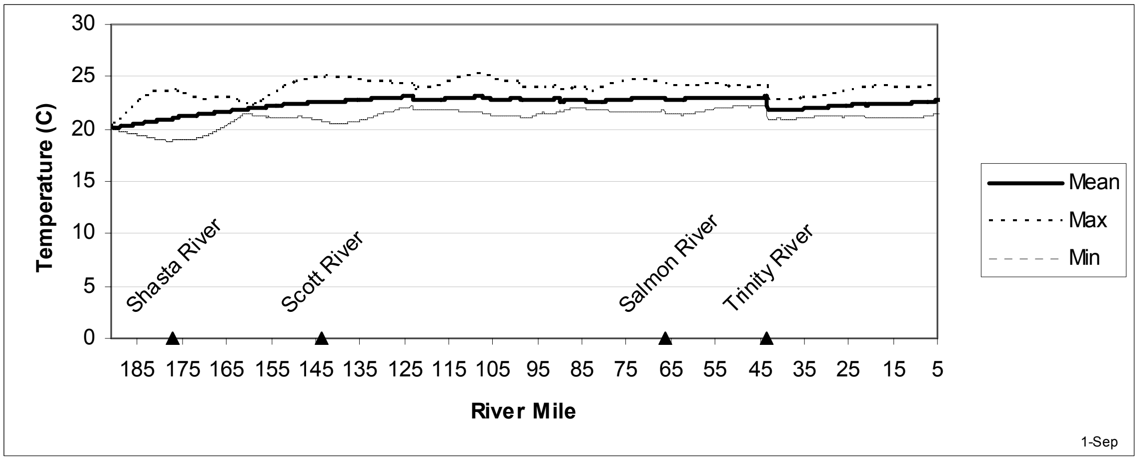
During smolt out-migration, the Proposed Action has some effect on temperatures downstream of IGD; however, temperatures remain within the optimum range for survival during the majority of the smolt migration for a wide range of flow releases (see Appendix 3-C), and therefore has a limited effect on smolt survival.

Later in the spring and on through the summer, temperatures exceed tolerable levels and coho salmon are relegated to thermal refugia throughout most of the main stem or must migrate into non-natal tributaries (Figure 3-17). During summer, releases from IGD have little influence on temperatures downriver of the Shasta River. Thus, high temperatures in the Klamath River sharply limit the rearing capacity for coho salmon in the main stem during summer, and heat energy balances dictate that releases of any magnitude from IGD can have little influence below the Shasta River (Cramer Fish Sciences 2007 Technical Memorandum 5).

Figure 3-17. Longitudinal profile of daily maximum, mean, and minimum water temperatures in the Klamath River for July 1 (top graph), August 1 (middle graph) and September 1 (bottom graph), as predicted from the temperature model, given 2001 meteorology and tributary flows.







Disease

Disease occurs when conditions for the pathogen are optimal and infection results in damage or death to the host. Baseline information on the distribution and even occurrence of most salmonid pathogens in this system is limited. Existing data and observations indicate that the most common pathogens of concern can be grouped into three categories: the bacterial pathogens *Flavobacterium columnare* (columnaris disease) and *Aeromonas hydrophila*; external parasites *Ichthyophthirius* (Ich), *Ichthyobodo*, and *Trichodina*; and the myxozoan parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis*. Other common pathogens are likely present in the system but are reported rarely.

Diseases are an integral part of the existence of all animals, including both hatchery-origin and natural-origin fish populations. Elton (1931) illustrates a widely held misperception of the public and scientific community regarding diseases in natural-origin animal populations. He stated, ‘‘[u]p to the present time it has been customary to believe that wild animals possess a high standard of health, which is rigidly maintained by the action of natural selection... ’’ Elton (1931) noted that diseases are inherent to aquatic ecosystems.

Numerous factors are causes of disease, but how all of them interact is a complex situation for which we have yet to develop a full appreciation. Understanding how pathogens and hosts evolve is critical to predicting the effectiveness of management and regulatory decisions. Human actions and disturbance can affect this balance, leading to artificially increased mortality (severity, distribution, and timing) from naturally occurring disease. What we do know is that environmental variables that affect the host-pathogen balance vary somewhat between the different pathogens. The three pathogens most commonly associated with disease-related mortality in Klamath River salmonids are: Columnaris, Ich and C. S*hasta*. The brief summary of these three pathogens follows. More detailed information is in pages 4 to 8 of Cramer Fish Sciences 2007 Technical Memorandum 6.

Columnaris, *Flavobacterium Columnare*

Columnaris, *Flavobacterium columnare* is ubiquitous in water and sediment and infects a wide variety of fish species including, but not limited to, salmonids. Disease often occurs under conditions where fish densities are high and water temperatures are elevated, allowing horizontal transmission and rapid replication of the bacterium, as was the case in the epizootic[35] in adult fish in the Klamath River in 2002 (Foott et al. 2003 and 2004).

Ich

As with bacterial pathogens, this organism is ubiquitous in the environment and affects both salmonids and non-salmonid fish. The parasite life cycle does not require an intermediate host, but it does involve off-host development. Development of this free-living stage occurs in the substrate, where the parasite undergoes division into free-swimming stages that are viable for only a few days. During low flows, disease transmission and infection risk can significantly increase (Bodensteiner et al. 2000). Ich outbreaks have occurred among adult salmon at relatively cold temperatures of less than 15 ºC (Traxler et al. 1998). Ich and other external parasites are more likely to cause severe effects on young fish but may contribute to the pre-spawning mortality of adult fish as seen in the Klamath River Basin 2002 adult fish kill (Foott et al. 2003 and 2004; Guillen 2003; and Belchik et al. 2004)

Ceratomyxa Shasta

Unlike the bacterial pathogens and external parasites, transmission of myxozoan parasites is limited to areas where the invertebrate (fresh water polychaete: *Manayunkia speciosa*) host is present (Bartholomew et al. 1997). The distribution of C. S*hasta* is limited to the Pacific Northwest of the U.S. And Canada where it is present in many of the larger river

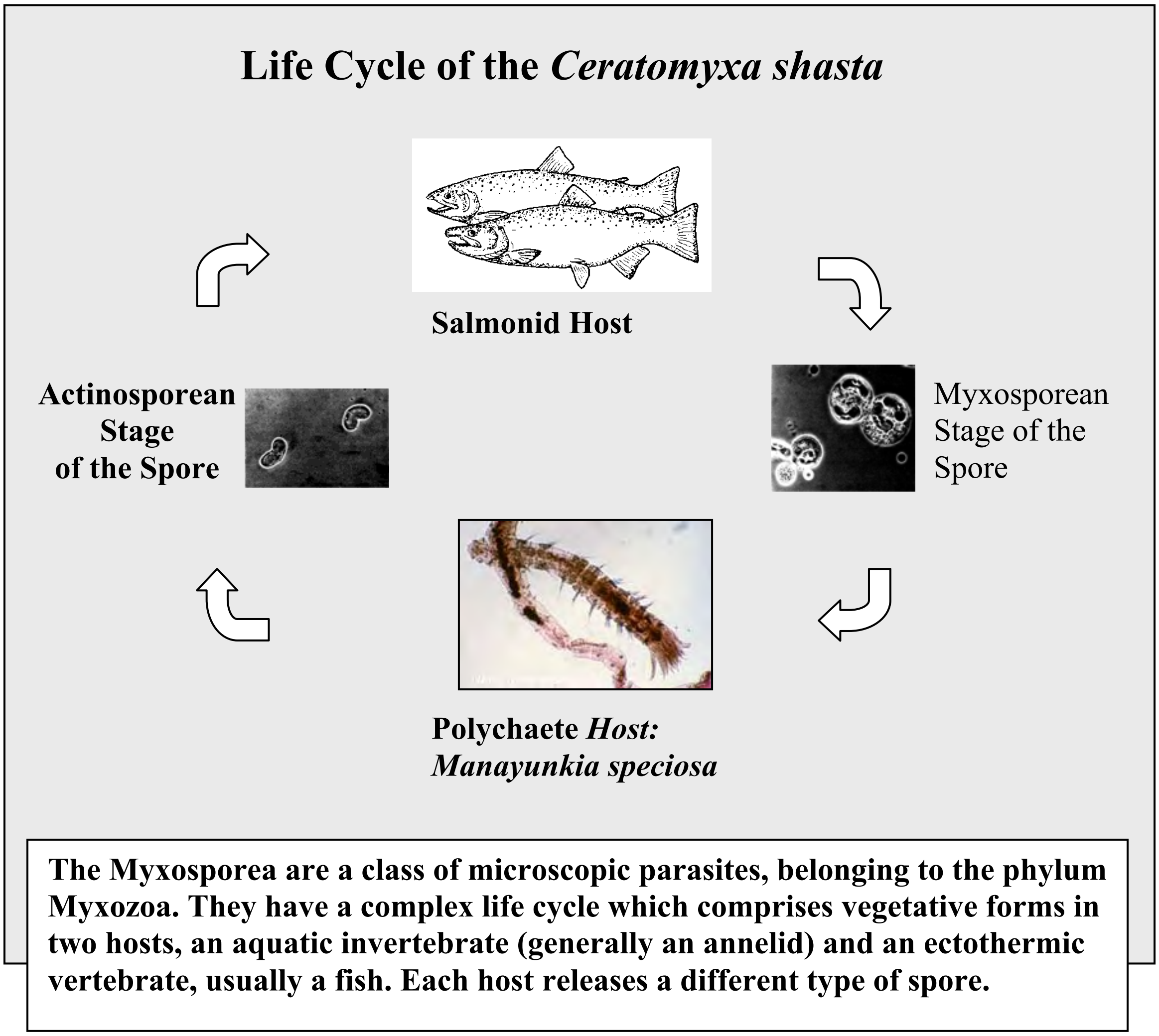
---

[35] Denoting a temporal pattern of disease occurrence in an animal population in which the disease occurs with a frequency clearly in excess of the expected frequency in that population during a given time interval.

systems. C. S*hasta* have a complex life cycle which comprises vegetative forms in two hosts, an aquatic invertebrate (generally an annelid) and an ectothermic vertebrate, usually a fish (Figure 3-18).

At this time, the relationship between Klamath Project operations, water quantity and water quality of IGD releases and conditions that exacerbate fish disease mechanisms is complicated and not fully understood.

Figure 3-18. Life cycle of the *Ceratomyxa Shasta. D*isease in salmon as a result of C. S*hasta* results from a series of complex interacting variables between hosts, spores, and the environment.



The Myxosporea are a class of microscopic parasites, belonging to the phylum Myxozoa. They have a complex life cycle which comprises vegetative forms in two hosts, an aquatic invertebrate (generally an annelid) and an ectothermic vertebrate, usually a fish. Each host releases a different type of spore.

NMFS acknowledged that the relationship between Klamath Project operations, water quantity and water quality of IGD releases, and conditions that exacerbate fish disease mechanisms is complicated and not fully understood (p. 67, NMFS 2002 BO). However, since that time, additional studies have been conducted on this topic indicating that C. S*hasta* infection and mortality are more sever at higher temperatures and lower flows.

Additionally, Stocking et al. (2007) concluded in his study that the lack of infection in groups exposed in tributaries supports the hypothesis that the parasite life cycle and the invertebrate host are largely confined to the main stem Klamath River. In addition, we have no way of determining the rate of exposure to any of these diseasse mechanisms (dose), which further complicates identifying solutions.

Pre-spawner Mortality

In 2002, approximately 30,000 migrating adult salmon died in the Klamath River from two common pathogens that become lethal to fish under specific stress conditions. Most of the salmon that died were Chinook salmon, which are not listed under the ESA as endangered or threatened. Only approximately one percent of the die-off were coho salmon, which migrate later than the Chinook salmon. In a report documenting their findings, the USFWS found that a "combination of factors" caused salmon die-off in Klamath River in 2002 (USFWS 2003 News Release). The USFWS (2003 News Release) further stated that "[s]everal factors, none unprecedented, combined to create conditions that led to an outbreak of two fish pathogens, Ich and columnaris. Those conditions included a large run of fall-run Chinook salmon; a high density of fish in the lower river, and relatively low flows and high temperatures. For unknown reasons, fish began arriving in the Klamath River system one to two weeks earlier than normal. But because of a lack of rainfall or freshwater pulses, the fish did not receive cues to begin their upstream migration. Because of the heavy congregation of fish, the pathogen outbreaks spreaded swiftly." Studies by the CDFG and the U.S. Geological Survey also showed that neither the river flows nor temperatures that occurred during the time the fish died were unprecedented, and in a news release issued by the National Academy of Sciences (NAS), they agreed that neither flow nor temperature conditions alone can explain the 2002 die-off.

Presentations at the workshop focused on the disease pathogens, *Ceratomyxa shasta*, *Parvicapsula minibicornis* (Parvicapsula), and their intermediate host, the polychaete worm, *Manayunkia speciosa*. Based on presentations at the workshop, effects of the disease will vary annually based on temperature, hydrology, and possibly other factors. Although no recommendations were made at the workshop, possible management measures to address Klamath River fish disease issues were discussed by panels of fish health experts and resource agency representatives.

At the workshop, flow alterations were discussed as the primary management tool. For example, one hypothesis is that flow increases in spring could dilute the concentrations of spores as well as augment out-migration of juvenile salmon through the high risk areas of the main stem Klamath River. The health and consequent ability of the juvenile salmon to resist infections may rise as well from increased flows. However, Reclamation notes that preliminary information suggests that high, cold flows from snowmelt in 2006 only delayed the disease breakout. As soon as the water temperature warmed up, the disease organisms rapidly reappeared. It is also unknkown whether or not changes in flow would affect the amount of pathogens that fish are exposed to.

The panels also discussed the approach of combating fish disease by disturbing the habitat of the polychaete worm. Disturbing the habitat could possibly be accomplished through high scouring flows, which are more typical in the winter. It may also have the opposite effect on available habitat for the disease mechanisms and their hosts. It is interesting to note that high scouring flows up to 11,000 cfs did occur below IGD in 2006, with mortality results that year are different from results obtained in June 2004 as mortality was both decreased and delayed (Stocking et al. 2006).

Disease Conclusions

Data are limited, and precise estimation of disease effects on coho salmon is not possible at this time. Though difficult to precisely quantify, Reclamation recognize that disease conditions in the main stem Klamath River between IGD and the Scott River are having unusually high impacts on juvenile salmonid survival. This conclusion is drawn from several sources of empirical data including parasite concentration sampled in the main stem Klamath River in the spring of 2005 (Bartholomew, unpublished data) and infection prevalence (Stocking and Bartholomew 2007). Researchers also reported many live fish captured in main stem traps below IGD exhibiting external signs of disease infection and/or stress (Chamberlain and Williamson 2006). It is important to note these fish were held in cages and wer e not free to move to other parts of the river where disease organism levels may be different.

Existing Klamath River data and laboratory data indicate that temperature strongly affects coho disease mortality. Available data also show an inconsistent relationship between flow and disease induced mortality. Although, it is likely that flow has a dilution effect on disease concentration, data is not available to quantify this relationship (Cramer Fish Sciences 2007 Technical Response Brief 6). However, given the increasing attention being made to understand the impacts of diseases on Klamath River salmonids, it is likely that data may be available in the near future.

Based on the discussion above, the discussions in Cramer Fish Sciences Technical 2007 Memorandum 6, Cramer Fish Sciences 2007 Technical Response Brief 6, the following conclusions that can be drawn about disease conditions and their effects on the coho salmon life-cycle in the Klamath River:

(1) Pathogen presence is affected by temperature

(2) Disease effects are highly influenced by water temperature

(3) Disease conditions vary widely from year to year, with largest effects evident during drought cycles

(4) Tributaries are not major sources of myxozoan pathogens

(5) Myxozoan concentration and thus infection prevalence is substantially higher between IGD and the Scott River than anywhere else in the Klamath mainstem

The interventions that flow from the IGD could provide to reduce downriver mortality due to disease are uncertain at this time. However, we must appreciate that diseases are and will be an inherent and important component of aquatic ecosystems. Under the IM approach proposed, Reclamation will continue to work with NMFS, the states of California and Oregon, and the Tribes to identify potential modifications to the existing operation that may reduce any direct and indirect impacts that the Klamath Project may have on mortality caused by disease.

Effects of the Proposed Action on Coho Salmon

When determining the effects of the Proposed Action on a listed salmonid species, the ESU is the listed entity under the ESA, not the individual listed specie, or even the individual populations within the ESU. However, it is necessary to assess the impacts of the Proposed Action on the populations to determine the aggregate impacts on the ESU.

Current information suggests relatively little main stem spawning is occurring within the main stem of the Klamath River (see Table 3-9). The vast majority of spawning within this basin occurs within the tributaries of the Klamath River. The Proposed Action would not be expected to affect salmon habitat within the tributaries of the Lower Klamath River Basin. However, main stem conditions affect tributary coho salmon populations by:

(1) Facilitating movement of juveniles into and between tributaries

(2) Providing rearing habitat for fry and juveniles produced in tributaries

(3) Providing adequate conditions for coho salmon smolts as they emigrate from tributaries to the sea

(4) Impactting the level of disease infection and mortality

Qualitative Analysis of the Effects of the Proposed Action by Population

in reviewing the envirogram (see Table 3-19), Reclamation identified three factors to be considered in assessing the impacts of the Proposed Action on coho salmon populations: flows, temperature, and disease[36]. For the purpose of a qualitative assessment of the impacts of the Proposed Action, Reclamation has grouped populations into three groupings: the upper Klamath River populations; the middle Klamath River populations, and the lower Klamath River populations.

The following is a general discussion (qualitative) of the impacts of the Proposed Action for these groupings. A more detail discussion (quantitative) of the effects of the Proposed Action on designated critical habitat will follow in section 3.7.2 Effects of the Proposed Action on Designated Critical Habitat. A more detail discussion (quantitative) of the effects of the Proposed Action on the SONCC coho salmon ESU will follow.

Upper Klamath River Populations

The Upper Klamath River populations include: that portion of the Upper Klamath River Population that spawn upstream of Scott River (river mile 144 to 227) and the Shasta River Population (see Table 3-11). Primarily because the upper Klamath River populations are immediately downstream of IGD, the Proposed Action will have the most impact (adverse and beneficial) on these populations. The effects of the Proposed Action on the upper Klamath River populations (Upper Klamath River and Shasta River Populations) will be discussed by two separate main stem reaches: IGD (river mile 190) to the confluence of the Shasta River (river mile 177) and from the Shasta River (inclusive) to the confluence of the Scott River (river mile 144).

Reach 1: IGD to the Shasta River (Exclusive)

IGD Flow:
Under the Proposed Action, Reclamation proposes to retain the NMFS 2002 BO's recommended long-term minimum flows (1,300 cfs) for releases from IGD during the October through February period. Additionally, Reclamation proposes to also retain the NMFS 2002 BO's recommended 1,000 cfs as the minimum flow for releases from IGD during the July through September period.

In regards to the time period of March through June, under the Proposed Action, Reclamation proposes to retain the NMFS 2002 BO's recommended long-term minimum flows for a dry year for releases from IGD[37]. However, unlike the NMFS 2002 BO,

---

[36] Dissolved oxygen and nutrient loading were discussed in an earlier section and are of secondary importance or discounted.

[37] Dry year water type releases: March 1,450 cfs; April 1,500 cfs; May 1,500 cfs; and June 1,400 cfs.

Reclamation proposes to use these minimum monthly dry water year type flows in place of four or five water year types (what was referred to as below average, average, above average and wet in the NMFS 2002 BO). In most years, Reclamation anticipates to be operating above the cumulative monthly minimum flows. Table 3-17, introduced earlier, reflects the estimated frequency of IGD flows that are anticipated in most years under the Proposed Action.

Reclamation acknowledges that the results of Klamath Project operations will reduce the total annual discharge at IGD. A reduction in flows as a result of Klamath Project operations may decrease the available habitat for juvenile and fry coho salmon in some months. However, the Proposed Action would provide higher-than-historical flows in February through July, and lower-than-historical flows during most of September through January (see Figure 3-14)

A more detail discussion (quantitative) of the effects of the Proposed Action on designated critical habitat will follow in section 3.7.2. The impacts of flow on the SONCC coho salmon ESU will be discussed quantitatively in section 3.7.3.

Temperature

Hardy and Addley (2006) concluded that the operational zone of impact on the thermal regime is pragmatically confined from IGD (river mile 190) downstream to the vicinity of Seiad Valley (river mile 129). Similarly, Cramer Fish Sciences concluded that releases from IGD have a limited ability to regulate temperature in the middle Klamath River downstream of the confluence with the Scott River (river mile 144) and increased discharges do not provide appreciable thermal benefits beyond reduced diel temperature fluctuation in the vicinity of the dam (Deas and Orlob 1999; Campbell et al. 2001; Watercourse 2003; Cramer Fish Sciences 2007 Report). See Appendix 3-C for more detail on the relationship between water temperature, distance from IGD, and flow.

Flows from IGD comprise a progressively smaller proportion of the average annual and seasonal main stem flows at locations further downriver (see Figure 3-16). The proposed project operations, integrated with PacifiCorp operations, will result in slightly cooler flows in the spring and more elevated temperatures are maintained in late fall within the IGD (river mile 190) to Shasta River (river mile 177), reach due to the thermal mass of the reservoirs (NAS 2004, PacifiCorp 2006, Dunsmoor and Huntington 2006).

Watercourse (2007) also found that the average decrease in temperature associated with increased flows from IGD, from 1400 cfs to 3000 cfs, is approximately 0.2 °C, with the greatest thermal benefit of increased flow in May with as much as 0.5 °C decrease in water temperature. See Appendix 3-C for more detail on the relationship between water temperature, distance from IGD, and flow.

Thermal mass of the reservoirs is also responsible for an increase in fall water temperature over what would be expected under a natural flow regime. This would be considered an adverse impact of PacifiCorp’s facilities on ESA-listed coho salmon. Flows from IGD during the fall period, can create lethal temperatures (seven days constant exposure) for rearing juvenile and migrating coho salmon in the range of 23 to 26 ºC and 21 to 22 ºC, respectively (see Table 3-22). These temperatures may be reached in some years within this reach.

However, NMFS concluded that flows in the vicinity of 1,000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature (NMFS 2002 BO). Under the Proposed Action, a flow of 1000 cfs or greater will be maintained during the fall (July through September). Additionally, during the critical time period of March through June, water temperatures are not anticipated to be lethal within this reach of the Klamath River to out-migrating coho salmon smolt, although disease effects related temperature will continue to be a problem.

Disease

In regards to disease, the relationship between the Klamath Project, water temperature, quantity and quality of IGD discharge, and conditions that exacerbate fish disease mechanisms is complicated and not fully understood. However, water quantity (flow) and temperature are interrelated. Given that pathogen presence and disease effects are highly influenced by water temperature, any impact of the Proposed Action through disease would be primarily through the relationship between the operations of the Klamath Project and its effects on water temperature. The extent of the impacts of the Proposed Action on disease may vary from year to year since disease conditions also vary widely from year to year, with largest effects evident during drought cycles.

It has been theorized that flow increases in spring could dilute the concentrations of spores and augment out-migration of juvenile salmon through the high risk areas of the main stem Klamath River. High scouring flows during the winter may also disturb the habitat of the polychaete worm. There may even be other methods to combat the fish disease that may not include flow alterations. Under the proposed IM approach, Reclamation will work with the Technical Team, NMFS, the states of California and Oregon, and the Tribes to identify potential uses of available water that may reduce any direct and indirect impacts caused by disease to coho salmon within this reach of the main stem of the Klamath River.

Summary – IGD to Shasta River Reach

Based on the discussion above, the Proposed Action may have the following impacts in the IGD to Shasta River reach of the main stem of the Klamath River: (-) an adverse impact in the form of reduced potential juvenile and fry habitat resulting from less than optimum flows at IGD; (+) proposed flows in the vicinity of 1,000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature.

In regards to disease, the conditions that exacerbate fish disease mechanisms is complicated and not fully understood, thus, the Proposed Action would have (?) an unknown impact through disease (Table 3-22). However, given that pathogen presence and disease effects are highly influenced by water temperature, any impact of the

Proposed Action through disease would be primarily through the relationship between the operations of the Klamath Project and its effects on water temperature. Any negative impact from disease may vary from year to year, since disease conditions also vary widely from year to year, with largest effects evident during drought cycles.

Reclamation also notes that NMFS has concluded the artificial coho salmon propagation program at the Iron Gate Hatchery is part of the SONCC coho salmon ESU. Annual releases of yearling coho salmon from the Iron Gate Hatchery have averaged 93,206 fish from 2003 to 2007 (see Table 3-14). Iron Gate Hatchery mitigation goal is currently 75,000 coho salmon yearlings released per year. A release of 75,000 smolts should produce at a range of survival rates: 750 at very poor marine survival (1 percent); 3,000 at moderate marine survival (4 percent) and 6,000 at high marine survival (8 percent). In the short-term, artificial propagation programs in the upper Klamath River will have a slight (+) beneficial effect on ESU abundance and spatial structure, but (=) neutral or (?) uncertain effects on the ESU productivity and diversity. As intended, the Iron Gate Hatchery mitigates adverse impacts of the operation of the IGD on coho salmon under the FERC hydropower license.

Reach 2: The Shasta River (Inclusive) to the Scott River (Exclusive)

IGD Flows

IGD has a diminishing ability to regulate main stem flow and temperature the further you go downstream. Although IGD discharge would still have a significant influence within this reach (river mile 177 to river mile 144), this portion of the main stem of the Klamath River is also influenced by tributary inputs, particularly the Shasta River (see Figure 3-16).

Reclamation acknowledges that the results of Klamath Project operations will reduce total annual discharge at the IGD in many years. A reduction in flows as a result of Klamath Project operations may decrease the available habitat for juvenile and fry coho salmon during some months. However, the Proposed Action would provide higher-than-historical flows in February through July, and lower-than-historical flows during most of September through January (see Figure 3-14).

A more detailed discussion (quantitative) of the effects of the Proposed Action on designated critical habitat will follow in the Effects of the Proposed Action on Designated Critical Habitat. The impacts of flow on the SONCC coho salmon ESU will be discussed quantitatively in Effects of the Proposed Action on the ESU.

Temperature

The main stem within this portion of the Klamath River (river mile 177 to 144) is already excessively warm.

A key finding from recent studies on main stem Klamath River water temperatures, (PacifiCorp 2006 and Dunsmoor and Huntington 2006), was that the operational zone of impact on the thermal regime is pragmatically confined from IGD, downstream to the vicinity of Seiad Valley (river mile 129). This reach, from and including the Shasta

River (river mile 177), the confluence of the Scott River (river mile 143) would represent the lower end of IGD discharge influence on the main stem's thermal regime.

Juvenile coho salmon living within this reach of the main stem Klamath River probably tolerate the temperature only by staying in pockets of cool water created by ground-water seepage or small cooler tributary flows. Juvenile salmon within this reach has been observed seeking refuge from high temperatures. As mentioned earlier, thermal refugia refer to cool water zones that may provide short-term refuge in systems with warm ambient temperatures. Given prolonged high ambient water temperatures in some reaches, the thermal refugia available may be too small and too infrequent to sustain high densities of coho salmon. However, these refugia could allow some coho salmon to persist, although at low densities, in warm stream reaches. The NAS stated that adding substantial amounts of warm water [such an increased discharge from IGD] could reduce the size of these thermal shelters.

In the NMFS 2002 BO, NMFS acknowledged that the interaction between IGD releases and these thermal refuge areas are complicated, vary among individual tributaries, and are substantially affected by meteorological conditions as well as associated tributary flows and temperature regimes. NMFS further stated "that the extent to which the value of these refuge areas are enhanced or degraded by relatively high versus relatively low IGD summer releases is unknown" (p. 68, NMFS 2002 BO).

In general, the water temperature model applied by Deas and Orlob (1999) indicates that temperatures increase more in this main stem reach under relatively low flows, and less under higher flows (p. 67, NMFS 2002 BO). This appears to support the general expectation that diurnal temperature fluctuations in the main stem are higher under lower summer flows. However, Cramer Fish Sciences (2007 Report) and Watercourse (2007) found that the average decreases in temperature associated with increased flows, from 1400 cfs to 3000 cfs, is approximately only 0.6 °C, with the greatest thermal benefit of increased flow in July with as much as 1.4 °C decrease in water temperature. See Appendix 3-C for more detail on the relationship between water temperature, flow and the distance from IGD.

In the 2002 BO, NMFS recommended that flows in the vicinity of 1,000 cfs may have the benefit of dampening the magnitude of diurnal fluctuations in temperature (p. 68, NMFS 2002 BO). The Proposed Action would maintain flows at 1,000 cfs or higher.

Disease

In regards to disease, the main stem of the Klamath River from and including the Shasta River to the confluence of the Scott River is regarded as a "hot spot" for disease. The conditions that exacerbate fish disease mechanisms is complicated and not fully understood, thus, the Proposed Action would have (?) an unknown impact through disease (Table 3-23). However, given that pathogen presence and disease effects are highly influenced by water temperature, any impact of the Proposed Action through disease would be primarily through the relationship between the operations of the Klamath Project and its effects on water temperature. Any negative impact from disease may vary from year to year, since disease conditions also vary widely from year to year, with largest effects evident during drought cycles

Summary –Shasta River to Scott River Reach

Based on the discussion above, the Proposed Action may have the following impacts in the Shasta River to Scott River reach of the main stem of the Klamath River: (-) an adverse impact in the form of reduced potential juvenile and fry habitat resulting from less than optimum flows at IGD; (+) proposed flows in the vicinity of 1,000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature ; and (?) an unknown impact from disease (Table 3-23).

Reclamation also noted that NMFS has concluded that coho salmon from the artificial coho salmon propagation program at the Iron Gate Hatchery is part of the SONCC coho salmon ESU. Annual releases of yearling coho salmon from the Iron Gate Hatchery have averaged 93,206 fish from 2003 to 2007 (see Table 3-14).

Middle Klamath River Populations

The middle Klamath River populations include: the Middle Klamath River Population; the Scott River Population; the Salmon River Population and that portion of the Upper Klamath River Population that spawn downstream of the confluence of the Scott River (see Table 3-11).

It is noted that the grouping of the middle Klamath River populations also includes that portion of the Upper Klamath River Population that spawn downstream of the confluence of the Scott River (river mile 144 to river mile 129). Although the vast majority of the Upper Klamath River Population spawns within tributaries of the Klamath River, information does suggest that a small portion of the Upper Klamath River Population spawns in the main stem of the Klamath River (see Table 3-9).

IGD Flow

IGD has a diminishing ability to regulate main stem flow the further you go downstream. Although IGD discharge would still have an influence within the upper portion of this reach, this portion of the main stem of the Klamath River is also influenced by tributaries' inputs; particularly the Shasta and Scott Rivers (see Figure 3-16).

A more detailed discussion (quantitative) of the effects of the Proposed Action on designated critical habitat will follow in the Effects of the Proposed Action on Designated Critical Habitat. The impacts of flow on the SONCC coho salmon ESU will be discussed quantitatively in Effects of the Proposed Action on the ESU.

Temperature

IGD has a diminishing ability to regulate main stem temperature the further you go downstream. Although IGD discharge would still have a minor influence within the upper portion of this reach, this portion of the main stem of the Klamath River is more heavily influenced by tributary inflows; particularly the Shasta and Scott Rivers (see Figure 3-16).

Modeling suggests that from approximately the Scott River (river mile 144) or Seiad Valley (river mile 129) to the mouth of the Klamath River, tributary inputs and meteorological conditions are the primary temperature drivers throughout the year (Deas and Orlob 1999; Campbell et al. 2001; Watercourse 2003; Cramer Fish Sciences 2007 Report). Consequently, the ability to control temperature below the Scott River through flow management at IGD is limited due to travel time downstream of the dam, the influence of local meteorological conditions, and flow accretions from springs and tributary sources. See Appendix 3-C for more detail on the relationship between water temperature, distance from IGD, and flow.

A key finding from recent studies on main stem Klamath River water temperatures, (PacifiCorp 2006 and Dunsmoor and Huntington 2006), was that the operational zone of impact on the thermal regime is pragmatically confined from IGD, downstream to the vicinity of Seiad Valley (river mile 129). This reach, the Scott River (river mile 143) to the Trinity River (river mile 43), the vast majority of the area would be essentially be beyond IGD discharge influence on main stem's thermal regime. Any impacts the Proposed Action may have on the middle Klamath River populations, through temperature, would be more prevalent for individuals and populations within the tributaries in the upper portion of the middle Klamath River. These impacts would be similar to those described for populations within the Shasta River to the Scott River reach discussed above.

Similar to the discussion for the Shasta River to Scott River reach, juvenile coho salmon living within the upper portion of this reach of the main stem Klamath River probably tolerate the temperature only by staying in pockets of cool water created by ground-water seepage or small cooler tributary flows. The impacts would be similar to those discussed for the Shasta River to Scott River reach.

Disease

In regards to disease, the conditions that exacerbate fish disease mechanisms is complicated and not fully understood, thus, the Proposed Action would have (?) an unknown impact through disease (Table 3-23). However, given that pathogen presence and disease effects are highly influenced by water temperature, any impact of the Proposed Action through disease would be primarily through the relationship between the operations of the Klamath Project and its effects on water temperature. Any negative impact from disease may vary from year to year, since disease conditions also vary widely from year to year, with largest effects evident during drought cycles.

Under the IM approach in the Proposed Action, Reclamation will work with the Technical Team, NMFS, the States of California and Oregon, and the Tribes to identifying potential modifications to the flows at IGD that may reduce any direct and indirect impacts of the Klamath Project may have on mortality caused by disease.

Summary - Scott River to Trinity River Reach

Based on the discussion above, the Proposed Action may have: (-) an adverse impact in the form of reduced potential juvenile and fry habitat resulting from reduced annual flows at IGD, (+) proposed flows in the vicinity of 1,000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature; and (?) an unknown impact on the availability of thermal refugia; and, an (?) unknown impact from disease.

Lower Klamath River Populations

The lower Klamath River populations include: Lower Klamath River Population; Lower Trinity River Population; Upper Trinity River Population; and, the South Fork Trinity River Population (see Table 3-11).

IGD Flow

IGD has a diminishing ability to regulate main stem flow and temperature the further you go downstream (see Figure 3-16). As mentioned earlier, modeling suggests that from approximately the Scott River downstream to the mouth of the Klamath River, tributary inputs and meteorological conditions are the primary temperature drivers throughout the year. During the critical summer months, monthly average discharge from IGD contributions to Klamath River flows, measured at Orleans (river mile 58; 1962 to 1991), is less than 20 percent in May and June (Figure 3, p. 88, NMFS 2002 BO). The Trinity River (river mile 43) is the major flow and temperature driver for the main stem of the Klamath River within this reach (see Figure 3-16). Consequently, the ability to control temperature in the lower Klamath River through flow management at IGD is limited due to travel time downstream of the dam, the influence of local meteorological conditions, and flow accretions from tributary sources

Temperature

IGD also has a diminishing ability to regulate the temperature within the main stem of the middle Klamath River. A key finding from recent studies on main stem Klamath River water temperatures, (PacifiCorp 2006 and Dunsmoor and Huntington 2006), was that the operational zone of impact on the thermal regime is pragmatically confined from IGD, downstream to the vicinity of Seiad Valley (river mile 129). This reach, from and including the Trinity River (river mile 43) to the mouth of the Klamath River is essentially beyond IGD discharge influence on main stem’s thermal regime. Thus, the Proposed Action, through temperature, will have minimal to no impact on the Lower Klamath River populations. Watercourse (2007) found that the average decrease in temperature associated with increased flows, from 1400 cfs to 3000 cfs, is approximately 0.2 °C, with the greatest thermal benefit of increased flow in February, March, and July with as much as 0.6 °C decrease in water temperature. See Appendix 3-C or more detail on the relationship between water temperature, distance from IGD, and flow.

Disease

In regards to disease, the relationship between the Klamath Project, water temperature, quantity and quality of IGD discharge, and conditions that exacerbate fish disease mechanisms is complicated and not fully understood. Under the IM approach in the Proposed Action, Reclamation will work with the Technical Team, NMFS, the States of California and Oregon, and the Tribes to identifying potential modifications to the flows at IGD that may reduce any direct and indirect impacts of the Klamath Project may have on mortality caused by disease.

Summary – Trinity River to Mouth Reach

Based on the discussion above, the Proposed Action, through flow, and temperature will have minimal to no impact on the Lower Klamath River populations. The Proposed Action would have an (?) unknown impact of these populations through disease.

Table 3-23. Qualitative summary of the effects of the Proposed Action by Population Group.

Factors to be considered in assessing the impacts of the Proposed Action on coho salmon.	**Effects**	**Effects of the Proposed Action by Population Group**		
		Lower Klamath River Populations	**Middle Klamath River Populations**	**Upper Klamath River Populations**
Water Quantity and Timing	Reduce rearing habitat Inhibit upstream and downstream passage Increase water temperatures	Minimal to no impact on lower Klamath River populations	Any impacts the Proposed Action may have on the middle Klamath River populations through water quantity would be more prevalent for individuals and populations within the tributaries in the upper portion of the middle Klamath River.	The Proposed Action may have: (-) An adverse impact in the form of reduced juvenile and fry habitat resulting from reduced annual flows at IGD; (?) an unknown impact on the availability of thermal refugia; (+) In the short-term, artificial propagation programs in the upper Klamath River will have a slight beneficial effect on ESU abundance and spatial structure,; and (?) neutral or uncertain effects on the ESU productivity and diversity.

Water Quality (Water Temperature)	Exceedence contributes to direct or delayed mortality.	Minimal to no impact on lower Klamath River populations	Any impacts the Proposed Action may have on the middle Klamath River populations through temperature would be more prevalent for individuals and populations within the tributaries in the upper portion of the middle Klamath River. These impacts would be similar to those described for populations within the Scott River to Shasta River reach.	IGD to Shasta River: The Proposed Action may have: (+) proposed flows in the vicinity of 1,000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature; and Shasta River to Scott River The Proposed Action may have: (+) proposed flows in the vicinity of 1,000 cfs are not expected to increase temperatures and would have the benefit of dampening the magnitude of diurnal fluctuations in temperature; and (?) an unknown impact on the availability of thermal refugia.
Disease	Contribute to direct or delayed mortality.		The conditions that exacerbate fish disease mechanisms is complicated and not fully understood, thus, the Proposed Action would have (?) an unknown impact through disease. However, given that pathogen presence and disease effects are highly influenced by water temperature, any impact of the Proposed Action through disease would be primarily through the relationship between the operations of the Klamath Project and its effects on water temperature. Any negative impact from disease may vary from year to year, since disease conditions also vary widely from year to year, with largest effects evident during drought cycles.	

Effects of the Proposed Action on Designated Critical Habitat

Introduction

Designated critical habitat for the SONCC coho salmon ESU includes all waterways, substrate, and adjacent riparian zones below longstanding, naturally impassable barriers (64 FR 24049; May 5, 1999). NMFS has identified twelve dams in the range of this ESU that currently block access to habitat historically occupied by coho salmon. However, NMFS has not proposed these inaccessible areas as critical habitat because areas downstream were believed to be sufficient for the conservation of the ESU until such time as a Recovery Team is convened to address whether additional habitat is necessary to recover coho salmon.

Available Juvenile and Fry Habitat by Reach

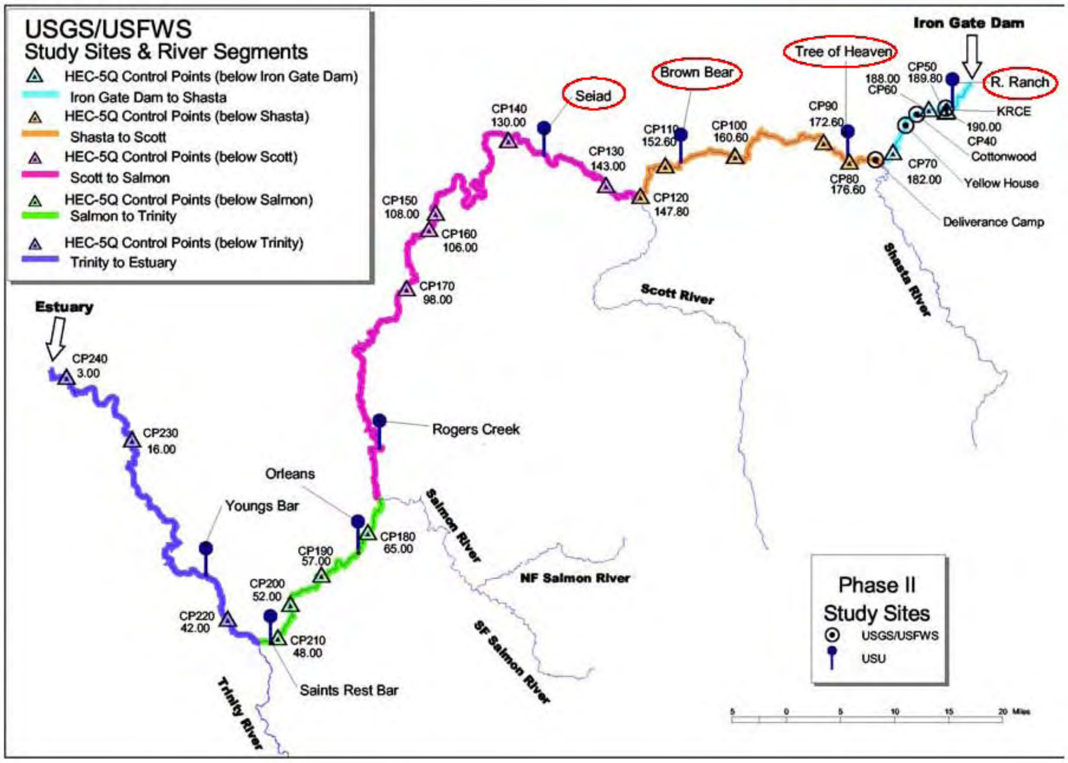
Critical Habitat within the action area has an associated combination of physical and biological features essential for supporting freshwater rearing and migration. The critical habitat elements most likely to be affected by the Proposed Action are water quantity and quality. As mentioned earlier, these two elements are highly interrelated.

Hardy and Addley's (2006) recommendations specify flow regimes that will provide for the long-term protection, enhancement, and recovery of the aquatic resources within the main stem Klamath River. This in light of the Department of the Interior's trust responsibility to protect tribal rights and resources as well as other statutory responsibilities, such as the ESA. Hardy and Addley state in the purpose of their report, "[t]he recommendations are made in consideration of all the anadromous species and life stages on a seasonal basis and do not focus on specific target species or life stages (i.e., coho [salmon])", page ii of 2006). Reclamation notes that these recommendations differ from the focus of this BA, which is for ESA-listed coho salmon.

Hardy and Addley (2006) conducted mesohabitat (pool, run, low slope, moderate slope, and steep slope) mapping for eight study sites throughout the main stem Klamath River (Figure 3-19). The habitat mapping results were utilized to model relationships between flow and available fish habitat within specific study sites. Hardy and Addley (2006) provided the percent of maximum habitat by species: Chinook salmon, coho salmon, and, steelhead at these site-level.

Hardy and Addley's (2006) site-level habitat mapping results provide some insight to the available habitat for juvenile and fry coho salmon within these study sites under the minimum flows, as well as 25 percent, 50 percent, and 75 percent exceedences for the 2008 to 1018 modeled flows (Appendix Table 3-D-7 through Appendix Table 3-D-10 and summarized in Table 3-23).

Figure 3-19. Hardy and Addley (2006) river reach delineations and study site locations within the main stem Klamath River. R. Ranch, Trees of Heaven, Brown Bear, and Seiad study sites are highlighted.



Source: Figure 16, p. 54, Hardy and Addley 2006.

These study site locations were chosen to be broadly representative of channel characteristics within each delineated river reach and in some cases to overlap with existing USGS/USFWS SIAM study sites (p. 53 of Hardy and Addley 2006). These site- level results were then expanded to estimate the available habitat for the entire study reach through the use of aerial photogrammetry image acquisition and digital terrain modeling (Hardy and Addley 2006).

Based on Hardy and Addley's (2006) habitat mapping results for these reaches, the maximum available habitat was estimated under the minimum flows, as well as 25 percent, 50 percent, and 75 percent exceedences for the 2008 to 1018 modeled flows (Appendix Table 3-D-11 through Appendix Table 3-D-14 and summarized in Table 3-25).

Appendix 3-D contains the tables for the percentage of maximum available habitat at each study site (Appendix Table 3-D-7 through Appendix Table 3-D-10) or study reach (Appendix Table 3-D-11 through Appendix Table 3-D-14) at different IGD discharge flows. These flows and resultant percent of available habitat represent discharge flows from IGD only and do not represent the accretions from multiple creeks, shallow groundwater inflow, and inflows from the Shasta and Scott Rivers. Thus, the estimated available habitat when applying these flows directly to these sites or reaches should be considered conservative. The exceedence tables for the Shasta and Scott Rivers contributions from 1961 to 2004 are also shown in Appendix Table 3-D-15 and Appendix Table 3-D-16, respectively.

IGD to Shasta River Reach

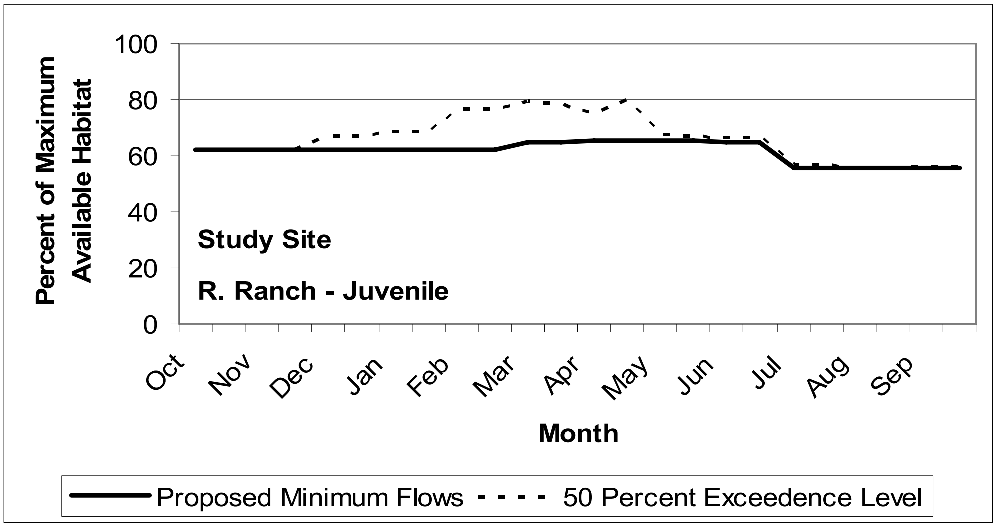
The “R. Ranch” site in Hardy and Addley (2006) is within the main stem of the Klamath River between IGD and the confluence of the Shasta River.

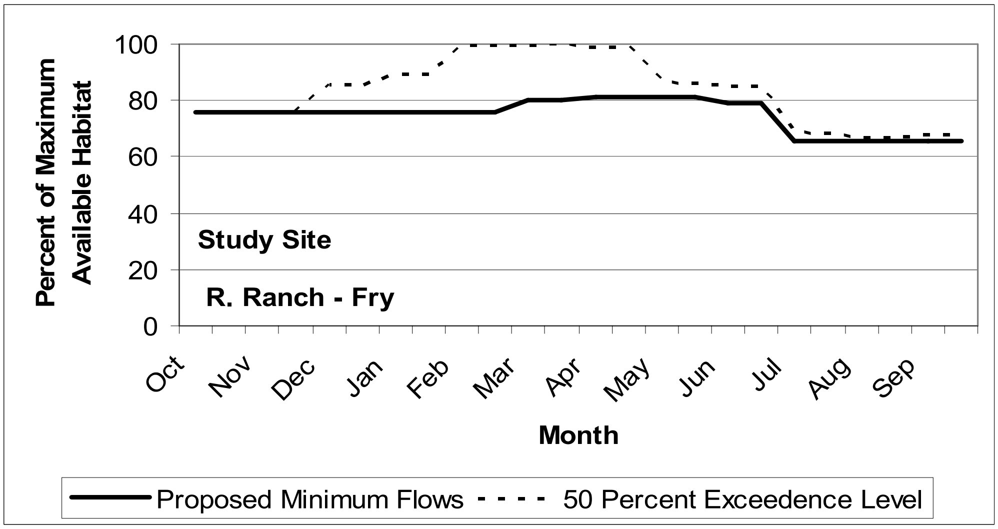
Based on the Hardy and Addley (2006) study site-level results, the minimum flows proposed under the Proposed Action would provide for at least 55 percent (occurring July through September; Figure 3-20 and Appendix Table 3-D-7) to 65 percent (occurring in March through June) of the available juvenile habitat. The minimum flows proposed under the Proposed Action would also provide for at least 66 percent (occurring July through September; see Appendix Table 3-D-7) to 81 percent (occurring in April and May) of the available fry habitat, within this study site. At the minimum flows and at this study site, additional flow would provide further habitat for both coho salmon juvenile and fry. However, it is noted that in most years, the annual flows will be much greater than the cumulative monthly minimum flows represent.

When viewed over the entire year, modeled flows at the 50 percent exceedence level under the Proposed Action (2008 to 2018) would provide for at least 56 to 80 percent of the available juvenile habitat and 67 to 100, or down to 99 percent of the available fry habitat. The “down to” 99 percent value indicates flows above the maximum available fry habitat flow. At flows above the maximum available habitat level, increase flow would further reduce available fry habitat at this study site.

During the March through June critical time period of coho salmon smolt out-migration, modeled flows at the 50 percent exceedence level under the Proposed Action (2008 to 2018) would provide for at least 67 to 80 percent of the available juvenile habitat and 85 to 100 or down to 99 percent of the available fry habitat, within this study site.

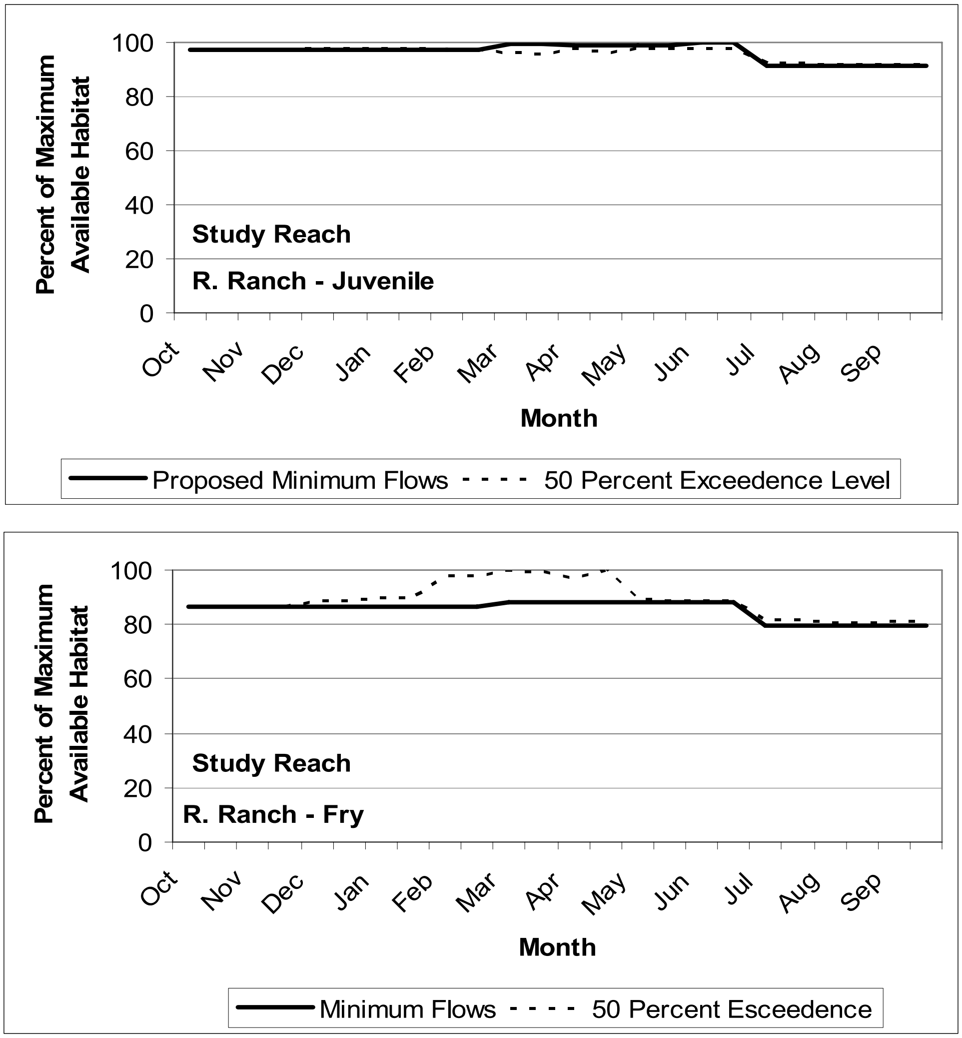
Figure 3-20. Estimated percent of the maximum available habitat for juvenile (top graph) and fry (bottom graph) coho salmon in the R Ranch study site under the proposed minimum flows and at the 50 percent modeled exceedence level under the Proposed Action.





When expanding the site-level results to estimate the available habitat for the entire reach, by applying the results of Hardy and Addley's (2006) aerial photogrammetry image acquisition and digital terrain modeling, the percentage of available habitat significantly increased (Table 3-24). For example, even at minimum flows, the maximum available habitat for juvenile coho salmon for the reach was reached or exceeded throughout the entire year (Figure 3-21 and Appendix 3-D-11).

Figure 3-21. Estimated percent of the maximum available habitat for juvenile (top graph) and fry (bottom graph) coho salmon in the R Ranch study reach under the proposed minimum flows and at the 50 percent modeled exceedence level under the Proposed Action.



Shasta to Scott River Reach

Two site-level results from Hardy and Addley (2006) are available for the main stem Klamath River between the Shasta River (river mile 177) and the Scott River (river mile 143). These two sites are the Trees of Heaven and Brown Bear sites (see Figure 3-19).

It is noted that in the following analysis, Reclamation applied the minimum and model flows from IGD directly to these two study sites to estimate coho salmon available habitat, assuming no tributary input. However, it is certain that flows would be greater under these IGD modeled flows at this site, given tributary inputs, particularly the input from the Shasta River. Thus, the flows considered to determine the percent of available habitat discussed below should be considered absolute minimums and extremely conservative.

Trees of Heaven Study Site:

The "Trees of Heaven" site in Hardy and Addley (2006) is within the main stem of the Klamath River, just below the confluence of the Shasta River.

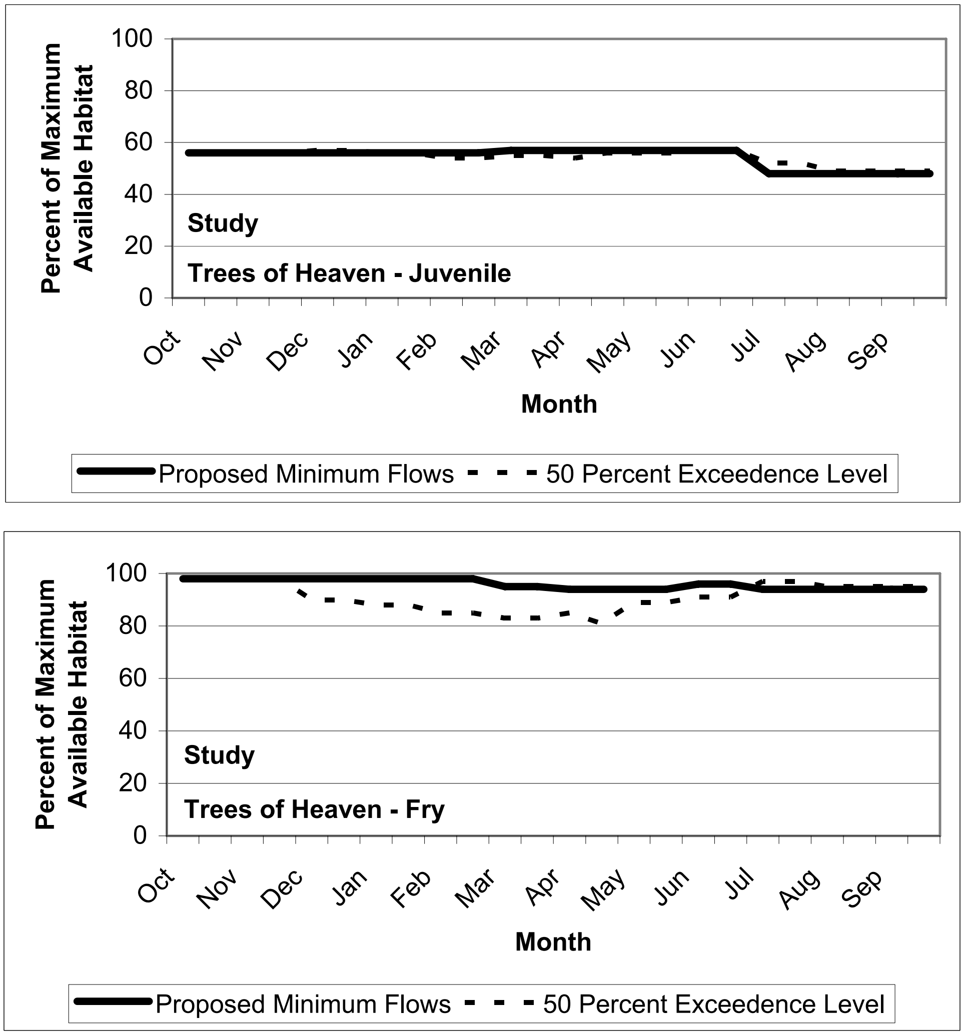
Based on Hardy and Addley's (2006) study site-level results, the minimum flows proposed under the Proposed Action, when applied directly to this study site, would provide for at least at least 94 to 100 percent, or down to 94 percent of the available fry habitat (Table 3-24). Again, the down to 94 percent value indicates flows above the maximum available coho salmon fry habitat flow. Once the flow is at the maximum available habitat levels, increased flows would reduce the available fry habitat. The available habitat for coho salmon fry within this study site, at minimum flows is already at the maximum available habitat flows or greater throughout the entire year (Appendix Table 3-D-8).

Based on Hardy and Addley (2006) study area results, when applied directly to this study site, the proposed minimum flows, assuming no tributary inflows, would provide for at least 48 (occurring in July through September; see Appendix Table 3-D-8) to 57 percent (occurring in October through June) of the available juvenile habitat. Additional flows from tributaries would provide additional available juvenile habitat.

Modeled flows at the 50 percent exceedence level under the Proposed Action, when applied directly to this study site, would provide for between 49 to 57 percent of the available juvenile. Modeled flows at the 50 percent exceedence level under the Proposed Action, when applied directly to this study site, would provide for 95 to 100, or down to 81 percent of the fry habitat (Table 3-24). During the March through June critical time period of coho salmon smolt out-migration, modeled flows at the 50 percent exceedence level under the Proposed Action (2008 to 2018) would provide for between 54 to 57 percent and 100 or down to 81 percent of the available juvenile and fry habitat, respectively, within this study site (Figure 3-22 and Appendix Table 3-D-8).

For fry, at this study site, the maximum available habitat flow is reached or exceeded at the minimum flows throughout this entire year. Increased flow would further reduce available fry habitat at this study site. Thus, at this study site, the Proposed Action should provide a balance between increased flows to provide for additional juvenile habitat and increased flows which would further reduce the available fry habitat.

Figure 3-22. Estimated percent of the maximum available habitat for juvenile (top graph) and fry (bottom graph) coho salmon in the Trees of Heaven study site under the proposed minimum flows and at the 50 percent modeled exceedence level under the Proposed Action.



When expanding the site-level results to estimate the available habitat for the entire study reach, by applying the results of Hardy and Addley's (2006) aerial photogrammetry image acquisition and digital terrain modeling, the percentage of available habitat at a given flow were similar (Appendix 3-D-12 and summarized in Table 3-24).

Brown Bear Study Site:

The "Brown Bear" site in Hardy and Addley (2006) is also within the main stem of the Klamath River, but just above the confluence of the Scott River (see Figure 3-19).

Throughout the entire year, based on Hardy and Addley (2006) study site-level results, the minimum flows proposed under the Proposed Action are greater then the flows required to provide for the maximum available juvenile habitat, when applied directly to this study site (Table 3-24 and Appendix Table 3-D-9). This would not include additional flows from tributaries. Increased flows from IGD above the proposed minimum required flows would further reduce available juvenile habitat at this study site.

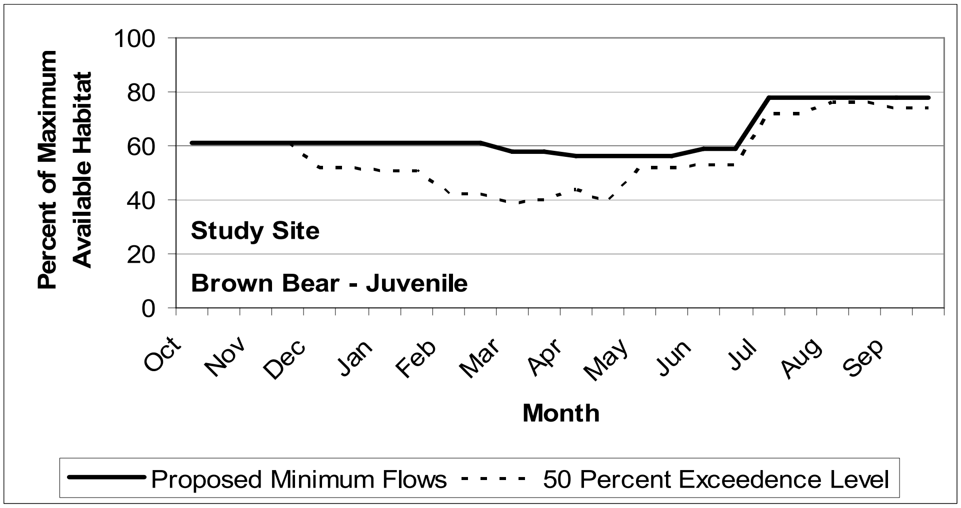
In regards to the available fry habitat, the proposed minimum flows, when applied directly to this study site, again with no inflows from all tributaries, would result in at least 35 to 36 percent of the available habitat throughout the entire year (Figure 3-23). At the minimum flow levels, any additional flows from tributaries would provide additional available fry habitat.

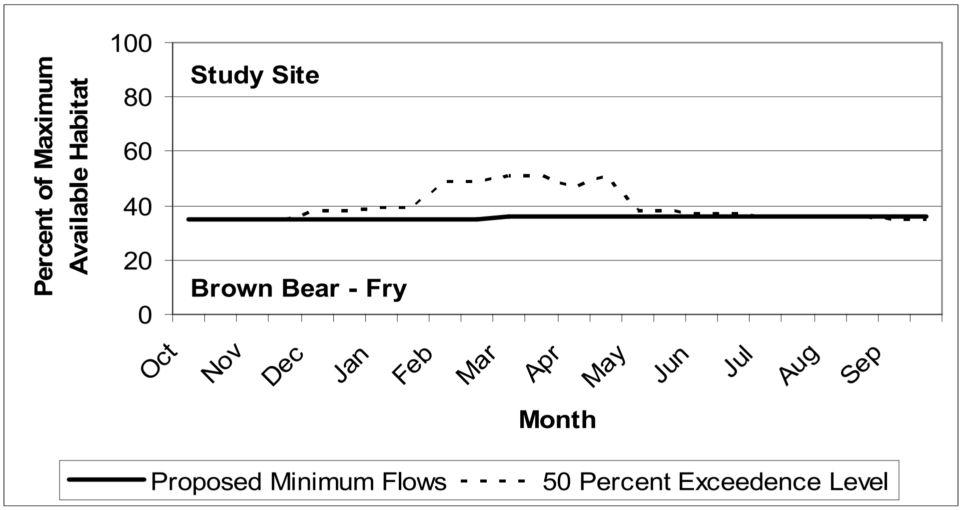
Modeled flows at the 50 percent exceedence level under the Proposed Action, when applied directly to this study site, would provide for 35 to 51 percent of the available fry habitat. During the March through June critical time period of smolt out-migration, modeled flows, at the 50 percent exceedence level under the Proposed Action (2008 to 2018), when applied directly to this study site, would provide for between 37 to 51 percent of the available fry habitat.

For this study site, the Proposed Action will provide for a balance between increased flows to provide for additional fry habitat and increased flows which would further reduce the available juvenile habitat. When expanding the site-level results to estimate the available habitat for the entire study reach, by applying the results of Hardy and Addley's (2006) aerial photogrammetry image acquisition and digital terrain modeling, the percentages of available habitat at a given flow were similar (Appendix 3-D-13 and summarized in Table 3-25).

Figure 3-23. Estimated percent of the maximum available habitat for juvenile (top graph) and fry (bottom graph) coho salmon in the Brown Bear study site under the proposed minimum flows and at the 50 percent modeled exceedence level under the Proposed Action

.





Scott River to Trinity River Reach

Four site-level results were within the main stem Klamath River between the Scott River (river mile 143) and the Trinity River (river mile 43). Three of these sites were located in the lower end of this reach (see Figure 3-19). However, the results for the Seiad site-level habitat mapping is located in the upper portion of this reach (see Figure 3-14). With caution, this site can still provide some insight on the available habitat for juvenile and fry coho salmon under modeled flows (Appendix Table 3-D-10 and summarized in Table 3-24).

As noted earlier, Reclamation applied the minimum and model flows at IGD directly to this study site to estimate coho salmon available habitat. This would assume no tributary input. However, it is clearly expected that flows would be much greater under these IGD modeled flows at this site, particularly given Shasta and Scott Rivers tributary inputs. Thus, the flows considered to estimate the percent of available habitat discussed below should be considered absolute minimums and conservative.

Throughout the entire year, based on Hardy and Addley (2006) study site-level results, the minimum flows proposed under the Proposed Action, when applied directly to this study site, would provide for at least 44 percent to 45 percent of the available juvenile habitat and 92 percent to 99 of the available fry habitat. At these minimum IGD flows, any additional flows from tributaries would provide additional available juvenile habitat. At the proposed minimum flows at IGD, the available habitat for fry is close to the maximum available habitat, for this study site (Table 3-24).

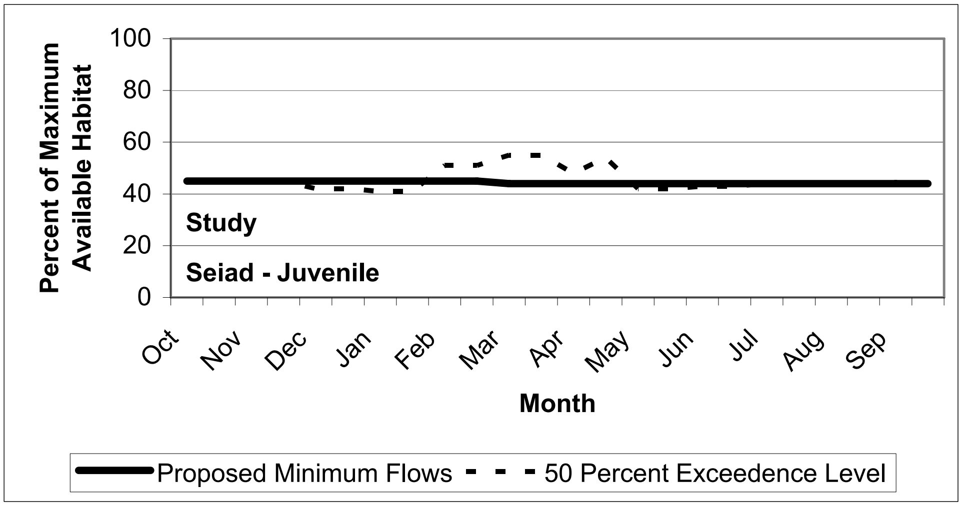
Modeled (2008 to 2018) flows at the 50 percent exceedence level under the Proposed Action, when applied directly to this study site, would provide for between 42 to 55 percent of the available juvenile habitat. Again, the flows considered to estimate the percent of available habitat should be considered absolute minimums and conservative. Actual flows would be greater given tributary inputs. For fry, the maximum available habitat flow is approached throughout the entire year (Figure 3-24).

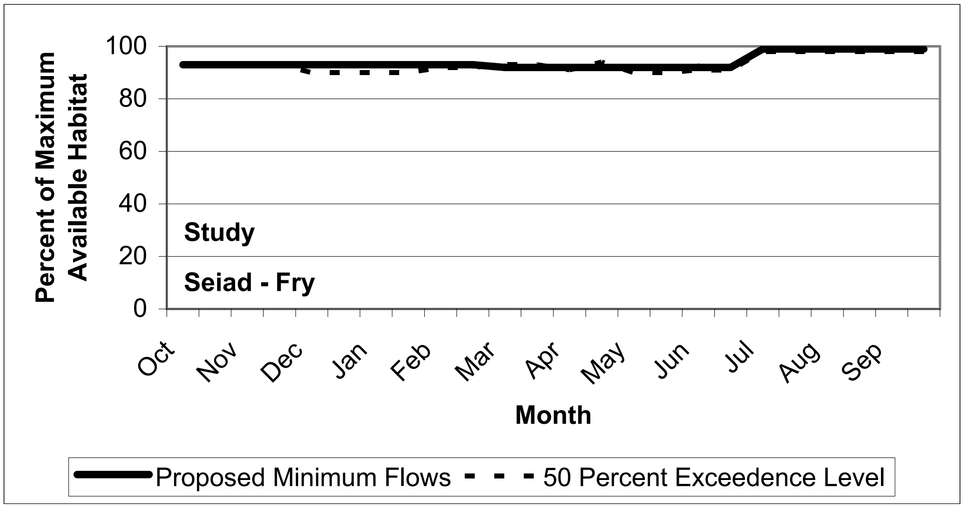
During the March through June period, when coho salmon smolt out-migration is occurring, modeled flows at the 50 percent exceedence level under the Proposed Action (2008 to 2018), when applied directly to this study site, would provide for between 42 to 54 percent of the available juvenile habitat. In regards to fry, the maximum available habitat flow is approached throughout this period.

When expanding the site-level results to estimate the available habitat for the entire study reach, by applying the results of Hardy and Addley's (2006) aerial photogrammetry image acquisition and digital terrain modeling, the percentage of available habitat at a given flow were similar (Table 3-25 and Appendix 3-D-14).

At this study site, within this reach, minimum flows provide for near the maximum available habitat for coho salmon fry. Increased flows further reduce the available fry habitat. However, at the minimum flows, increased flows would provide additional available juvenile habitat. Taking into account the importance of fry habitat to out-migration, for this study site, the anticipated flows during most years (modeled 25 to 75 percent exceedences) provides for a balance between juvenile and fry habitat for coho salmon. However, it is recognized, that within the upper portion of this reach of the main stem, temperature may be the primary limiting factor, not the overall available habitat.

Figure 3-24. Estimated percent of the maximum available habitat for juvenile (top graph) and fry (bottom graph) coho salmon in the Seiad study site under the proposed minimum flows and at the 50 percent modeled exceedence level under the Proposed Action.(Trinity River to the Mouth Reach.)





IGD has a diminishing ability to regulate main stem flow and temperature the further you go downstream. As mentioned earlier, modeling suggests that from approximately the Scott River downstream to the mouth of the Klamath River, tributary inputs and meteorological conditions are the primary temperature drivers throughout the year. During the critical summer months, monthly average discharge from IGD contributions to Klamath River flows, measured at Orleans (river mile 58 from 1962 to 1991), is less than 20 percent in May and June (Figure 3, p. 88, NMFS 2002 BO). The Trinity River (river mile 43) is the major flow and temperature driver for the main stem of the Klamath River within this reach (see Figure 3-16). Consequently, the ability to control temperature in the lower Klamath River through flow management at IGD is limited due to travel time downstream of the dam, the influence of local meteorological conditions, and flow accretions from tributary sources

The Proposed Action, through flow, would not be expected to significantly affect the salmon habitat quantity or quality within the main stem or the tributaries of the lower Klamath River.

Table 3-24. Summary of available juvenile and fry coho salmon habitat at proposed minimum flows and at the modeled 50 percent exceedence levels for four study sites. (Study Site-level Summary Results)

Study Site [1]	Coho Salmon Life Stage	Coho Salmon Available Habitat		
		October through September		March through June
		Proposed Minimum Flows	Modeled 50% Exceedence	Modeled 50% Exceedence
R. Ranch	Juvenile	55% to 65%	56% to 80%	67% to 80%
	Fry	66% to 81%	67% to 100%, or down to (99%)	85% to 100%, or down to (99%)
Trees of Heaven [2]	Juvenile	48% to 57%	49% to 57%	54% to 57%
	Fry	94% to 100%, or down to (94%)	95% to 100%, or down to (81%)	100% or down to (81%)
Brown Bear [2]	Juvenile	Down to (78%), down to (56%)	Down to (76%), down to (39%)	Down to (53%), down to (39%)
	Fry	35% to 36%	35% to 51%	37% to 51%
Seiad [2]	Juvenile	44% to 45%	42% to 55%	42% to 54%
	Fry	92% to 99%	90% to 99%	90% to 94%

[1] The percentage in () in the available habitat range indicates flows above the maximum available habitat flow. Once the flow is at the maximum available habitat levels, increase flows would reduce the available fry habitat.

[2] Reclamation applied the minimum and 50 percent exceedence model flows at IGD directly to these study sites to determine coho salmon available habitat. This would assume minimum tributary input. However, it is likely that flows would be much greater under these assumed IGD flows at these sites, particularly given tributary inputs. Thus, the flows considered to determine the percent of available habitat should be considered minimums.

Table 3-25. Summary of available juvenile and fry coho salmon habitat at proposed minimum flows and at the modeled 50 percent exceedence levels for four reaches. (Study Reach Summary Results)

Reach [1]	**Coho Salmon Life Stage**	**Coho Salmon Available Habitat**		
		October through September		**March through June**
		Proposed Minimum Flows	**Modeled 50% Exceedence**	**Modeled 50% Exceedence**
R. Ranch	Juvenile	91% to 100%, or down to (99%)	92% to 100%, or down to (96%)	Down to (98%), to down to (96%)
	Fry	80% to 88%	80% to 100%	89% to 100%
Trees of Heaven [2]	Juvenile	36% to 42%	37% to 43%	37% to 43%
	Fry	89% to 94%	86% to 100%, or down to (96%)	86% to 100%, or down to (96%)
Brown Bear [2]	Juvenile	Down to (79%), down to (57%)	Down to (78%), down to (41%)	Down to (54%), down to (41%)
	Fry	35% to 36%	34% to 56%	34% to 56%
Seiad [2]	Juvenile	45% to 46%	44% to 51%	44% to 51%
	Fry	97% to 100%	97% to 100%, or down to (93%)	100%, down to (93%)

[1] The percentage in () in the available habitat range indicates flows above the maximum available habitat flow. Once the flow is at the maximum available habitat levels, increase flows would reduce the available fry habitat.

[2] Reclamation applied the minimum and 50 percent exceedence model flows at IGD directly to these reaches to determine coho salmon available habitat. This would assume minimum tributary input. However, it is likely that flows would be much greater under these assumed IGD flows at these reaches, particularly given tributary inputs. Thus, the flows considered to determine the percent of available habitat should be considered minimums.

Spawning Habitat

Under the current (NMFS 2002 BO) and under the Proposed Action, the October through February minimum flow requirements are the same. This minimum flow regime, for this time period (1,300 cfs), for all NMFS year types, was based on limited measurements and observations "that fall Chinook [salmon] spawning habitat would be adequate in the IGD to Shasta River reach under this IGD discharge" (p. 68, NMFS 2002). NMFS further assumed that main stem passage, tributary access, and spawning habitat for coho salmon will also be adequate under this IGD flow regime.

Riparian Habitat

As cited in Hardy and Addley (p. 49, 2006), analyses conducted by Ayres Associates (1999) and PacifiCorp (2004) suggest that riparian vegetation encroachment downstream of IGD is not occurring due to the confined nature of the channel, frequent inundation, mobilization of the bed margins, and scour. This is further supported by flood frequency analyses, sediment transport analyses (PacifiCorp 2004), and observed flood events that show that flood magnitudes are sufficiently high and enough frequent to move most sediment fractions as well as cause substantial alterations in the riparian community structure and alluvial features throughout the main stem river corridor.

ESA Recovery Plan

No recovery plan has been completed for the SONCC coho salmon ESU, but recovery planning is under way (NMFS 2007). Based on the discussion above, Reclamation concludes that although no recovery plan has been completed for this ESU to date, the Proposed Action is sufficient for the conservation of the ESU until such time as a Recovery Team is convened to address whether additional efforts are necessary to recover coho salmon.

Summary of the Effects of the Proposed Action on Designated Critical Habitat

Using the habitat mapping results of Hardy and Addley (2006), in the area immediately downstream of IGD, the Proposed Action will provide flows that will make available the majority of the coho salmon juvenile and fry habitat, particularly during the critical March through June time period. From Shasta River to Trinity River, the anticipated flows during most years (modeled 25 to 75 percent exceedences) provides for a balance between juvenile and fry habitat for coho salmon, even without the certain addition of tributary inflows. As assumed under the NMFS 2002 BO, Reclamation continues to assume that main stem passage, tributary access, and spawning habitat for adult coho salmon will be adequate under this IGD flow regime. Additionally, Reclamation noted that riparian vegetation encroachment downstream of IGD is not currently occurring due to the confined nature of the channel, frequent inundation, mobilization of the bed margins, and scour. With the limited storage capacity of the Klamath Project, based on modeling, spill events will occur under Proposed Action, which will continue scouring events into the future.

Effects of the Proposed Action on the ESU

The following provides a quantitative analysis of the effects of the Proposed Action on the SONCC coho salmon ESU. The qualitative analysis provided in section 7.1 is taken into consideration in quantifying the effects of the Proposed Action.

The following analysis follows the guidance provided in May 2006 by a committee of leading scientists from NMFS Science Centers (Lindley et al. 2006). That committee was formed to consider how NMFS should respond to the critiques of independent scientist panels which had reviewed the NMFS BO for the long-term operations of the Central Valley Project and State Water Project in the Sacramento-San Joaquin basins of California (hereafter referred to as Central Valley BO). There are many parallels biologically and physically between the Central Valley Project and the Klamath Project (large scale water management influencing ESA-listed salmonids), so the committee's guidance is appropriate for the Klamath Project.

The committee agreed with the criticisms of the independent scientists in that, [t]he fundamental improvement would be a better-developed conceptual framework for analyzing the impacts of large-scale actions. The reviewers suggest a "life-cycle" approach. Further, the NMFS committee stated, "[i]t is our opinion that the overall decision analysis of the [Central Valley BO], while consistent with current NMFS guidance, lacked temporal and spatial resolution and omitted important linkages between the project effects and salmon survival, reproduction, abundance, distribution, and diversity."

The committee found that the VSP framework described by McElhaney (et al. 2000) was "a broader and more general biological framework for considering the effects of proposed actions on salmon viability and recovery." However, the committee also found that, "while VSP would provide a conceptual framework, an analytical framework will still need to be assembled to assess the impacts of specific projects on VSP parameters."

In keeping with these recommendations, Reclamation contracted with Cramer Fish Sciences to develop a coho salmon life-cycle model capable of quantifying how natural coho salmon production would change in response to changes in water management by the Klamath Project. Further, Cramer Fish Sciences was to synthesize available information on coho salmon at all life stages as well as the factors affecting them in the Klamath River Basin, and use this information to the fullest extent possible in formulating the life-cycle model. Model development has proceeded over the past year. Invitations to review and respond to a series of "Technical Memorandums" and workshops that described data received and analyses performed by Cramer Fish Sciences were sent to biologists from all Tribes as well as Federal and State agencies working with salmon and steelhead throughout the Klamath River Basin. Those Technical Memorandums as well as the Cramer Fish Sciences' responses to comments received are posted on a website dedicated to this modeling effort[38]. A report describing the completed model and its findings is attached to this BA, as Appendix 3-B.

Components of the Analytical Framework

Three quantitative models were combined to produce an analytical framework for evaluating the Proposed Action's effects on the four VSP criteria:

(1) A spatially and temporally explicit life-cycle model used to evaluate the relative change in abundance, productivity, spatial structure and diversity of Klamath River coho salmon based on different temperature and flow conditions

(2) An operations model used to provide the flow release schedule from IGD according to a range of precipitation inflow scenarios for the Upper Klamath River Basin

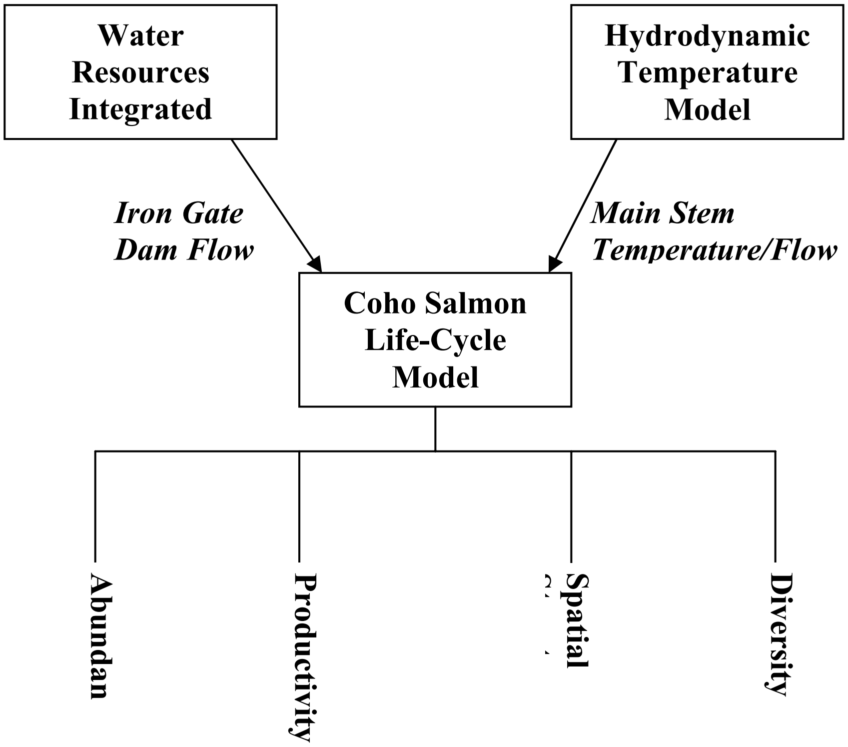
(3) A hydrodynamic temperature model (Watercourse Engineering 2007) was used to simulate temperature and flow conditions from IGD to the estuary for a wide range of flow releases

Simulated temperature and flow data provided the inputs for the coho salmon life-cycle model. The combined information from these three models allows Reclamation to evaluate the effects of their proposed action on the four VSP criteria for Klamath River coho salmon (Figure 3-25).

---

[38] <http: //www.fishsciences.net/projects/klamathcoho/index.php.>

Figure 3-25. Major components of the analytical framework assembled to assess the Proposed Action's effects on coho salmon viability.



Overview of Coho Salmon Life-Cycle Model

The Klamath River coho salmon life-cycle model was developed to predict the effects of Reclamation's operation of the Klamath Project on natural production of coho salmon within the Klamath River Basin. These predictions were used to evaluate how different water management scenarios might affect production and sustainability of Klamath River Basin coho salmon.

Life-cycle modeling was chosen to provide a quantitative framework that can accumulate effects of flow on multiple life stages of coho salmon that occur at a variety of times and locations within the Klamath River Basin. By tracking the abundance and survival of coho salmon through successive life stages, life-cycle modeling made it possible to roll up effects at specific times and places to examine their cumulative effect at the population level. Most naturally-produced coho salmon in the Klamath River Basin spawn and rear in tributaries, but all must migrate to and from the ocean by means of the Klamath River main stem. Thus, the model tracked spatially and temporally explicit information, such that tributary populations and the factors affecting them could be distinguished from the effects of flow and temperature on coho salmon in the Klamath River main stem.

The model examined the effect of different environmental variables on specific life stages including: fry, sub-yearling emigrants, parr, smolt, and adult, (Figure 3-26). The model captured the range of species diversity known to occur within the basin. This included three life history strategies for juvenile rearing: those that rear exclusively in their natal streams (including a unique population of age-0 smolt produced in the Shasta River); those that migrate into and rear in the Klamath River main stem; and those that migrate out of the main stem and rear in non-natal tributaries. The model segregated the coho salmon life-cycle into specific life stages so that effects of water management could be evaluated for each life stage.

The geographic extent of the Klamath River model was from IGD to the estuary and included all the major tributaries within the Lower Klamath River Basin. The Klamath River coho salmon life-cycle model tracked coho salmon production specifically from 16 spatial units (Figure 3-27). Model spatial units were based on the historic coho salmon population structure (NMFS 2006 Historical Populations) and changes in temperature and flow near major tributary entry points. The spatial units included six main stem reaches; four major tributaries (the Shasta, Scott, Salmon, and Trinity Rivers); and six groups of small tributaries.

The six main stem reaches were: 1) IGD to Shasta River; 2) Shasta River to Scott River; 3) Scott River to Portuguese Creek; 4) Portuguese Creek to Salmon River; 5) Salmon River to Trinity River; and 6) Trinity River to Klamath River at Turwar. Some of these boundaries are similar to those used to segregate the Lower Klamath River Basin into the upper, middle, and lower Klamath River (see Figure 3-1). Dividing the Lower Klamath River Basin into reaches provided sufficient spatial resolution to capture the different flow and thermal regimes experienced by fish in different portions of the project area. Temperature and flow functions were applied only to the main stem Klamath River because those were the variables directly influenced by the Proposed Action.

Because flow and temperature change over time, the model tracked a “cohort” of fish that migrated together in the same time step. The term “cohort” refers to specific groups of fish that spawn, rear, or emigrate together on a weekly or bi-weekly time-step. For example, adult coho salmon that spawn between October 1 and October 6 were considered one cohort and those that spawn between October 7 and October 13 as another cohort. This convention helped to predict the effects of temperature and flow on temporally explicit groupings of fish. The time period for each cohort and the proportion of the population within that cohort were defined by either spawn timing distributions or emigration timing distributions.

Figure 3-26. Conceptual diagram of the Klamath River coho salmon life-cycle model. Red indicates values that are scaled within the model depending on temperature and/or flow conditions. Green indicates survival rates set prior to model runs.

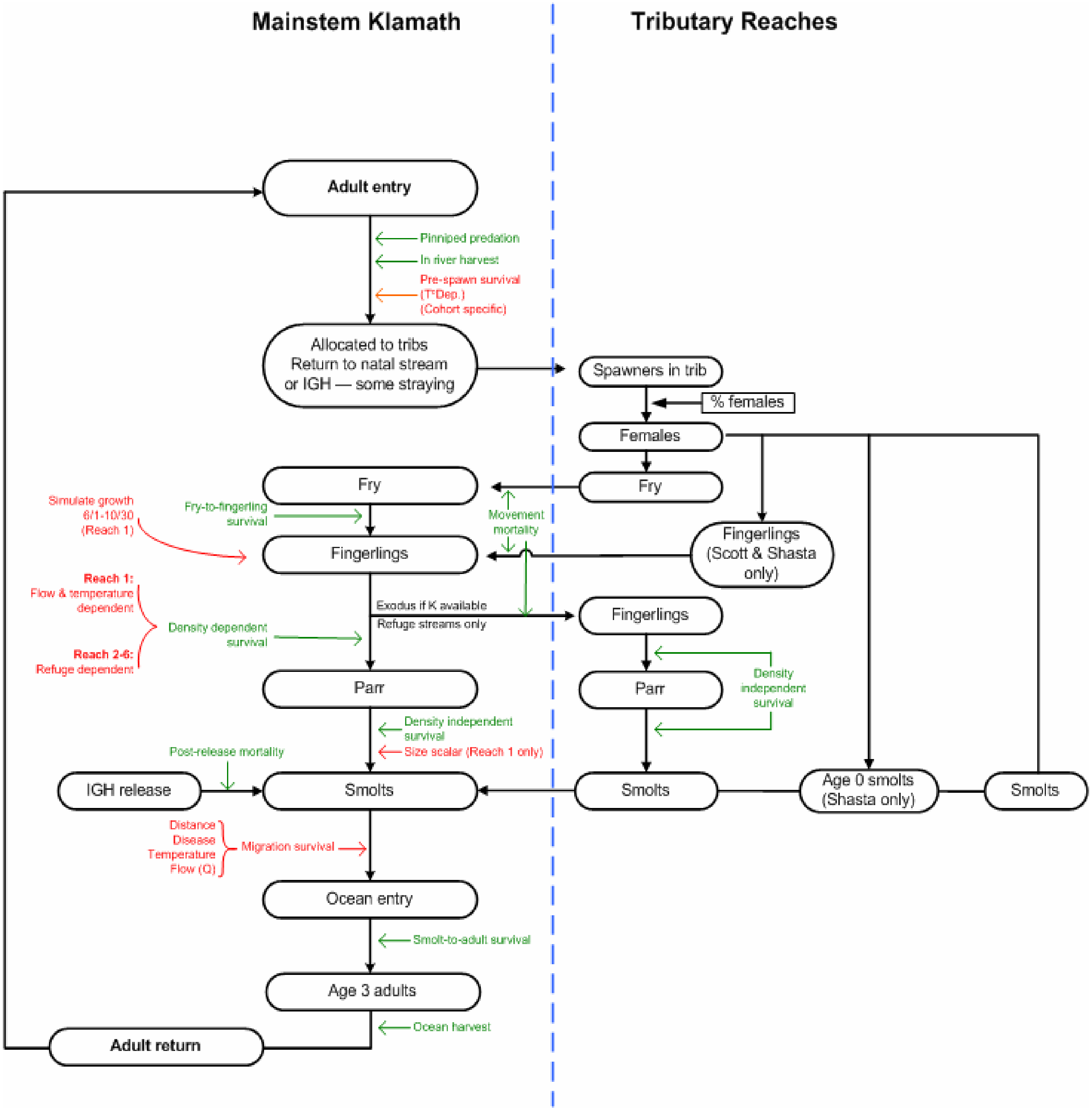
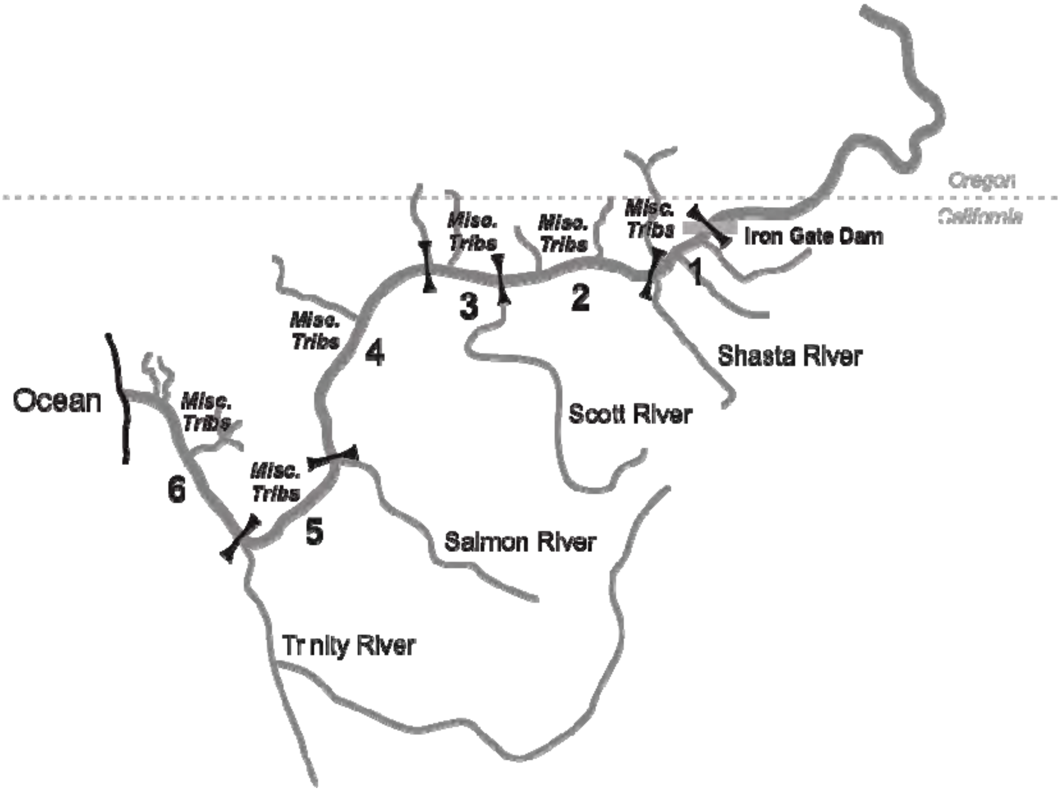


Figure 3-27. Map of the Lower Klamath River Basin denoting the 16 model reaches. These boundaries are similar to those used to segregate the Lower Klamath River Basin into the upper, middle, and lower Klamath River (see Figure 3-1).



In summary, the life-cycle model simulated the effects of temperature and flow on individual coho salmon populations and life stages as they migrated through the Klamath River main stem. Temperature effects were treated in the model through adult pre-spawning survival, juvenile carrying capacity, growth, and smolt survival. Flow effects were explicitly treated in the model through juvenile carrying capacity and smolt survival. The model simulated the effects of temperature and flow on 50 spawning populations, through 5 life stages, over a span of 40 weeks for each year. Each model simulation was run for 12 years (3 complete life-cycles) under constant conditions. The model can be extended over a greater time period to include variable environmental conditions.

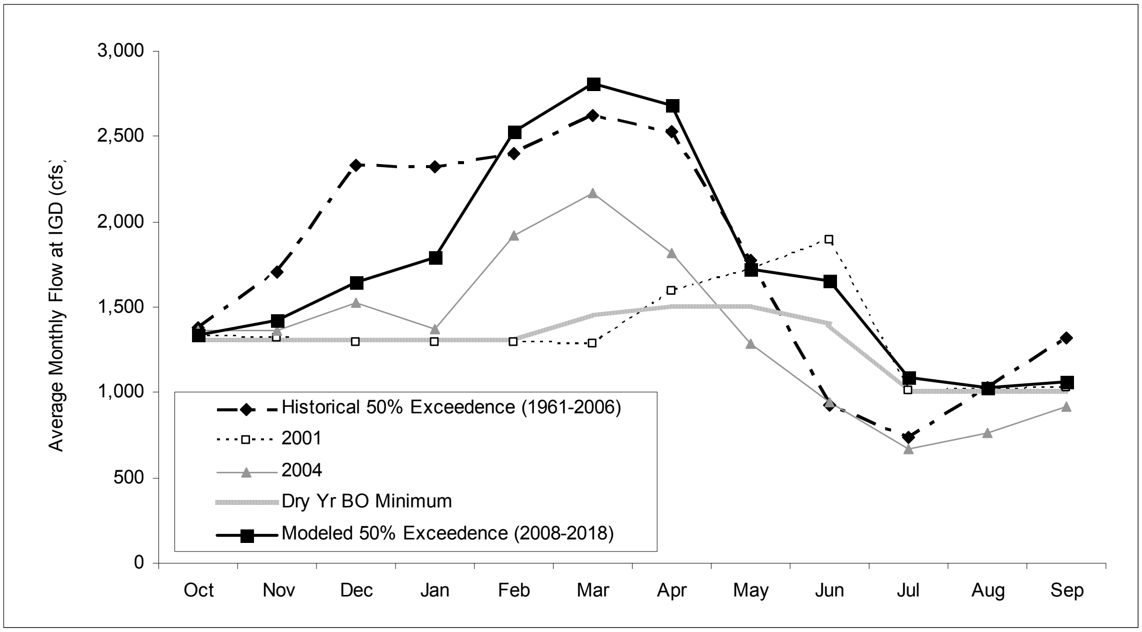
VSP Guidance

The format for this section of the BA will provide an analysis of the Proposed Action's effects that correspond to each of the four VSP criteria: abundance, productivity, spatial structure, and diversity. Life-cycle simulations are used to examine how the Proposed Action will influence the four VSP criteria for the SONCC coho salmon ESU.

Effects on ESU Abundance

Population abundance is an important criterion for VSP because large populations exhibit a high degree of resilience (McElhany et al. 2000). To assess the impacts of the Proposed Action, simulations for 10 years into the future where conducted, with environmental conditions fixed at either 2001 or 2004 meteorology and tributary flows downstream of IGD. These are the two years for which the hydrodynamic temperature model was fully populated with meteorological and tributary flow data for the Klamath River below IGD. Although both flows at IGD during 2001 and 2004 were both below normal (Figure 3-28) those same years produced 95 percent and 55 percent exceedence flows from the Salmon River, respectively.

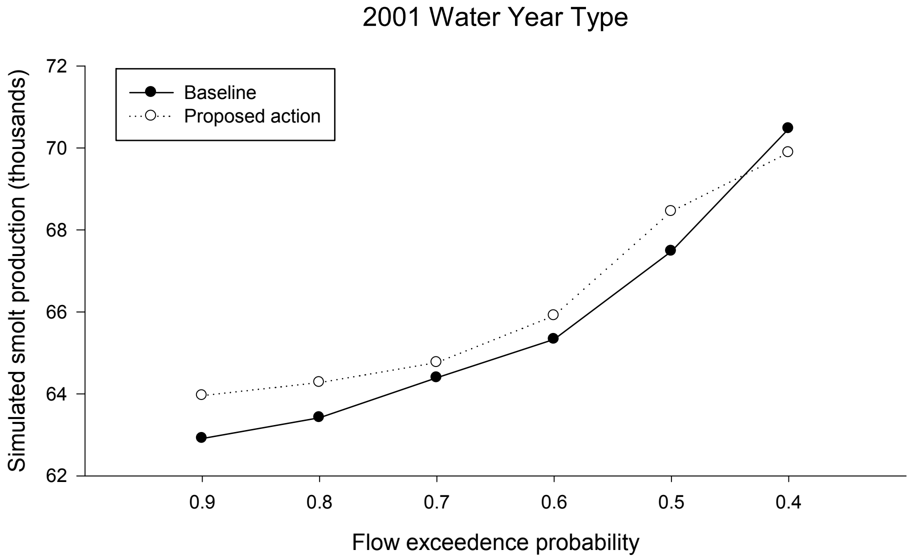
Figure 3-28. Depictions of the flows at IGD during 2001 and 2004, the historical (1961 to 2006) 50 percent exceedence, the modeled (2008 to 2018) 50 percent exceedence (smoothed), and the proposed minimum flows (dry water year flows as outlined in NMFS 2002 BO).



In these simulations, total smolt production represented coho salmon abundance because smolts are the final life stage in freshwater. Returning adults might also be affected by pre-spawning mortality in freshwater, but such effects would be reflected in the abundance of smolts the next generation. Smolt production in year 10 was used because it represents the fourth generation of naturally produced coho salmon smolts that would have resulted from the fixed environmental condition being simulated. Such simulations with fixed environments represent extreme cases to reveal how good or bad production will become after extended exposure to the same condition. As an illustration of the extreme nature of this simulation, 2001 was a 95 percent exceedence year for the Salmon River, meaning that it would only be expected to recur once in every 20 years. Thus, a 10 year simulation of 2001 conditions represents a dry year sequence that has a very small chance of ever occurring.

Simulation of the Proposed Action showed that a wide range of flow releases from IGD had little effect on coho salmon smolt production from the Klamath River Basin (Figure 3-29). The downstream effects from a different set of meteorology and tributary flows had a far greater effect on smolt production (approximately a 35 percent increase) than did increasing IGD flows from a 90 percent exceedence to a 40 percent exceedence (approximately a 10 percent increase). This is a dramatic result, which the modeling revealed was caused by the inability of flows from IGD to produce suitable rearing temperatures for coho salmon during summer in the main stem below the Shasta River. If the temperature model had also been populated with a high runoff year such as 2006, another substantial increase in smolt production above the 2004 condition would have been indicated.

Figure 3-29. Total simulated smolt production in year 10 using proposed flows (modeled 2008 to 2018) at IGD for the 2001 and 2004 water year types.



The simulation results (displayed in Figure 3-29) suggest that the population can endure even in adverse environmental conditions in freshwater. Although smolt production is less than for the 2004 conditions when compared to 2001 tributary conditions, the simulated population did not collapse after four generations of continuous extreme drought (90 percent exceedence releases with 2001 meteorology and tributary flows).

An analysis was also completed for the smolt production under the Proposed Action and the smolt production under historic operations with a similar water year. Under all low modeled flow conditions (less than or equal to 50 percent exceedence) smolt production was 1 to 2 percent greater under the Proposed Action for conditions set either at 2001 or 2004 (Figure 3-30 and Figure 3-31).

Although these graphs show a substantial rise as the flow increases (exceedence decreases), the change in smolt production is actually quite small (roughly 10 percent). Note that the y-axis has been compressed (does not start at 0) to emphasize the difference in the outcomes of the different scenarios.

Figure 3-30. Total simulated smolt production in year 10 using proposed flows (modeled 2008 to 2018) and historical flows (1961 to 2006) at IGD for the 2001 water year type. Y-axis compressed to emphasize differences between operating scenarios.

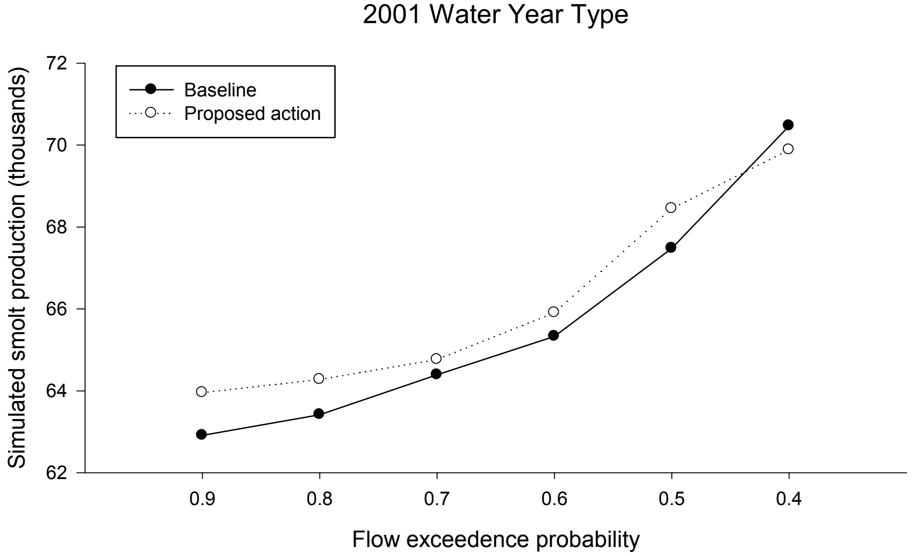
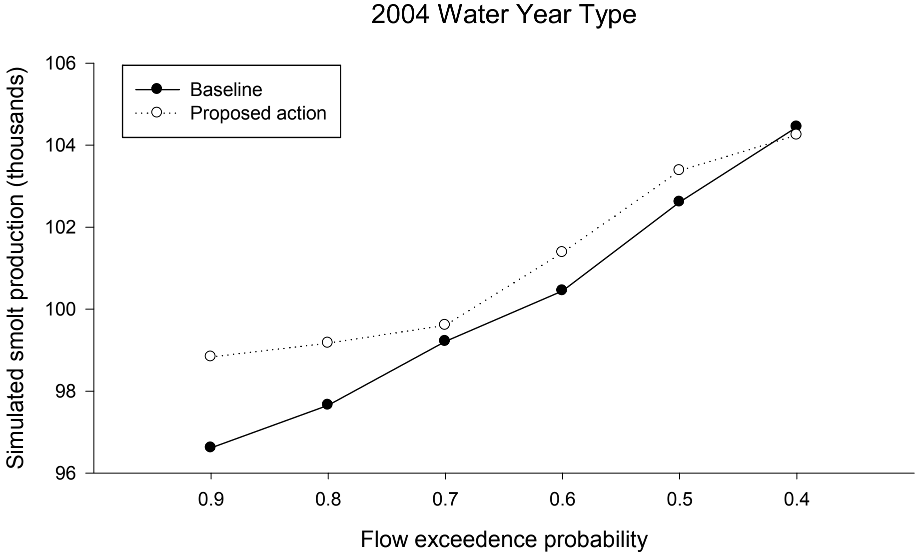


Figure 3-31. Total simulated smolt production in year 10 using proposed flows (modeled 2008 to 2018) and historical flows (1961 to 2006) at IGD for the 2004 water year type. Y-axis compressed to emphasize differences between operating scenarios.



Effects on ESU Productivity

Population growth rate and related parameters, such as survival, reflect how well a population is performing in the habitats it occupies during the life cycle (McElhany et al. 2000). The smolt production in simulation year 10 for the Proposed Action and the historical flow was completed for incremental increases of 10 percent exceedence from IGD. Figure 3-32 and Figure 3-33 depict the net change in smolt production for the Proposed Action and the historical flow for each of the independent populations. Although the total smolt production for the basin shows little change between IGD release regimes, the breakdown for individual populations shows substantial increase in smolt production for populations originating above the Scott River, but no change below there (Figure 3-32 and Figure 3-33). This difference results from the greater relative effect that IGD releases have on smolt survival above the Scott River. The simulations indicate that the benefits to smolt production were greatest at the lowest flow conditions (90 percent exceedence flow and 2001 conditions downstream).

Figure 3-32. Percentage change in simulated smolt production from historical flows at IGD (1961 to 2006) to proposed flows (modeled 2008 to 2018) by population for the 2001 water year type.

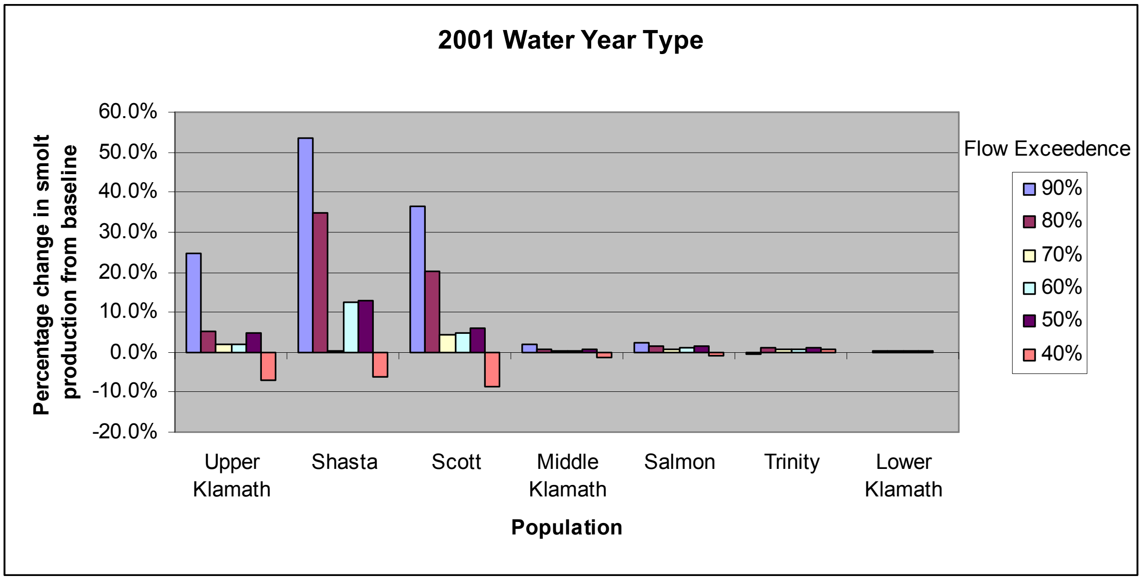
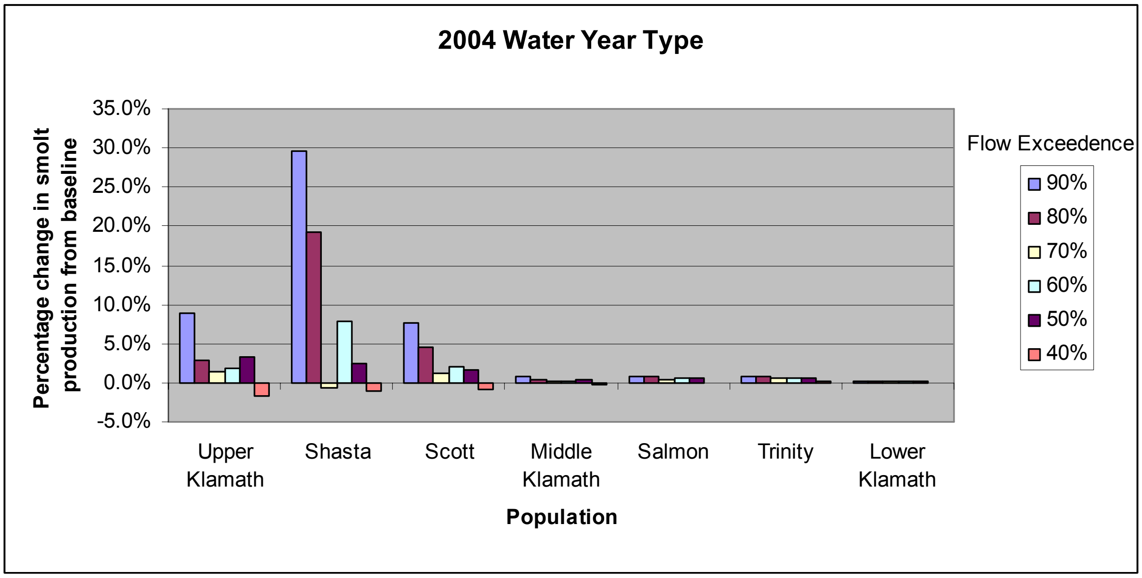


Figure 3-33. Percentage change in simulated smolt production from historical flows at IGD (1961 to 2006) to proposed flows (modeled 2008 to 2018) by population for the 2004 water year type.



The effects of environmental uncertainty were examined on smolt production by modeling the smolt production between 10 years of extended high, medium, and low ocean survival, and also with dry and average hydrologic conditions. In order to obtain an appropriate range of ocean survivals for Klamath River coho salmon, the percentile distribution of smolt-to-adult survival rates were determined for coho salmon released from Iron Gate Hatchery for the 1976 to 2002 brood years. These data are described in the Life-Cycle Model Report (Appendix 3-B), and in Cramer Fish Sciences 2007, Technical Memorandum 3. Ocean survival for Iron Gate Hatchery coho salmon has varied from a 25 percentile value of 2.1 percent to a 75 percentile valued of 7.6 percent (Table 3-25). The default ocean survival rate used in all simulations, unless specified otherwise, is 4 percent.

Table 3-26. Percentiles of smolt-to-adult survivals for natural-origin Klamath River coho salmon based on return rates of coho salmon released from Iron Gate Hatchery, 1976 to 2002 broods.

Percentile	Survival
10%	0.88%
25%	2.1%
50%	3.8%
75%	7.6%
90%	9.32%

Source: Figure 1, Cramer Fish Sciences 2007 Technical Memorandum 3 and assuming wild fish survival is double that of hatchery fish.

The range of ocean survival had a dramatic effect on the simulated smolt production. Smolt production rose sharply by over 300 percent if survival was held at the 75 percentile and dropped sharply by approximately 85 percent if survival was held at the 25 percent level (Figure 3-34 and Figure 3-35).

Again, these steady-state simulations represent extremes that would not occur (10 straight years at the 25 or 75 percentiles), but they illustrate why coho salmon populations undergo large variations in abundance. These simulations also demonstrate how rapidly the populations can rebound from depressed abundance to high abundance when ocean survival turns favorable. It is noted that the simulations in Figure 3-35 represent a worst case freshwater condition of 90 percent exceedence flows at IGD (Proposed Action operations) combined with 2001 meteorological and tributary flow. This simulation suggests that the population could withstand 10 straight years of worst case freshwater conditions combined with 10 straight years of poor ocean conditions.

Figure 3-34. Total simulated smolt production over time under low (2.0 percent), medium (4.0 percent), and high (7.5 percent) marine survival rates using proposed 90 percent exceedence flows at IGD combined with 2001 meteorological and tributary flow data.

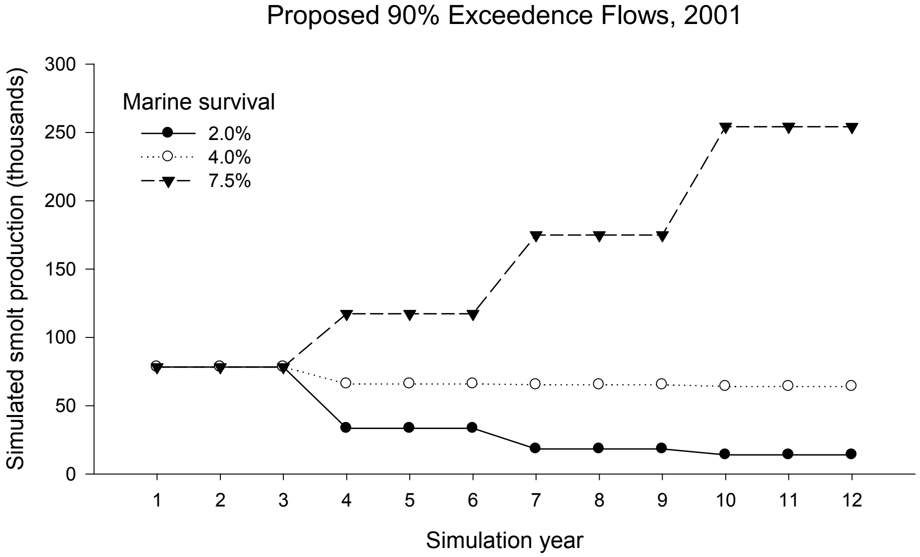
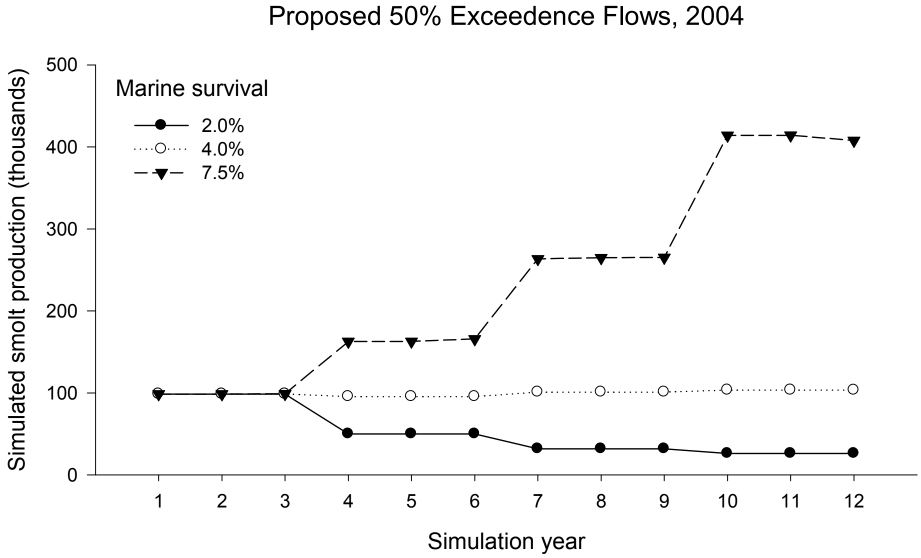


Figure 3-35. Total simulated smolt production over time under low (2.0 percent), medium (4.0 percent), and high (7.5 percent) marine survival rates using proposed 90 percent exceedence flows at IGD combined with 2004 meteorological and tributary flow data.

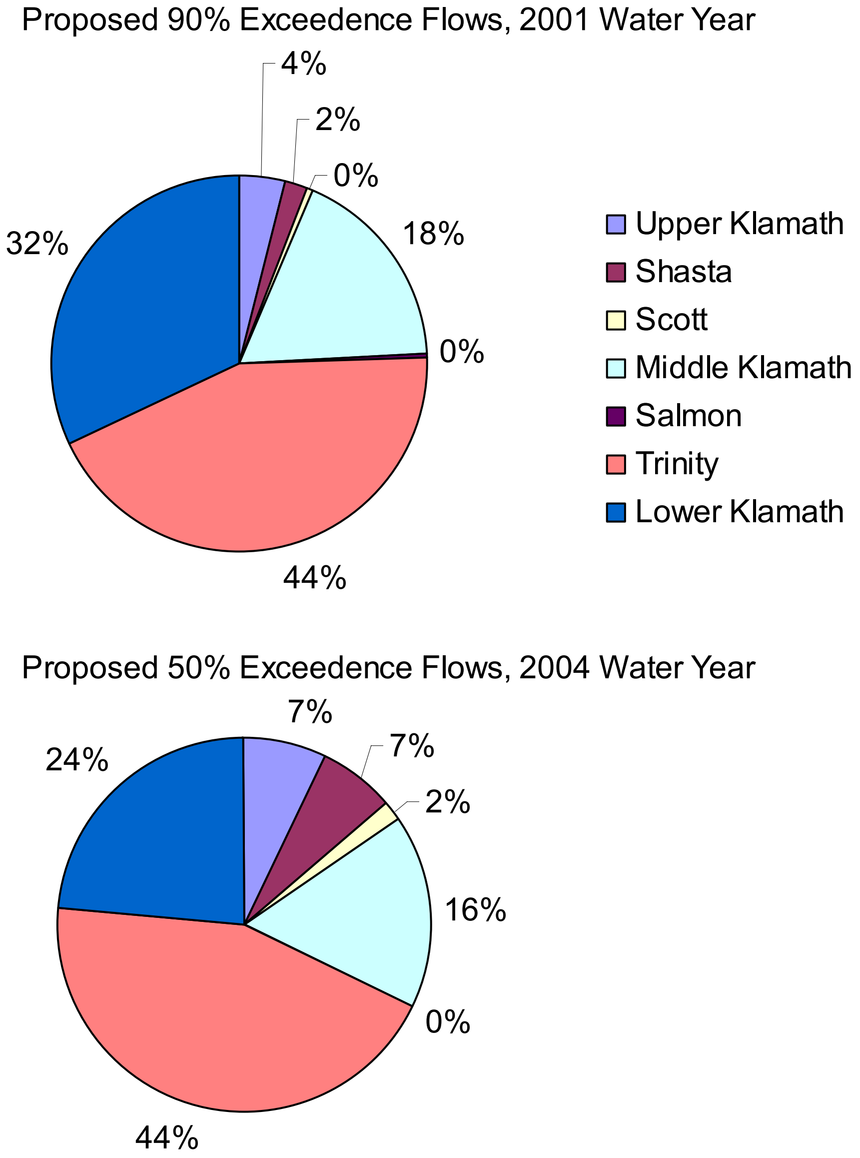


The above simulation results provide the "accounting of uncertainty through the use of scenarios of future conditions and the response of salmonids to these conditions " that was recommended for use in the Central Valley Biological Opinion BO by the NMFS Science Center committee (Lindley et al. 2006). They noted that "[u]ncertainty could further be incorporated into [the Central Valley BO] through the use of scenarios, both best and worst case, to examine the robustness of the analysis results." Further, they specifically recommend that variation in ocean survival be included in these scenarios to evaluate "whether the populations will be able to bear the increased mortality under the full range of ocean conditions, which will include periods of poor survival as well as good periods." The above analyses have included a range of water availability conditions and a range of ocean conditions.

Effects on ESU Spatial Structure

Spatial structure is an important component of population viability for two main reasons: 1) because there is a time lag between changes in spatial structure and species-level effects, and 2) population structure affects evolutionary processes and may therefore alter a population's ability to respond to environmental change (McElhany et al. 2000). A variety of metrics might be used from simulations with the coho salmon life-cycle model. The percentage of natural smolts that are produced from each independent population in the basin is presented (except that the three Trinity River Basin populations are combined) in Figure 3-36. This figure shows how the relative distribution of smolt production changes only slightly in response to a 10 year extreme drought (top graph) compared to 10 years of average conditions under the Proposed Action.

Figure 3-36. Proportion of simulated smolt production in year 10 by population of origin for proposed 90 percent exceedence flows combined with 2001 meteorological and tributary flow data, and 50 percent exceedence flows combined with 2004 data meteorological and tributary flow data.



These distributions of smolt production indicate that the large Trinity River Basin is the largest contributor of coho salmon smolts, followed by the lower Klamath River, and Middle Klamath River. This concentration of smolt production in the Lower Klamath River Basin means that most manipulations of IGD flow releases are only affecting a small portion of the coho salmon (6 to 16 percent in these cases from the Scott, Shasta, and upper Klamath rivers). The number of independent populations that continue to produce coho salmon is also a key substantial buffer against extinction risk (McElhany et al. 2000).

Effects on ESU Diversity

The VSP guidance document cites three reasons why diversity is important for species and population viability:

(1) Diversity allows a species to use a wider array of environments than they could without it

(2) Diversity protects a species against short-term spatial and temporal changes in the environment

(3) Genetic diversity provides the raw material for surviving long-term environmental changes

The simulations with the coho salmon life-cycle model make it possible to track the amount of smolt production that results from various life histories. Among the life history types tracked, there are three smolt types: those that rear in tributaries, those that rear in the main stem, and those that moved through the main stem to rear in non-natal tributaries. The model predicts that approximately 85 percent of smolts are produced in tributaries, 4 percent in the main stem Klamath River, and 10 to 12 percent in non-natal tributaries (Table 3-26). The simulations were conducted for the Proposed Action with and under the historical flow conditions, for a dry year (2001 with 90 percent exceedence releases at IGD) and average year (2004 with 50 percent exceedence releases at IGD) were. After 10 years of these conditions, there was little change in relative contribution of these life history pathways.

Table 3-27. Total smolt production in year 10 by smolt type for historical flows (1961 to 2006) and proposed flows (modeled 2008 to 2018) at IGD using 90 percent exceedence flows combined with 2001 meteorological and tributary flow data, and 50 percent exceedence flows combined with 2004 data meteorological and tributary flow data

	Historical Flows		Proposed Action		% Change (Prop-Base)
Smolt Type	**Smolts produced**	**% of total**	**Smolts produced**	**% of total**	**Smolts produced**
Type I (tributary)	53,254	84.7%	53,892	84.3%	1.2%
Type II (main stem)	2,216	3.5%	2,344	3.7%	5.8%
Type III (non-natal tributary)	7,389	11.8%	7,673	12.0%	3.8%
Total	**62,859**		**63,908**		**1.7%**
Type I (tributary)	88,160	86.0%	88,814	86.0%	0.7%
Type II (main stem)	4,362	4.3%	4,497	4.4%	3.1%
Type III (non-natal tributary)	9,932	9.7%	9,968	9.7%	0.4%
Total	**102,454**		**103,280**		**0.8%**

Another metric used to examine population diversity is the percentage of hatchery fish among fish spawning naturally. The potential certainly exists for hatchery fish to compose a large share of natural spawners, and this appears to be the case in the Trinity River main stem. Only within the last few years has coho salmon spawning been surveyed in a number of streams throughout the basin, and we have received anecdotal reports that marked hatchery fish were rarely recovered in tributaries, except in close proximity to the hatchery. Regardless of what proportion that the hatchery fish compose of spawners in different areas, we are unaware of evidence anywhere that suggest the operations of IGD will influence straying of hatchery fish. Accordingly, there is no function in the life cycle model that relates straying to project operations.

Reintroduction of Coho Salmon

Reclamation notes that the in the draft environmental impact statement for the FERC licensing for the continued operation of PacifiCorp's Klamath Hydroelectric Project, PacifiCorp proposes a suite of studies to be conducted during Phase 1 of the adaptive salmon reintroduction plan. These studies are listed in Table 3-75 of the draft environmental impact statement. Many of the key uncertainties would be addressed in the first five years of study. Although PacifiCorp indicates that some aspects of the Phase 1 studies may require 10 years to complete. PacifiCorp proposes that based on the results and analysis of the six studies, fisheries' managers would decide if self sustaining runs of anadromous fish can be established (FERC, 2006).

However, in Table 1, page 16, in the associated draft BO on the proposed relicensing of the Klamath Hydroelectric Project[39], FERC Project No. 2082, a summary of USFWS proposed modified fishway prescriptions and timetable for the Klamath Hydroelectric Project are listed. Within this table, fish ladders are prescribed for IGD within five years and for the Copco Dams within six years (USFWS 2007 Opinion).

By providing fish passage at these dams, anadromous coho salmon may be reintroduced to habitats above IGD that they formerly occupied. Reintroduction of coho salmon into the Upper Klamath River watershed may affect non-salmon fish communities up to and including Spenser Creek. However, these species coexisted for thousands of years before access to the Upper Klamath basin was blocked in 1918 (USFWS 2007 Opinion).

Summary of the Effects of the Proposed Action on the ESU

Analysis of the Proposed Action's effects was provided that corresponds to each of the four VSP criteria: abundance, productivity, spatial structure, and diversity. Life-cycle simulations were used to examine how the Proposed Action will influence the four VSP criteria for the SONCC coho salmon ESU.

(1) *Abundance:* Simulation of the Proposed Action showed that a wide range of flow releases from IGD had little effect on coho salmon smolt production from the Klamath River Basin. The downstream effects from a different set of meteorology and tributary flows had a far greater effect on smolt production. The simulation results suggest that the population can tolerate adverse environmental conditions in freshwater without collapsing within four generations (12 years).

(2) *Productivity:* Simulations were completed for smolt production under the Proposed Action and under historical flows conditions. Although the total smolt production for the Klamath River Basin shows little change between IGD release regimes, the breakdown for individual populations shows

---

[39] On February 25, 2004, PacifiCorp filed an application with the Commission for a new license for the 161-megawatt Klamath Hydroelectric Project, FERC No. 2082, located principally on the Klamath River, between Klamath Falls, Oregon and Yreka, California. The existing project consists of eight developments, one of which, (Keno) has no generating facilities. Major project dams with generating facilities are Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle dams. The existing project occupies a total of 219 acres of lands of the United States, which are administered by BLM and Reclamation. PacifiCorp proposes to decommission two powerhouses (East Side and West Side) and to remove Keno Dam from the project.

substantial increase in smolt production for populations originating above the Scott River, but no change below there. The simulations indicate that the benefits to smolt production were greatest at the lowest flow conditions. The range for ocean survival had a dramatic effect on the simulated smolt production. Simulations also demonstrate how rapidly the populations can rebound from depressed abundance to high abundance when ocean survival turns favorable.

(3) *Spatial Structure:* Simulations using the life-cycle model shows how the relative distribution of smolt production changes only slightly in response to a 10 year extreme drought compared to 10 years of average conditions under the Proposed Action. Distributions of smolt production indicate that the large Trinity River Basin is the largest contributor of coho salmon smolts. This concentration of smolt production in the Lower Klamath River Basin means that most manipulations of IGD flow releases are only affecting a small portion of the Klamath River coho salmon.

(4) *Diversity:* The model predicts that approximately 85 percent of smolts are produced in tributaries, 4 percent in the main stem Klamath River, and 10 to12 percent in non-natal tributaries. The simulations were conducted under the Proposed Action and under historical flow conditions, for a dry year (2001 tributary inputs with 90 percent exceedence releases at IGD) and average year (2004 tributary inputs with 50 percent exceedence releases at IGD). After 10 years of these conditions there was little change in the relative contribution of these life history pathways.

Cumulative Effects

Cumulative effects are those effects of future State, local, or private activities not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402). Future Federal actions that are unrelated to the Proposed Action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. The purpose of the cumulative effects analysis in the BA is to aid NMFS in making jeopardy and no jeopardy calls for listed species potentially affected by a Proposed Action.

State and Local Actions

The State of Oregon government and the State of California government are cooperating with each other and other governments to increase environmental protection for listed salmon ESUs through development and implementation of habitat restoration, hatchery and harvest reform, and water resource management actions. Many State initiatives benefit the listed species if implemented and sustained.

Local governments will be faced with similar but more direct pressures from population increases and attendant activities. There will be demands for intensified development in rural areas as well as increased demands for water, municipal infrastructure and other resources. The reaction of local governments to such pressures is difficult to assess at this time without certainty in policy and funding. In the past, local governments in the action area generally have accommodated additional growth in ways that adversely affected listed fish habitat, allowing for development to destroy wetlands, stream-banks, estuarine shorelines, and other areas critical to listed species.

Some local government programs, if submitted for consideration, may qualify for a limit under the ESA section 4(d) rule, which is designed to conserve listed species. Local governments also may participate in regional watershed health programs, although politics and funding will determine participation and therefore the effect of such actions on listed species. Overall, without comprehensive and cohesive beneficial programs as well as the sustained application of such programs, it is likely that local actions will have few measurable positive effects on listed species and their habitat and may even contribute to further degradation.

Tribal Actions

Tribal governments participate in cooperative efforts involving watershed and basin planning designed to improve fish habitat and are expected to continue to do so. The results from changes in tribal forest and agriculture practices, water resource allocations, and land uses are difficult to assess for the same reasons discussed under State and Local Actions. The earlier discussions related to growth impacts apply also to tribal government actions. Tribal governments will need to apply comprehensive and beneficial natural resource programs to areas under their jurisdiction to produce measurable positive effects for listed species and their habitat.

Private Actions

The effects of private actions on ESA-listed resources are the most uncertain. Private landowners may convert current use of their lands, or they may intensify or diminish current uses. Individual landowners may voluntarily initiate actions to improve environmental conditions, or they may abandon or resist any improvement efforts. Their actions may be compelled by new laws, or may result from growth and economic pressures. Changes in ownership patterns will have unknown impacts.

Summary

Non-Federal actions are likely to continue affecting listed species. The cumulative effects of these actions are difficult to analyze considering the geographic landscape of the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether effects associated with these actions will increase or decrease is a matter of speculation; however, based on the recent trends, the adverse cumulative effects on listed salmon are likely to increase. Although Tribal, State, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before they can be considered "reasonably foreseeable" in an analysis of cumulative effects.

Interactive Management Approach

Uncertainty

While drought exacerbates water supply issues, conflicts over water use have been continuous in the Klamath River Basin. Reducing demand has proven difficult due to the importance of water for sustaining irrigation, two National Wildlife Refuges and endangered fish. However, some progress has been made in recent years. Studies have increased understanding of fish needs, groundwater aquifers, and the geology of storage sites. Reclamation anticipates that many of the ecosystem restoration projects within the tributaries of the Klamath River are improving habitat and water quality. While some progress has been made, a number of uncertainties remain.

Uncertainty may be defined as a condition where the outcome can only be estimated[40]. There are significant uncertainties as to the benefits of efforts to date in habitat restoration, harvest management, mitigation through hatcheries and modifications to hydropower production. For example, while habitat restoration actions continue and new ones are being implemented in the Klamath River Basin, it is important to recognize the unavoidable uncertainties inherent in complex ecological challenges like salmon conservation. These uncertainties originate in the unpredictability of the response of salmon to habitat restoration efforts, the limits of existing analytical techniques to accurately capture this response, and the varying and potentially very long timeframes necessary for data collection to accurately describe the response. Actions on policy, regulation, and implementation for each of the restoration options are taken in many separate decision arenas, each with its own set of objectives and priorities.

---

[40] Definition obtained from <http: //www.mc2consulting.com/riskdef.htm on June 15>, 2007.

In an effort to develop useful tools in the future to assess the operational impacts of the Klamath Project on coho salmon, Reclamation commissioned Cramer Fish Sciences to conduct a life-cycle analysis of coho salmon in the Klamath River Basin. The life-cycle model (Klamath Coho Integrated Modeling Framework) objective includes predicting coho salmon production under differing flow regimes in the Klamath River downstream of IGD. However, with all the assumptions and "uncertainties" in the model's inputs, we believe that it is too early to rely solely on the model's output at this time to determine a jeopardy threshold. However, model results were used to support a slight modification to the NMFS 2002 BO minimum flows.

The Klamath Coho Integrated Modeling Framework is intended to evolve over time along with the growing body of best available science. Reclamation plans for annual updates following analysis of new data from ongoing studies. This report should be viewed as drafts because the model structure and some parameters will be revised as part of the continuing public review process. As more information and experience is gained and data gaps filled, Reclamation is optimistic that the model will continually be more of a useful tool to further assess the impacts of the Klamath Project operation.

Future Modifications to the Proposed Action

Assessment tools will evolve to improve estimation of impacts. Identified data gaps will be addressed. As new data is accumulated, Reclamation will periodically re-assess the minimum flows for IGD. In making its determination, Reclamation encourages NMFS to recognize that the Integrated Modeling Framework will be more of a useful tool to further assess the impacts of the Klamath Project operation as well as to determine jeopardy thresholds. Consistent with an adaptive management approach outlined in the Proposed Action, Reclamation suggests that a proposed change in the minimum flow regime in the future (2008 through 2018), by itself, will not necessarily be considered grounds to re-initiate this consultation as long as the change in the minimum flows are based on the best estimates of the productivity and capacity of the system. Reclamation will notify NMFS of any proposed change to the minimum flows as well as the biological rationale for those changes. Reclamation proposes that prior to determining whether re-initiation is necessary, NMFS will review the proposed change in the minimum flow regime and document its findings.

Biological Assessment Impact Conclusions

The majority of coho salmon spawn within the tributaries of the Klamath River. On page 56 of the 2002 BO, NMFS states “[g]iven that coho [salmon] are primarily tributary spawners, that main stem spawning and rearing habitat is likely not limiting at the current population size…." Given that the coho salmon are primarily tributary spawners, Reclamation agrees with the NAS in the conclusion that the biggest detriment to coho salmon in the Klamath River is probably excessively high summer temperatures in tributary waters.

The NAS recommended the re-establishment of lower summer temperatures in streams and that woody vegetation be restored along the tributaries to provide shade. The NAS also concluded that tributary conditions, in fact, appear to be the critical factor governing the welfare of coho salmon. The habitat of the tributaries of the Klamath River would not be impacted by the Proposed Action Reclamation acknowledges that there are numerous voluntary activities that are helping to restore fish habitat throughout the tributaries of Klamath River. However, efforts to improve habitat conditions in these tributaries will take several years or decades to fully realize what affect the projects have, or will have, on fish survival and reproduction.

Reclamation also notes that NMFS has concluded that coho salmon from the artificial coho salmon propagation program at the Iron Gate Hatchery is part of the SONCC coho salmon ESU. In the short-term, artificial propagation programs in the upper Klamath River will have a slight beneficial effect on ESU abundance and spatial structure, but neutral or uncertain effects on the ESU productivity and diversity. As intended, the Iron Gate Hatchery mitigates adverse impacts of the IGD on coho salmon. Iron Gate Hatchery mitigation goal is currently 75,000 coho salmon yearlings released per year.

After reviewing the status of the SONCC coho salmon ESU and its designated critical habitat, the environmental baseline, and the effects of the Proposed Action, including an analysis of the Proposed Action's effects that corresponds to each of the four VSP criteria: abundance, productivity, spatial structure, and diversity, Reclamation concludes that the action, as proposed, *may affect, and is likely to adversely affect*[41] the SONCC coho salmon ESU.

However, only a small portion of the populations within this ESU are likely to be affected by any adverse effects of the Proposed Action, primarily those populations in the upper Klamath River. In combination with ongoing habitat restoration and hatchery efforts, Reclamations recommends that NMFS find that

---

[41] If an adverse effect on a listed species may occur as a direct or indirect result of a Proposed Action, and these effects are not discountable, insignificant, or beneficial, the appropriate conclusion or effect determination for a Proposed Action is may affect, likely to adversely affect. If the overall effect of the Proposed Action is beneficial to the listed species (or its designated critical habitat), but is also likely to cause some adverse effects, even in the short term, the Proposed Action would still be considered a may affect, likely to adversely affect.

the Proposed Action would not diminish the SONCC coho salmon ESU numbers, reproduction, or distribution such that the likelihood of survival and recovery in the wild is appreciably reduced.

In regards to critical habitat, based on the above discussion, Reclamation concludes that the Proposed Action *may adversely affect critical habitat*. However, using the habitat mapping results of Hardy and Addley (2006), in the area immediately downstream of IGD, the Proposed Action will provide flows that will make available the majority of the coho salmon juvenile and fry habitat, particularly during the critical March through June time period. As assumed under the NMFS 2002 BO, Reclamation continues to assume that main stem passage, tributary access, and spawning habitat for adult coho salmon will be adequate under the proposed IGD flow regime. Additionally, with the limited storage capacity of the Klamath Project, based on modeling, spill events will occur under Proposed Action, which will continue scouring events into the future. Thus, Reclamation concludes, the Proposed Action, through flow, would not be expected to significantly affect the salmon habitat quantity or quality within the main stem or the tributaries of the lower Klamath River.

Reclamation also concludes that although no recovery plan has been completed for this ESU to date, the Proposed Action is sufficient for the conservation of the ESU until such time as a Recovery Team is convened to address whether additional efforts are necessary to recover coho salmon. In reaching these recommendations and conclusions, Reclamation has utilized the best scientific and commercial data available.

Part 4 APPLEGATE'S MILK VETCH

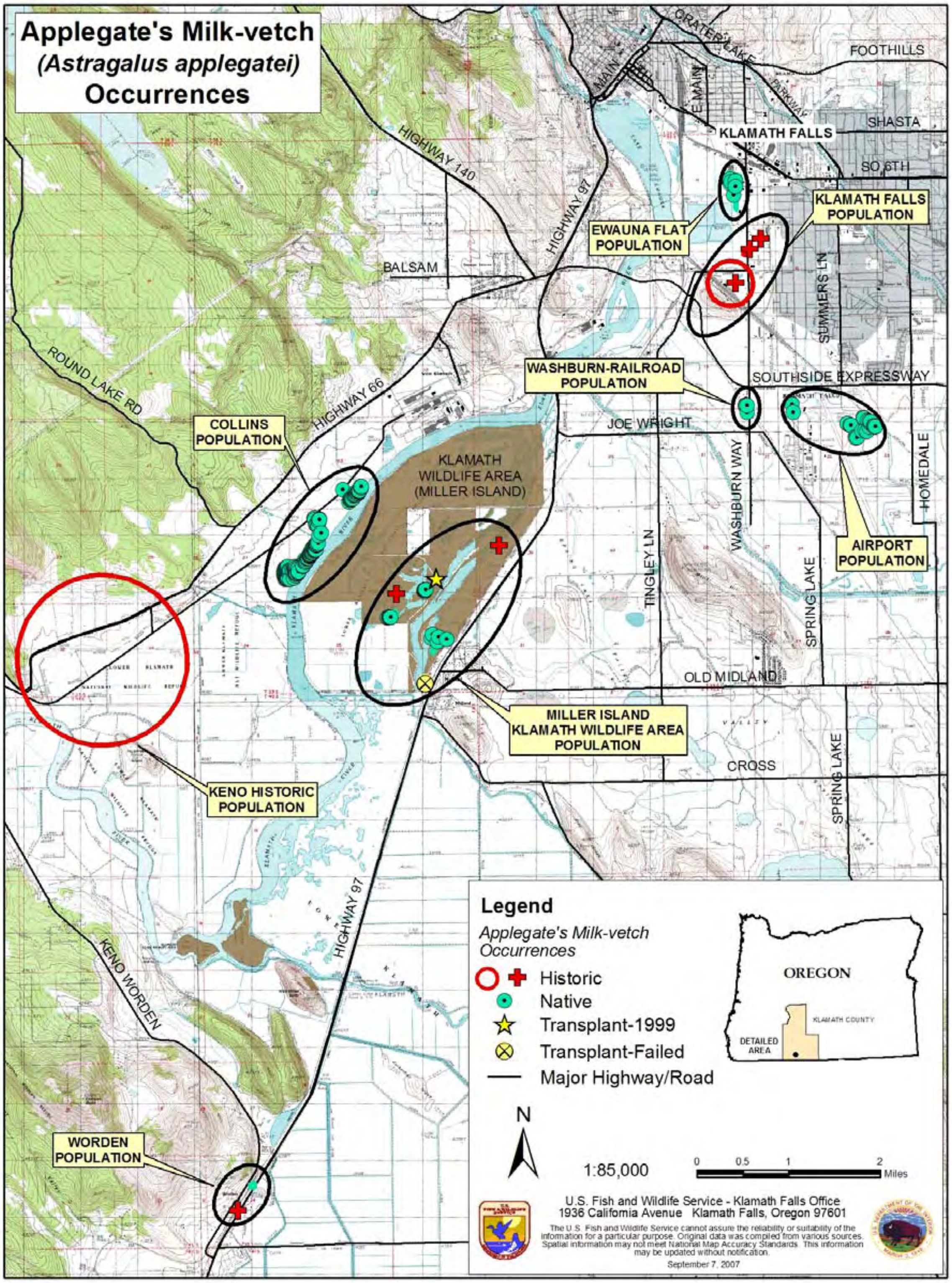
Applegate's Milk-vetch (*Astragalus applegatei*) was believed to be extinct until 1983. Applegate's milk-vetch was federally listed as endangered without critical habitat on June 24, 1993 (USFWS, 1993 Milk-vetch), and a recovery plan was published in 1998 (USFWS 1998). It is a slender, low growing perennial in the pea family with multiple sprawling stems 12 to 36 inches long and small white to light-pink to lavender pea-like flowers measuring up to 7 mm (0.3 in) long. The tip of the keel is faintly lilac- tinged. Flowers are present from June to September. The anthers and stigma ripen simultaneously, enabling self-pollination. The leaves are typically 3.5-7 cm (1.4-2.8 in) long with 7-11 leaflets, with stems 3-4 dm (12-16 in) long. Plants produce 0.3-05 inch seed pods during June and July, and are widely spreading or declined. Dehiscence (pod opening at maturity) starts at the top of the pod and continues downward.

Distribution and Abundance (at time of listing and current)

Applegate's milk-vetch is a narrow endemic, known to occur only in southern Klamath County, Oregon, with most occupied sites a few miles south of the city of Klamath Falls. It is currently known from three large sites and several smaller ones, collectively supporting approximately 10 to 15 thousand individuals. The three large sites are Ewauna Flats Preserve, Collins Tract, and the Klamath Falls Airport (Figure 4-1).

The Service's Recovery Plan for Applegate's Milk-vetch (1998) reported the species was present at 3 of the 4 historically known sites. It is thought this species was historically more prevalent, based on habitat surveys, but there is only one known location of an extinct population. In 2007, Oregon Natural Heritage Information Center (ORNHIC) conducted surveys of selected known populations of Applegate's milk-vetch. These surveys attempted to relocate and provide a summary of the population status for each inventoried site (ORNHIC 2007). Relocation efforts in that area have been unsuccessful, most likely due to severe habitat modification (Ron Larson, USFWS, Klamath Falls Ecosystem Restoration Office, Fisheries Biologist. 2007, pers. comm.
).

Figure 4-1. Distribution map of Applegate's Milk-vetch occurrences.



Not only are reduced and highly modified habitat a threat, but so are caterpillars, beetles, and low seed production (USFWS 1998). There are a number of research projects focused at Astragalus applegatei's recovery conducted by TNC and the Oregon Department of Agriculture. These include: extent of exotic plant influence, population monitoring, experimental habitat management treatments, habitat analysis, reproductive and pollination biology, propagation, transplantation, seed perdition, and mycorrhizal and other microbial studies. The recovery criteria for down listing a species to "threatened" is the existence of six self-sustaining populations (defined as having a minimum of 1,500 reproductive plants) in secure habitats (USFWS 1998). With only 3 known populations currently, and reintroduction into the forth known population location unsuccessful, it is doubtful that down listing is reasonably certain to occur in the near future (Ron Larson, USFWS, Klamath Falls Ecosystem Restoration Office, Fisheries Biologist. 2007, pers. comm.).

Threatened and Endangered Species Effects

The only population of this plants species in the action area that could be affected by the proposed action is the population located near Lake Ewauna. TNC manages this property to protect this population of Applegate's milk-vetch. ODFW also manages the Miller Island properties to protect this smaller population. The proposed action will not result in increased lake surface elevations of Lake Ewauna, nor will the proposed action increase development of new agricultural lands in the areas where existing populations occur. Therefore, Reclamation has determined there would be no effect on the continued existence of the species from it's proposed action on these populations.

Part 5 BALD EAGLES

Description

A large raptor, the bald eagle (*Haliaeetus leucocephalus*) has a wingspread of about 7 feet. Adults have a dark brown body and wings, white head and tail, and a yellow beak. Juveniles are mostly brown with white mottling on the body, tail, and undersides of wings. Adult plumage usually is obtained by the 6th year. In flight, the bald eagle often soars or glides with the wings held at a right angle to the body.

Status

On August 8, 2007, the bald eagle was removed from the List of Endangered and Threatened Wildlife (Federal Register 72: 37346-37372). The bald eagle is still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. On July 12, 1995, the U.S. Fish and Wildlife Service reclassified the bald eagle from endangered to threatened throughout the 48 conterminous States (Federal Register 60: 35999-36110). Previously, the eagle was protected under the Bald Eagle Protection Act of 1940 and the ESA in 1978 (Federal Register 43: 6230-6233). Delisting was proposed in 1999 because recovery goals were reached around 1990 and the Bald Eagle Recovery Team determined that the bald eagle to be recovered (Federal Register 64: 36453-36464).

Reasons for Current Status:

The major factors leading to the decline of the bald eagle were persecution by humans and lowered reproductive success following the introduction of the pesticide DDT in 1947. DDT residues caused eggshell thinning which led to broken eggs. Bald eagle populations began to show signs of recovery 10 to 20 years after DDT use was banned. Population increases have been assisted by protective buffer zones around nests, reduced shooting, and restoration of aquatic habitat. Currently, shoreline development may be the most limiting factor impacting populations (USFWS 2002).

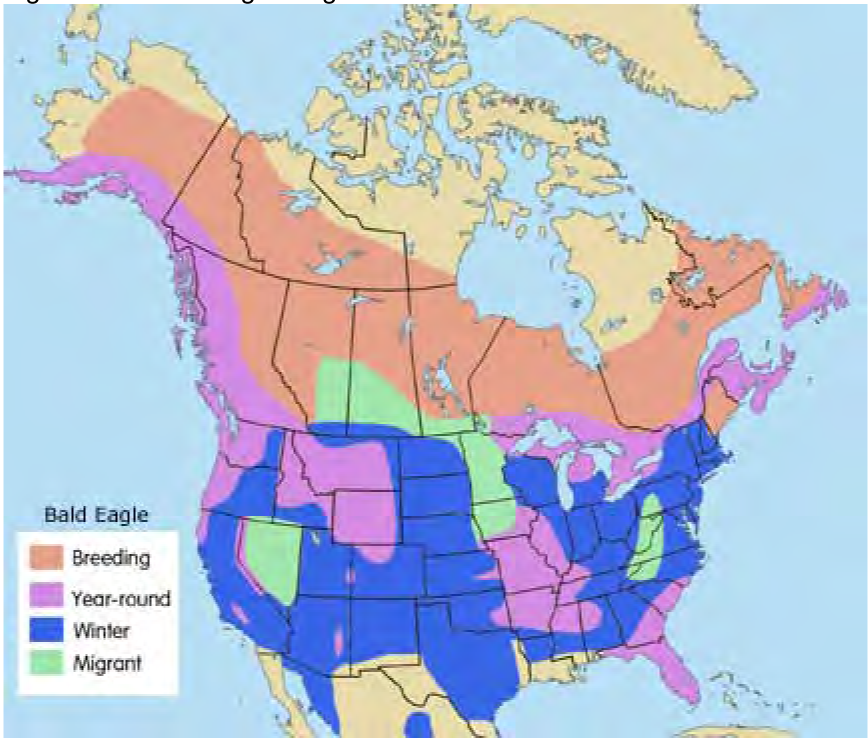
Reproduction and Development

The breeding season of bald eagles varies with latitude. The general tendency is for winter breeding in the South with a progressive shift toward spring breeding in northern locations. In the Southeast, nesting activities generally begin in early September; egg laying begins as early as late October and peaks in late December. The female does most of the nest construction but the male assists. The typical nest is constructed of large sticks with softer materials such as dead weeds, cornstalks, grasses, and sod added as nest lining. Bald eagle nests are very large, sometimes measuring up to 6 feet in width and weighing hundreds of pounds. Many nests are used year after year. Eagles may lay from one to three eggs, but the usual clutch size is two eggs. A second clutch may be laid if the first is lost. Incubation lasts 34 to 38 days. The young fledge 9 to 14 weeks after hatching but parental care may continue for another 4 to 6 weeks. Bald eagles reach sexual maturity at 4 to 6 years of age. The species is long-lived, and individuals do not reach sexual maturity until 4 or 5 years of age. Bald eagles nest in large trees near and usually within sight of large bodies of water. Nests are constructed of large sticks, are typically 4 ½ ft wide and 3 ft deep, are used year after year and may attain weights of several hundred pounds (USFWS 2002). Life span is not known, but it is potentially long since eagles have been known to live for 50 years in captivity.

Range

Found in North America from central Alaska and Canada south to Baja and northern Mexico; southern populations are depleted. Most leave the inland northern breeding grounds to form winter concentrations, especially along areas like the Chilkat River in Alaska, the Klamath Basin in Oregon, and the upper Mississippi River valley. The Klamath Basin is home of the largest winter concentration of bald eagles in the contiguous United States (USFWS 2002, http: //www.eraptors.org/BaldEagle-range.htm)

Figure 5-1. Bald Eagle range in North America.



Source <http: //www.eraptors.org/BaldEagle-range.htm>

Population Level

In 1997, the number of breeding pairs in the lower 49 was > 5,000 pairs. The total population was estimated at around 100,000 individuals in 1999 including Alaska and British Columbia. Unlike nationwide trends that suggest that the number of bald eagles is increasing, preliminary analyses suggest that counts of eagles in the southwestern portion of the country have decreased over the same period[42].

Habitat

Bald eagles are associated with riparian habitat along coasts, rivers, and lakes. Most eagles will leave the valley bottoms by late afternoon and head to sheltering night roosts. Winter roost sites typically consist of large, open-crowned conifers, providing easy landings and takeoffs, associated with food sources such as

---

[42] <http: //fresc.usgs.gov/news/highlights.asp?HDate=09142007>

waterfowl and fish. The most important roost was protected in 1982 as Bear Valley National Wildlife Refuge. In reality this refuge is not a valley, but an old-growth forested hillside west of highway 97 near Worden, Oregon. Eagles tend to use the same roosts each year. Roost sites usually are in areas protected from harsh weather and human disturbance[43].

Nests are found in mature, old-growth trees located in close proximity to water with adequate food resources. Quality of habitat appears more important than distance to water. Suitable habitat supports a diversity of prey and experiences little human disturbance. As with winter roost sites, nest trees usually are used for many years (USFWS 2002).

Each year during the month of November, bald eagles begin to appear en masse on their Klamath Basin wintering grounds. Having traveled from as far away as Northwest Territories in Canada and Glacier National Park, these birds quickly settle into a daily routine of waterfowl scavenging throughout the Basin's marshes by day and locating sheltered roosts at night. Most bald eagles congregate in the Tule Lake and Lower Klamath National Wildlife Refuges, where surveys document up to 500 birds in January and February. Most bald eagles move to their nightly roosts in the Bear Valley National Wildlife Refuge[44].

Management and Protection

Although bald eagle populations have increased, they continue to be threatened by habitat loss, environmental contaminants (i.e., organophosphate pesticides, heavy metals, and oil spills), incidence of disease, injury from wind turbines and electrocution by power lines, and human disturbance (USFWS 2002). Management strategies include use of buffer zones around nests, and continued monitoring of populations. Bald eagles are protected by Federal and State laws enforced by U.S. Fish and Wildlife Service and State Game Departments. Nest sites and roosts are generally protected by a buffer zone of one-quarter mile when roosts are active and during the nesting season. Despite these and other threats, bald eagle numbers are generally increasing or stable, and as such, no additional specific conservation needs were identified in the Service's rule to delist bald eagles (USFWS 2002).

---

[43] <http: //www.fws.gov/klamathbasinrefuges/eagle.html>

[44] <http: //www.fws.gov/klamathbasinrefuges/eagle.html>

Determination

Reclamation has determined that continued operation of the Klamath Project will have no effect on bald eagle as water deliveries to the Refuges will continue as they have previously. The Project's effects to nesting and wintering eagles are not likely to lead to death or injury of eagles by significantly impairing essential behavioral patterns such as breeding, feeding or sheltering.

Part 6 OREGON SPOTTED FROGS

Oregon Spotted Frog (*Rana pretiosa*) is a candidate for listing under ESA. Historically, the Oregon spotted frog ranged from British Columbia to the Pit River drainage in northeastern California. Based on surveys of historical sites, the Oregon spotted frog is now absent from at least 76 percent of its former range. The majority of the remaining Oregon spotted frog populations are small and isolated. These factors make the Oregon spotted frog more vulnerable than large, connected populations to random, naturally occurring events, such as drought, disease, and predation. (Federal Register: September 12, 2006)

The Spotted Frog can be found in the southwestern most parts of British Columbia, and from the eastern side of the Puget/Willamette Valley Trough and into the Columbia River Gorge Oregon and Southern Washington. The Oregon Spotted Frog habitat historically covers Clackamas, Linn, Klamath, Multnomah, Wasco, and Benton counties. Today the species has only been found to occur in the Deschutes, Klamath, and Lane counties[45].

Habitat of the Spotted Frog

Oregon Spotted Frog is an aquatic species found near recurrent bodies of water. The Spotted Frog can be found in the shallows typically and prefers areas that provide abundant floating aquatic plants. (Leonard et al. 1993, Corkran and Thoms 1996, McAllister and Leonard 1997).

The Oregon Spotted Frogs habitats are identified by:

- Overwintering, Breeding sites are related by year-round water
- Reliable water levels that maintain depth between times of laying eggs (oviposition) and species development (metamorphosis)
- Absence of predators, especially warm-water game fish and bullfrogs[46]

---

[45] <http: //www.herpetologynorthwest.org/nwherps/toads-and-frogs/oregon-spotted-frog.html>

[46] <http: //www.herpetologynorthwest.org/nwherps/toads-and-frogs/oregon-spotted-frog.html>

Reclamation cooperated with the BLM to conduct surveys of ALR, Barnes, and Wood River properties in 2006. Due to the large populations of bullfrogs on ALR and Barnes, it was determined there were no suitable habitats for Oregon spotted frogs on these properties.

Description of Species

The Oregon spotted frog is named for the black spots that cover the head, back, sides, and legs. The dark spots have ragged edges and light centers, which are usually associated with tubercles or raised areas of skin; these spots become larger and darker and the edges become more ragged with age. Body color also varies with age. Juveniles are usually brown or, occasionally, olive green on the back and white or cream with reddish pigments on the under legs and abdomen. Adults range from brown to reddish brown, but tend to become redder with age; large, presumably older individuals may be brick red over most of the back. Red increases on the abdomen with age, and the under legs become a vivid orange-red. This red coloration can be used to distinguish the spotted frogs from other native frogs[47].

The Oregon spotted frog is a medium-sized frog, ranging from 44-100 mm (1.74-4 in) in body length (McAllister and Leonard 1997). Females are typically larger than males and can reach up to 100 mm (4 in) (Leonard et al. 1993).

Life History

This species begins to breed at three years of age. Breeding occurs in February or March at lower elevations and in late May or early June at higher elevations. Females may deposit egg masses at the same location in successive years in shallow, often temporary, pools no more than 6 inches deep. Eggs usually hatch within 3 weeks after oviposition. Tadpoles are grazer, having rough tooth rows for scraping plant surfaces and ingesting plant tissue and bacteria. They also consume algae, detritus, and probably carrion (Licht 1974, McAllister and

---

[47] <http: //www.herpetologynorthwest.org/nwherps/toads-and-frogs/oregon-spotted-frog.html>

Leonard 1997). Tadpoles then metamorphose into froglets during their first summer (Leonard et al. 1993). Post-metamorphic Oregon spotted frogs feed on live animals, primarily insects[48].

Decline of the Oregon Spotted Frog

Many factors are believed to have caused Oregon spotted frogs to decline and continue to threaten this species, including loss of habitat, non-native plant invasions, changes in hydrology due to construction of dams and alterations to seasonal flooding, and poor water quality. Additional threats to the species are predation by nonnative fish and introduced bullfrogs; competition with bullfrogs for habitat; and diseases, such as oomycete water mold Saprolegnia and chytrid fungus infections. The magnitude of threat is high for this species because the small populations with patchy and isolated distributions are subject to a wide range of threats to both individuals and their habitats that could seriously reduce or eliminate any of these isolated populations and further reduce the range of the species. Habitat restoration and management actions have not prevented a decline in the reproductive rates in some populations. The threats are imminent because each population is faced with multiple ongoing and potential threats. (Federal Register: September 12, 2006). Over 95% of historic marsh habitat, and consequently Oregon spotted frog habitat, has been lost in the Willamette and Klamath basins. Non-native plant invasions, by such aggressive species as reed canary grass (Phalaris arundinacea), and succession of plant communities from marsh to meadow also threaten this species' existence[49].

Conservation Measures

Efforts are being made to eliminate and to prevent future introductions of bullfrogs and warm-water game fish from spotted frog habitat. Active management is also required to control non-native plant species like reed canary grass. Protecting Oregon spotted frog populations through maintaining healthy aquatic habitats will continue to be the key objective of land managers[50].

---

[48] <http: //www.herpetologynorthwest.org/nwherps/toads-and-frogs/oregon-spotted-frog.html>

[49] <http: //www.herpetologynorthwest.org/nwherps/toads-and-frogs/oregon-spotted-frog.html>

[50] <http: //www.herpetologynorthwest.org/nwherps/toads-and-frogs/oregon-spotted-frog.html>

Part 7 CONSULTATION HISTORY

Section 7(a) (2) of the ESA requires Federal agencies to consult over their proposed actions to ensure that they are not likely to jeopardize the continued existence of listed species or adversely modify critical habitat. Reclamation first consulted over the effects of Klamath Project operations on listed suckers in 1991. As a result of that consultation, the FWS issued a BO, which determined that proposed Project operations were likely to jeopardize the continued existence of the Lost River and shortnose sucker species. In 1997 SONCC ESU of the coho salmon was listed by NMFS as threatened. Since that time, Reclamation has consulted on coho as well. The complete history of all subsequent consultations and determinations is listed in Table 7-1, below.

Reclamation consulted over the effects of Project Operations on both listed sucker species and the coho salmon in 2001. In response to Reclamation's 2001 BA, USFWS and NMFS issued separate BOs that recommended Reclamation take actions, including maintenance of end-of-month minimum lake levels in UKL and specified discharges from IGD. Issuance of these BOs coincided with a severe drought. Compliance with the 2001 BOs precluded Reclamation from delivering water to the Project water users for most of the irrigation season in 2001.

The reduced 2001 water deliveries severely impaired agricultural production on a significant portion of the Klamath Project, resulting in tremendous controversy between the agricultural community and those concerned with protecting the listed fish, including Indian Tribes and environmental and fisheries organizations.

In order to alleviate this tension and to better analyze the needs of listed species, the Departments of the Interior and the Department of Commerce asked the National Academy of Sciences (NAS) to evaluate the strength of scientific support for the BAs and BOs on the three listed species, and to identify requirements for recovery of the species. NAS's National Research Council formed a Committee on Endangered and Threatened Fishes in the Klamath River Basin, which conducted the review and released an Interim Report in February 2002 and a Final Report in 2004. The Committee found substantial scientific support for all recommendations made by the two listing agencies for the benefit of the endangered and threatened species, except for recommendations requiring more stringent controls over water levels in UKL and flows at IGD (pg. 3, NRC, 2004,).

After the Committee issued its Interim Report (NRC 2002), Reclamation released a new BA in 2002. FWS and NMFS responded with new, separate BOs. FWS concurred with Reclamation's proposed action and consulted based on certain lake levels for four water year types. NMFS, on the other hand, recommended certain river flows for five water year types, and presented a three-phase approach to gradually increasing river flows over the course of 10 years. The BOs were designed to avoid the likelihood of jeopardy to the listed suckers and coho, respectively, and to avoid adverse modification to critical habitat. The river flows and lake levels of the recommended reasonable and prudent alternatives conflicted with each other at times (i.e., Both river flow and lake levels potentially could not be simultaneously met even if no water was diverted for the Project under certain conditions). This conflict occurred every year during certain months, and was especially a problem in 2007, when supplementary water was required to meet the Phase III flows in the absence of the water bank (which was eliminated in 2006 with Armstrong' order). To ensure minimum levels for the river and lake were met with the least impact to Project deliveries; Reclamation operated the Klamath Project conservatively. Reclamation also began development of alternative methods for reducing Project demand and increasing water storage opportunities at the Project (i.e., the Pilot Water Bank and the Barnes and ALR purchase). Reclamation struggled to meet the lake levels and river flow requirements in most years during the irrigation season (April 1 through September 30).

Several fisheries groups (including the Pacific Coast Federation of Fishermen Association) and environmental organizations, later joined by the Yurok and Hoopa Valley Tribes, filed a lawsuit against Reclamation and NMFS arguing that the NMFS BO's phased-in flow requirements were not adequate to protect listed salmon. The district court (ND/CA) ruled that the NMFS RPA did not avoid the likelihood of jeopardy to the coho. After review and remand by the Ninth Circuit Court of Appeals, the court issued an injunction directing Reclamation to maintain Phase III flows at IGD and to reinitiate consultation on Klamath Project operations. Reclamation began operating under Phase III flows on April 1, 2006, and will continue to meet these flow requirements until a new BO is issued.

The Table 7-1 and Table 7-2 summarize previous ESA section 7 consultations on the Operations of the Klamath Project.

Table 7-1. Consultation history of Reclamation's Klamath Irrigation Project with USFWS for Lost River and shortnose sucker, and bald eagle.

Date	Subject of Consultation	Determination
8/14/1991	Formal consultation on the effects of the 1991 operation of the Klamath Project	Likely to jeopardize suckers No jeopardy to Bald Eagle No effect Peregrine Falcon
1/6/1992	Formal consultation on the effects of the 1992 operation of the Klamath Project (interim BO)	Not likely to jeopardize suckers or Bald Eagle No effect Peregrine Falcon
3/27/1992	Reinitiation of formal consultation on the effects of the 1992 operation of the Klamath Project	Likely to jeopardize sucker species No jeopardy to Bald Eagles No effect Peregrine Falcon
5/1/1992	Reinitiation of formal consultation on the effects of the 1992 operation of the Klamath Project at Clear Lake Reservoir	No jeopardy to affected species
7/22/1992	Formal consultation of long term operation of the Klamath Project	Likely to jeopardize sucker species No jeopardy to Bald Eagles No effect Peregrine Falcon
2/22/1993	Reinitiation of formal consultation on long-term operation of the Klamath Project at UKL operations	One-year modification of lake elevation 4141.0 on 3/1/1993
8/11/1994	Reinitiation of formal consultation on long-term operation of the Klamath Project, with special reference to operations at Clear Lake Reservoir	Established new minimum elevation for Clear Lake Reservoir
4/20/1998	Amendment to the 1992 BO to cover operation of ALR impoundment	Not likely to jeopardize the affected species
7/13/1998	Amendment to the 1992 BO dealing with Anderson-Rose Dam releases	Not likely to jeopardize the affected species
4/15/1999	Amendment to the 1996 BO addressing lowered water levels in UKL to reduce risk of flooding in spring 1999	Not likely to jeopardize the affected species
9/10/1999	Revised amendment to the 1992 BO to cover operation & maintenance of ALR impoundment	Not likely to jeopardize the affected species
4/5/2001	Reinitiation of formal consultation on long-term operations of the Klamath Project; a one year consultation at Reclamation's request	Likely to jeopardize sucker species No jeopardy to Bald Eagle
4/13/2001	Reinitiation of formal consultation on releases at Anderson Rose Dam	Not likely to jeopardize sucker species. Concur with drought year assessment.

Date	Subject of Consultation	Determination
8/22/2001	Amendment to 4/5/2001 BO on Klamath Project operations to cover Safety of Dams modification of Clear Lake Dam	Not likely to jeopardize the affected species
3/28/2002	Formal consultation for continued operation of Klamath Project from 4/1/2002 to 5/31/2012	Not likely to jeopardize the affected species

Table 7-2. Consultation history of Reclamation's Klamath Irrigation Project with NMFS for coho salmon.

Date	Document Type & Subject of Consultation	Determination
6/2/1998	BA on Klamath Project Operations; Requested formal consultation	NMFS deferred consultation until the following year
3/9/1999 6/18/1999	Requested formal consultation, Draft Klamath Project Annual Operation Plan EA; modified operation period between 4/1999 to 3/2000	
7/12/1999	NMFS BO	Issued the BO for Project Operations through March 2000
4/4/2000	NMFS letter regarding BO & Incidental Take Statement; advised Reclamation should request consultation on project operations	1999 BO & Incidental Take Statement was expired
4/26/2000	Reclamation letter acknowledged receipt of NMFS letter	Determined proposed flows were sufficient & necessary to avoid 7(d) foreclosures & fulfill obligation to protect Tribal trust resources
1/22/2001	Reclamation BA; initiation of formal consultation	Detailed proposed operations into the future
4/6/2001	NMFS BO	Jeopardy BO. Included RPA of minimum flow release for IGD for April-Sept 2001
9/28/2001	NMFS BO amendment	Provided flow for Oct-Dec 2001
12/28/2001	NMFS BO amendment	Provided flows for Jan-Feb 2002
2/27/2002	Reclamation Letter & BA	Requested initiation of formal ESA section 7 consultation; Final BA of Effects of Proposed Actions related to Klamath Project Operation between 4/1/2002-3/31/2012
3/28/2002	NMFS letter	Concurred with "not likely to adversely affect" determination
5/31/2002	NMFS BO	Jeopardy Opinion. Provided analysis of Project Operations, included 5 water year types and 3 flow regimes to be phased in over the 2002-2012 period

Part 8 CONCLUSION

Reclamation has analyzed the past and present impacts of all Federal, State, or private actions and other human activities in the action area; the anticipated future impacts of all proposed Federal projects in the action area that have undergone consultation; and the impact of state or private actions contemporaneous to this consultation. Using the best scientific and commercial data available, Reclamation has made the conclusions regarding the Proposed Action shown in Table 8-1.

Table 8-1. Determination of Effects.

Species –common name	**Scientific Name**	**Status**	**Project Effect**
Coho Salmon	*Oncorhynchus kisutch*	Threatened	May affect, and is likely to adversely affect
Lost River sucker	*Deltistes luxatus*	Endangered	May affect, and is likely to adversely affect
Shortnose sucker	*Chasmistes brevirostris*	Endangered	May affect, and is likely to adversely affect
Applegate's milk vetch	*Astragalus applegatei*	Endangered	No Effect
Critical Habitat		**Status**	**Project Effect**
Coho Salmon	*Oncorhynchus kisutch*	Designated May 5, 1999 (64 FR 24049)	May adversely modify
Lost River sucker	*Deltistes luxatus*	Proposed	May adversely modify
Shortnose sucker	*Chasmistes brevirostris*	Proposed	May adversely modify

Part 9 LITERATURE CITED

Agrawal, A., R.S. Schick, E.P. Bjorkstedt, R.G. Szerlong, M.N. Goslin, B.C. Spence, T.H. Williams, and K.M. Burnett. 2005. Predicting the potential for historical coho, Chinook and steelhead habitat in Northern California. NOAA Technical Memo NMFS-SWFSC-379.

Andreasen, J.K. 1975. Systematics and status of the Family *Catostomidae* in southern Oregon. Ph.D. Thesis, Oregon State University, Corvallis, Oregon. 76 p.

Andrewartha, H. G. and Birch, L. C. 1984. The ecological web: more on the distribution and abundance of animals.– Univ. Chicago Press.

Ayres Associates. 1999. Geomorphic and Sediment Evaluation of the Klamath River, California, below IGD. Report to USFWS by Ayres Associates, Fort Collins, Colorado.

Banish, N.P., B.J. Adams, and R.S. Shively. 2007. Distribution and habitat associations of radio-tagged adult Lost River and shortnose suckers in UKL, Oregon: 2005 and 2006 report. U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 56p.

Banner, C. 2006. Oregon Department of Fish and Wildlife Fish Exam CB06-232. 2p. In USFWS. 2007. Formal ESA, Section 7 consultation for the collection, examination, and treatment for pathogens and parasites of juvenile Lost River and shortnose suckers taken from Klamath County, Oregon. Klamath Falls, Oregon. 16p.

Barbiero, R.P. and J. Kann. 1994. The importance of benthic recruitment to the population development of *Aphanizomenon flos-aquae* and internal loading in a shallow lake. Journal of Plankton Research 16: 1581-1588.

Barry, Matt. 2007. Williamson River Preserve Director, The Nature Conservancy. pers. comm.

Barry, P.M., and A.C. Scott. 2007. Monitoring of Lost River, shortnose, and Klamath largescale suckers in the lower Williamson River. In "Investigations of adult Lost River, shortnose, and Klamath largescale suckers in UKL and its tributaries, Oregon: Annual Report 2005" U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 76p.

Barry, P.M., B.S. Hayes, E.C. Janney, R.S. Shively, A.C. Scott, and C.D. Luton. 2007 (Lost). Monitoring of Lost River (Deltistes luxatus) and shortnose

(Chasmistes brevirostris) suckers in Gerber and Clear Lake reservoirs 2005-2006. USGS, Western Fisheries Research Center, Klamath Falls Field Station. 25p.

Barry, P.M, A.C. Scott, C.D. Luton, and E.C. Janney. 2007 (Sprague) Monitoring of Lost River, shortnose, and Klamath largescale suckers at the Sprague River Dam Fish Ladder. In "Investigations of adult Lost River, shortnose, and Klamath largescale suckers in Upper Klamath Lake and its tributaries, Oregon: Annual Report 2005" U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 76p.

Barry, P.M., B.S. Hayes, A.C. Scott, and E.C. Janney. 2007 (UKL). Monitoring of Lost River and shortnose suckers at shoreline spawning areas in Upper Klamath Lake. In "Investigations of adult Lost River, shortnose, and Klamath largescale suckers in Upper Klamath Lake and its tributaries, Oregon: Annual Report 2005" U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 76p.

Bartholomew, J. L., M. J. Whipple, D. G. Stevens and J. L. Fryer. 1997. The life cycle of
Ceratomyxa shasta, a myxosporean parasite of salmonids, requires a freshwater polychaete as an alternate host. American Journal of Parasitology. 83: 859-868.

Beak Consultants Inc. 1987. Shortnose and Lost River sucker studies: Copco Reservoir and the Klamath River. Report prepared for the city of Klamath Falls, Oregon. June 30, 1987. 55 p.

Beechie, T.J., Liermann, E.M., Beamer, E.M., and Henderson, R. 2005. A classification of habitat types in a large river and their use by juvenile salmonids. Trans. Am. Fish. Soc. 134: 717-729.

Belchik, M. 2003. Use of thermal refugia areas on the Klamath River by juvenile salmonids; Summer 1998. Yurok Tribal Fisheries Program. 36pp.

Belchik, M., D. Hillemeier, and R. M. Pierce. 2004. The Klamath River Fish Kill of 2002; Analysis of Contributing Factors. Yurok Tribal Fisheries Program. 42pp.

Benson, R.B. and J.E. Holt. 2006. Daytime use of the Red Cap Creek thermal refuge by juvenile steelhead and Chinook salmon in the Klamath River, August 2005. Yurok Tribal Fisheries Program Technical Report. KR-06-01. 19p.

Bennetts, Dan. 2007. Fisheries Biologist, Bureau of Reclamation, pers. comm.

Bennetts, D., and C. Korson. 2005. A-canal fish screen monitoring and evaluation activities, 2004. Bureau of Reclamation, Klamath Falls, OR.

Bennetts, D., C. Korson, and R. Piaskowski. 2004. A-canal fish screen monitoring and evaluation activities, 2003. U.S. Bureau of Reclamation, Klamath Falls, OR.

Bienz, C.S. and J.S. Ziller. 1987. Status of three lacustrine sucker species (*Catostomidae*). Report to the USFWS, Sacramento, California.
39 p.

Bodensteiner, L. R., R. J. Sheehan, P. S. Wills, A. M. Brandenburg, and W. M. Lewis. 2000. Flowing water: an effective treatment for *Ichthyophthiriasis*. J. Aqua. Animal Health 12: 209-219.

Borthwick, S.M., and E.D. Weber. 2001. Larval fish entrainment by Archimedes lifts and an internal helical pump at Red Bluff research pumping plant, Upper Sacramento River, California. Red Bluff Plant Report Series, volume 12, Bureau of Reclamation, Red Bluff, CA.

Bortleson, G.C. and M.O. Fretwell. 1993. A review of possible causes of nutrient enrichment and decline of endangered sucker populations in Upper Klamath Lake, Oregon. Portland, OR, United States Geological Survey. Water Resources Investigation Report 93-4087. 24p.

Boyle, J.C. 1987. Fifty years on the Klamath. J. Shaw Historical Library 1(2): 17-43.

Bradbury, J.P., S.M. Colman, and R.L. Reynolds. 2004. The history of recent limnological changes and human impact on Upper Klamath Lake, Oregon. Journal of Paleolimnology 31: 151-165

Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. N. Am. J. Fish. Manag. 14: 23–261.

Buehlar, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). In The Birds of North America, No. 506 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Buettner, M. and G. Scoppettone. 1990. Life history and status of catostomids in Upper Klamath Lake, Oregon. Completion Report. USFWS, National Fisheries Research Center, Reno Field Station, Nevada.

Buettner, M. and C. Scoppettone. 1991. Distribution and information on the taxonomic status of the Shortnose sucker, *Chasmistes brevirostris*, and Lost River sucker, *Deltistes luxatus*, in the Klamath River Basin, California. Completion report. CDFG Contract FC-8304. USFWS, Seattle National Fishery Research Center, Reno Substation, Nevada. 101 p.

Bureau of Land Management see U.S. Bureau of Land Management

Bureau of Reclamation. 1994. Klamath Project. Biological assessment on long-term operations of the Klamath Project, with speccial emphasis on Clear Lake operations.

Bureau of Reclamation (Reclamation). 1998 (Water Use). Klamath Project Historical Water Use Analysis, Klamath County, Oregon and Siskiyou count, California. Review Draft. October 1998.

Bureau of Reclamation (Reclamation). 1998 (Sucker Salvage). Klamath Project sucker salvage report – 1997. Unpublished report. Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon.

Bureau of Reclamation (Reclamation). 2000 (Water Quality). Analysis of Tule Lake water quality and sucker telemetry, 1992-1995. Unpublished report. U.S. Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon.

Bureau of Reclamation (Reclamation). 2000 (Sucker Salvage). Klamath Irrigation project sucker salvage and Langell Valley fish survey report – 1999. Unpublished report. U.S. Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon.

Bureau of Reclamation (Reclamation). 2001. Biological Assessment of Klamath Project's continuing operations on the endangered Lost River sucker and shortnose sucker. February 2001. Klamath Falls, Oregon.

Bureau of Reclamation (Reclamation). 2002. Final Biological Assessment: the effects of proposed actions related to Klamath Project operation (April 1, 2002 – March 31, 2012) on federally-listed threatened and endangered species. February 2002. Klamath Falls, Oregon.

Bureau of Reclamation (Reclamation). 2003. Chiloquin Dam fish passage appraisal study, project 1989, Klamath River basin, Oregon. Klamath Falls, Oregon.

Burnett, K.M. 2001. Relationships among juvenile anadromous salmonids, their freshwater habitat, and landscape characteristics over multiple years and spatial scales in the Elk River, Oregon. Ph.D. Thesis, Oregon State University, Corvallis, OR.

Burnett, K. M., G. H. Reeves, D. Miller, S. E. Clarke, K. C. Christiansen, and K. Vance-Borland. 2003. A first step toward broad scale identification of freshwater protected areas for Pacific salmon and trout. Pages 144-154 In J. Beumer, A. Grant, and D.C. Smith (eds.) Aquatic Protected Areas: what works best and how do we know? Proceedings of the World Congress on Aquatic Protected Areas, Cairns, Australia, August 14-18, 2002. Australian Society for Fish Biology, University of Queensland, Australia.

Bury, R.B., Pearl, C.A., 1999, The Klamath-Siskiyou herpetofauna-Biogeographic patterns and conservation strategies: Natural Areas Journal, v. 19, no. 4, p. 341-350. Catalog No: 634

California Department of Fish and Game (CDFG). 1965. California fish and wildlife plan. Volume III supporting data: Part B, inventory salmon-steelhead and marine resources. (Available from California Department of Fish and Game, 1416 Ninth St., Sacramento, CA 95814.)

California Department of Fish and Game (CDFG). 1994. Petition to the California Board of Forestry to list coho salmon (Oncorhynchus kisutch) as a sensitive species. (Available from California Department of Fish and Game, 1416 Ninth St., Sacramento, CA 95814.)

California Department of Fish and Game (CDFG). 2000. Fishery management and evaluation plan, south-central California coast ESU, steelhead, draft document. (Available from California Department of Fish and Game, Fisheries Programs Branch, 1416 Ninth St., Sacramento, CA 95814.)

California Department of Fish and Game (CDFG). 2002 Status Review. Status review of California coho salmon north of San Francisco. Report to the California Fish and Game Commission. Candidate Species Status Review Report 2002-3. (Available from California Department of Fish and Game, 1416 Ninth St., Room 1320, Sacramento, CA 95814.)

California Department of Fish and Game (CDFG). 2003. Annual Report: 2003. Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations, Siskiyou County, CA

California Department of Fish and Game (CDFG). 2003 Recovery Strategy. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission, 594 pages.

California Department of Fish and Game (CDFG). 2003 Preliminary Conclusions. Letter dated 20 March 2003 from Robert C. Hight to Dr. Michael F. Tillman, containing review of February 2003 draft of “Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead.” (Available from Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, CA 95060.)

Cameron, J. M. 2007. Unpublished data.

Cameron, Jason. 2007. Physical Scientist, Bureau of Reclamation, pers. comm.

Campbell, S.G., editor. 1993a. Environmental research in the Klamath Basin, Oregon: 1991 Annual Report, R-93-13. U.S. Department of the Interior, Bureau of Reclamation, Research and Laboratory Services Division, Denver. 212 p.

Campbell, S.G., editor. 1993b, Environmental research in the Klamath Basin, Oregon: 1992 Annual Report, R-93-16. U.S. Department of the Interior, Bureau of Reclamation, Research and Laboratory Services Division, Denver. 341 p.

Campbell, S. G. 1995. Klamath River Basin flow-related scoping study - phase I, water quality. In: Compilation of phase I reports for the Klamath River Basin, May 1995. Prepared for the Technical Work Group of the Klamath River Basin Fisheries Task Force by River Systems Management Section, National Biological Service, Midcontinent Ecological Service Center, Fort Collins, CO

Campbell, S. G., R. B. Hanna, M. Flug, and J.F. Scott. 2001. Modeling Klamath River System Operations for Quantity and Quality. Journal of Water Resources Planning and Management, September/October 2001: 284-294.

Cascades Raptor Center, nd. Bald Eagle Range. <http: //www.eraptors.org/BaldEagle-range.htm>. accessed October 17, 2007.

Chamberlain, C.D. and S.C. Williamson. 2006. Klamath River salmonid emigrant trapping catch, mortality, and external health indicators – 2004. USFWS, Arcata Fish and Wildlife Office, Arcata California.

Chamberlin, T. W., R. D. Harr, and F. H. Everest. 1991. Timber harvesting, silviculture, and watershed processes. Pages 181-205 in W.R. Meehan (ed.), Influences of Forest and Rangeland Management. American Fisheries Society Special Publication 19.

CH2M Hill. 1995. Water Quality Model of the Klamath River. Report prepared for U.S. Department of the Interior, Bureau of Reclamation, December 1995.

Cooperman, M. 2002. Clarification of the role of submergent macrophytes to larval shortnose and Lost River suckers in the Williamson River and Upper Klamath Lake. Comments sent by Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, to NRC, Washington, D.C. March 7, 2002. 3pp.

Cooperman, M. and D.F. Markle. 2000. Ecology of Upper Klamath Lake Shortnose and Lost River suckers. 2. Larval Ecology of Shortnose and Lost River suckers in the Lower Williamson River and Upper Klamath Lake. Oregon State University, Department of Fisheries and Wildlife, Corvallis, Oregon. 27 pp.

Cooperman, M., and D.F. Markle 2003. Rapid out-migration of Lost River and shortnose sucker larvae from in-river spawning beds to in-lake rearing grounds. Transactions of the American Fisheries Society 132: 1138-1153.

Coots, M. 1965. Occurrences of the Lost River sucker, *Deltistes luxatus* (Cope), and Shortnose sucker, *Chasmistes brevirostris* (Cope), in Northern California. California Department of Fish and Game 51: 68-73.

Cope, E.D. 1879. The fishes-of Klamath Lake, Oregon. American Naturalist 13: 784-785.

Cramer Fish Sciences. 2006 Technical Memorandum 1. Estimation of Returns of Naturally Produced Coho to the Klamath River, dated November 2, 2006. Klamath Coho Integrated Modeling Framework Technical Memorandum Series. The memorandum was prepared by Cramer Fish Sciences for the Bureau of Reclamation. 25 pages.

Cramer Fish Sciences. 2007 Report. Klamath Coho Integrated Modeling Framework, Draft Version 1.1 Model Report. Prepared by: Cramer Fish Sciences/ Submitted to the Bureau of Reclamation, Klamath Basin Area Office, September 10, 2007. 44 pages.

Cramer Fish Sciences. 2007 Technical Memorandum 4. Juvenile coho emigration survival in the Klamath River, dated January 17, 2007. Klamath Coho Integrated Modeling Framework Technical Memorandum Series. The memorandum was prepared by Cramer Fish Sciences for the Bureau of Reclamation. 24 pages.

Cramer Fish Sciences. 2007 Technical Memorandum 5. Estimating the Capacity of the Klamath Basin to Rear Coho, dated April 30, 2007. Klamath Coho Integrated Modeling Framework Technical Memorandum Series. The memorandum was prepared by Cramer Fish Sciences for the Bureau of Reclamation. 28 pages.

Cramer Fish Sciences. 2007 Technical Memorandum 6. Disease Effects on Coho Survival in the Klamath River, dated April 20, 2007. Klamath Coho Integrated Modeling Framework Technical Memorandum Series. The memorandum was prepared by Cramer Fish Sciences for the Bureau of Reclamation. 75 pages.

Cramer Fish Sciences 2007 Technical Memorandum 7. Temperature and flow dynamics of the Klamath River, dated April 20, 2007. Klamath Coho Integrated Modeling Framework Technical Memorandum Series. The memorandum was prepared by Cramer Fish Sciences for the Bureau of Reclamation. 75 pages.

Cramer Fish Sciences 2007 Technical Memorandum 8. Simulation of the Life Cycle of Klamath Coho from Adult Entry to Summer Rearing, dated April 27, 2007. Klamath Coho Integrated Modeling Framework Technical Memorandum

Series. The memorandum was prepared by Cramer Fish Sciences for the Bureau of Reclamation. P. 30.

Cramer Fish Sciences 2007 Technical Response Brief 6. Response to Comments on Technical Memorandum 6: "Disease Effects on Coho Survival in the Klamath River" Klamath Coho Integrated Modeling Framework Technical Memorandum Series. Submitted to the Bureau of Reclamation Klamath Basin Area Office. Dated August 7, 2007. p. 12.

Cunningham, M. E., R. S. Shively, E. C. Janney, G. N. Blackwood. 2002. Monitoring of
Lost River and shortnose suckers in the lower Williamson River, 2001. In "Monitoring of Lost River and shortnose suckers in the Upper Klamath Basin, Oregon: Annual Report 2001." U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 135p.

Deas, Michael L. and G.T. Orlob. 1999. Klamath River Modeling Project. Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, Water Resources Modeling Group. University of California, Davis. Sponsored by the United States Fish and Wildlife Service, Klamath Basin Fisheries Task Force. December.

Deas, M., and J. Vaughn. 2006. Characterization of organic matter fate and transport in the Klamath River below Link Dam to assess treatment/reduction potential: Completion report. Watercourse Engineering Incorporated, Davis, California. Report prepared for the U.S. Department of the Interior, Bureau of Reclamation, Klamath Basin Area Office. 152p.

Desjardins, M. and D.F. Markle. 2000. Distribution and biology of suckers in Lower Klamath Reservoirs. 1999 Final report submitted to PacifiCorp, Portland, Oregon.

Donaldson, L. R., and G. H. Allen. 1958. Return of silver salmon, *Oncorhynchus kisutch* (Walbaum) to point of release. Trans. Am. Fish. Soc. 1957: 13-22

Dowling, T. 2005. Conservation genetics of endangered Lost River and shortnose suckers. Unpublished report for USFWS, Klamath Falls, OR. 14p.

Doyle, M.C., and D.D. Lynch. 2005. SOD in Lake Ewauna and the Klamath River, Oregon, June 2003: U.S. Geological Survey Scientific Investigations Report 2005-5228. 14 p.

Dunsmoor L.K. and C.W. Huntington. (2006). Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical memorandum to the Klamath Tribes. March 2006. 147 pp.

Dunsmoor, Larry. 2007. Senior Aquatics Biologist, Klamath Tribes, pers comm.

Dunsmoor, L. 1993. Laboratory studies of Fathead minnow predation on Catostomid larvae. Klamath Tribes research report KT-93-01. 16 pp.

Dunsmoor, L., L. Basdekas, B. Wood, and B. Peck. 2000. Quantity, composition, and distribution of emergent vegetation along the lower river and Upper Klamath Lake shorelines of the Williamson River delta, Oregon. 27p.

Eilers, J.M., J. Kann, J. Cornett, K. Moser, A. St. Amand, and C. Gubala. 2001. Recent paleolimnology of Upper Klamath Lake. J.C. Headwaters, Inc. Report submitted to U.S. Bureau of Reclamation. March 16, 2001.

Eilers, J.M., J. Kann, J. Cornett, K. Moser, and A. St. Amand. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, Hydrobiologia, 520: 7-18.

Ellsworth, C.M., T.J. Tyler, C.D. Luton, S.P. VanderKooi, and R.S. Shively. 2007. Spawning migration movements of Klamath largescale, Lost River, shortnose suckers in the Williamson and Sprague rivers, Oregon prior to the removal of Chiloquin Dam: Annual Report 2005. U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 42p.

Ellsworth, C.M., T.J. Tyler, S.P. VanderKooi, and D.F. Markle. In Review. Patterns of larval catostomid emigration from the Sprague and lower Williamson rivers of the Upper Klamath Basin, Oregon, prior to the removal of Chiloquin Dam: 2004-2005 Annual Report. Annual report of research to the U.S. Bureau of Reclamation.

Elton, C. 1931. Epidemics among sledge dogs in the Canadian Arctic and their relation to disease in the arctic fox. Canadian Journal of Research 5: 673–692.

Environmental Protection Agency (EPA), 1993. EPA Region 10 Guidance For Pacific Northwest State and Tribal Temperature Water Quality Standards. Region 10, Office of Water, EPA 910-B-03-002, April 2003. 57 pp.

Environmental Protection Agency (EPA), 2003. Quality Criteria for Water. Issued April 2003.

Esleroad, A. 2004. Williamson River delta restoration program vegetation technical report. The Nature Conservancy. 23p.

FERC. 2006. Draft Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, Oregon and

California. Dated September 2006. Office of Energy Projects, Division of Hydropower Licensing, 888 First Street, NE, Washington, DC 20426. p. 801.

Fish and Wildlife Service. See U.S. Fish and Wildlife Service

Fisher, L.H. and T.M. Wood. 2004. Effect of water-column pH on sediment-phosphorous release rates in Upper Klamath Lake, Oregon, 2001: U.S. Geological Survey Water-Resources Investigations Report 03-4271. 25p.

Fisher, L. E., J. G. Hartman, J. A. Howell, and D. E. Busch. 1981. A survey of wintering bald eagles and their habitat in the Lower Missouri Region, Denver, Colorado.

Fishpro. 2000. Fish passage conditions on the Klamath River. Submitted to the Karuk Tribe and PacifiCorp.

Foott, J.S. 2004. Health monitoring of adult Lost River Sucker (*Deltistes luxatus*) and Shortnose Sucker (*Chasmistes brevirostris*) in upper Klamath Lake, Oregon, April – September 2003. Joint FWS and USGS project. USFWS, California-Nevada Fish Health Center. 37p.

Foott, J. S., R. Harmon, and R. Stone. 2003. FY2002 Investigational report: *Ceratomyxosis* resistance in juvenile Chinook salmon and steelhead trout from the Klamath River. USFWS California-Nevada Fish Health Center, Anderson, California.

Foott, J. S., R. Harmon, and R. Stone. 2004. FY2003 Investigational report: Abundance of Ceratomyxa shasta in Iron Gate and Copco Reservoirs. USFWS California-Nevada Fish Health Center, Anderson, California.

Foott, J.S., and R. Stone. 2005. FY2004 report: Bio-energetic and histological evaluation of juvenile (0+) sucker fry from Upper Klamath Lake collected in August and September 2004. USFWS, California-Nevada Fish Health Center. 14p.

Forbes, M.G., J.J. Sartoris, and D. Sisneros. 1998. Selected water quality dynamics and horizontal zonation of water quality in Hanks Marsh: Technical memorandum 8220-98-11. U.S. Department of the Interior, Bureau of Reclamation, Denver Technical Service Center, Denver, Colorado.

Foster, K., and D. Bennetts. 2006. Link River Dam surface spill: 2005 pilot testing report. Bureau of Reclamation. 5p.

Furniss, M. J., T. D. Roelofs, and C. S. Yee. 1991. Road construction and maintenance. Pages 297- 323 in W.R. Meehan (ed.), Influences of Forest and Rangeland Management. American Fisheries Society Special Publication 19.

Gearheart, R.A., J.K. Anderson, M.G. Forbes, M. Osburn, and D. Oros. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon. Humboldt State University, Arcata, California.

Geological Survey. See U.S. Geological Survey

Geiger, N.S. 2001. Reassociating wetlands with Upper Klamath Lake to improve water quality. Paper presented at the Klamath Fish and Water Management Conference in Arcata, California, May 22-25, 2001.

Geiger, N.S., Gearheart, R., Henry, E., and Rueter, J. 2005. Preliminary Research on *Aphanizomenon flos-aquae* at Upper Klamath Lake, Oregon. Aquatic Scientific Resources, Portland, Oregon, Report prepared for the U.S. Department of the Interior, Fish and Wildlife Service, Klamath Basin Ecosystem Restoration Office, Project Number 20046-5.

Golden, M.P. 1969. The Lost River sucker. Oregon Game Commission Administrative report No. 1-69. 11 p.

Government Accountability Office, 2005. Klamath River Basin: Reclamation Met Its Water Bank Obligations, but Information Provided to Water Bank Stakeholders could be Improved (March 2005), GAO-05-283

Graham, S.A., C.B. Craft, P.V. McCormick, and A. Aldous. 2005. Forms and accumulation of soil P in natural and recently restored peatlands—Upper Klamath Lake, Oregon, USA. Wetlands 25(3): 594-606.

Guillen, G. 2003. Klamath River Fish Die-off, September 2002: Causative Factors of Mortality. US Fish and Wildlife Service. Report Number AFWOF-02-03. 128pp.

Gutermuth, B., C. Watson, and R. Weider. 1999. Link River hydroelectric project—Eastside and westside powerhouses annual entrainment study report (March 1997 - July 1998). New Earth Corp., Klamath Falls, Oregon.

Gutermuth, B., C. Watson, and J. Kelly. 2000. Link River hydroelectric project (Eastside and westside powerhouses) Final entrainment study report. Cell Tech, Klamath Falls, Oregon and PacifiCorp Environmental Services, Portland, Oregon.

Hardy, T.B. and R.C. Addley. 2001. Evaluation of interim instream flow needs in the Klamath River: Phase I - Volume I. Final Report. Prepared for: U.S. Department of Interior. Institute for Natural Systems Engineering, Utah State University, Logan, Utah. 53 pages plus appendices.

Hardy, T.B. and R.C. Addley, 2006 Evaluation of Instream Flow Needs in the Lower Klamath River Phase II Final Report. Prepared for: U.S. Department of the Interior. Pages 151 plus Volume II.

Hartman, G.F., and J.C. Scrivener. 1990. Impacts of forest practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Canadian Bulletin of Fisheries and Aquatic Sciences 223.

Hayes, B.S. and R. Shively. 2001. Monitoring of Lost River and shortnose suckers at shoreline spawning areas in Upper Klamath Lake, Oregon. USGS, BRD. Annual Report 2000.

Hayes, B.S., R.S. Shively, E.C. Janney, and G.N. Blackwood. 2002. Monitoring of Lost River and shortnose suckers at Upper Klamath Lake shoreline spawning areas in Upper Klamath Lake, Oregon. In "Monitoring of Lost River and shortnose suckers in the Upper Klamath Basin, Oregon: Annual Report 2001." U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 135p.

Hayes, B.S., E.C. Janney, and R.S. Shively. 2004. Monitoring of Lost River and shortnose suckers at Upper Klamath Lake shoreline spawning areas. In "Monitoring of adult Lost River suckers and shortnose suckers in Upper Klamath Lake and its tributaries, Oregon: Annual Report 2003." U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 121p.

Hecht, B., and G. R. Kamman. 1996. Initial Assessment of Pre- and Post-Klamath Project Hydrology on the Klamath River and Impacts of the Project on Instream Flows and Fishery Habitat. Balance Hydrologics, Inc. March 1996.

Hendrixson, H.A., S.M. Burdick, B.L. Herring, and S.P. VanderKooi. 2007a. Differential habitat use by juvenile suckers in Upper Klamath Lake, Oregon. In "Nearshore and offshore habitat use by endangered, juvenile Lost River and shortnose suckers in Upper Klamath Lake, Oregon: Annual Report 2004." USGS, Western Fisheries Research Center, Klamath Falls Field Station. 84p.

Hendrixson, H.A., S.M. Burdick, B.L. Herring, and S.P. VanderKooi. 2007b. Ecology of juvenile suckers in open waters of Upper Klamath Lake, Oregon. In "Nearshore and offshore habitat use by endangered, juvenile Lost River and shortnose suckers in Upper Klamath Lake, Oregon: Annual Report 2004." U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 84p.

Hendrixson, H.A., E.C. Janney, and R.S. Shively. 2004. Monitoring of Lost River and shortnose suckers at Upper Klamath Lake non-spawning locations. In "Monitoring of adult Lost River suckers and shortnose suckers in Upper Klamath

Lake and its tributaries, Oregon: Annual Report 2003." U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 121p.

Hicks, L.A., D.M. Mauser, J. Beckstrand, and D. Thomson. 2000. Ecology of Shortnose and Lost River suckers in Tule Lake National Wildlife Refuge, California, Progress report, April - November 1999. Klamath Basin National Wildlife Refuges, Tulelake, California. 39 p.

Howe, C.B. 1968. Ancient tribes of the Klamath country. Binfords and Mort, Portland, Oregon. 252 p.

Independent Multidisciplinary Science Team. (IMST) 2003. IMST review of the USFWS and NMFS 2001 Biological Opinions on management of the Klamath Reclamation Project and related reports. Technical Report 2003-1 to the Oregon plan for salmon and watershed enhancement board, Salem, OR. 115p.

Independent Scientific Review Panel (ISRP). 2005. The current risk of extinction of the Lost River and shortnose suckers. Cascade Quality Solutions, Natural Resource Mediation and Facilitation, Klamath Falls, Oregon. 230p.

Jacoby, J.M., D.D. Lynch, E.B. Welch, and M.A. Perkins. 1982. Internal phosphorus loading in a shallow eutrophic lake. Water Rec. 16: 911-919.

Janney, E.C., P.M. Barry, B.S. Hayes, R.S. Shively, and A. Scott. 2007. Demographic analysis of adult Lost River suckers and shortnose suckers in Upper Klamath Lake and its tributaries, Oregon: Annual Report 2006. U. S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 42p.

Janney, E.C., and R.S. Shively. 2007. U.S. Geological Survey administrative report: an updated analysis on the population dynamics of Lost River suckers and shortnose suckers in Upper Klamath Lake and its tributaries, Oregon. January 2007. U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 18p.

Kann, J. 1998. Ecology and water quality dynamics of a shallow hypereutrophic lake dominated by cyanobacteria. PhD. Dissertation. University of North Carolina, Chapel Hill. 110 p.

Kann, J. and V.H. Smith. 1993. Chlorophyll as a predictor of elevated pH in a hypertrophic lake: Estimating the probability of exceeding critical values for fish success. The Klamath Tribes Natural Resources Department Research Report: KT-93-02, Chiloquin, Oregon. 22 p.

Kann, J. and V.H. Smith. 1999. Estimating the probability of exceeding elevated pH values crtitical to fish populations in a hypereutrophic lake. Can. J. Aquati. Sci. 56: 2262-2270

Kann, J. and W.W. Walker. 1999. Nutrient and hydrologic loading to Upper Klamath Lake, Oregon, 1991-1998. Aquatic Ecosystems Sciences LLC, Ashland, Oregon. Report submitted to Klamath Tribes, Chiloquin, Oregon and the Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon. 114 p.

Laufle, J. C., G. B. Pauley, and M. F. Shepard. 1986. Species profiles. Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest): Coho salmon. U.S. Fish and Wildl. Serv. Biol. Rep. 82(11.48).

Lestelle, L.C. 2007. Coho Salmon (Oncorhynchus kisutch) Life History Patterns in the Pacific Northwest and California, March 2007). Biostream Environmental. Poulsbo, WA. Prepared for US Bureau of Reclamation, Klamath Area Office.

Leonard, W.P., H.A. Brown, L.L.C. Jones, K.R. McAllister, and R.M. Storm. 1993. Amphibians of Washington and Oregon. Oregon Fish & Wildlife Office 2002. `Published online by Herpetology Northwest Copyright 2003`

Licht, L.E. 1974. Survival of embryos, tadpoles, and adults of the frogs Rana aurora aurora and Rana pretiosa pretiosa sympatric in southwestern British Columbia. Canadian Journal of Zoology 52: 613-627.

Licht, L.E. 1974. Survival of embryos, tadpoles, and adults of the frogs Rana aurora aurora and Rana pretiosa pretiosa sympatric in southwestern British Columbia. Canadian Journal of Zoology 52: 613-627.

Lindley S., C. Legault, P. Mundy, J. Murphy, and R. Waples. 2006. NMFS Science Center Evaluation of the Peer Reviews of the Long-Term Central Valley Project and State Water Project Operations Section 7 Consultation. NOAA Tech. Memo.

Klamath River Basin Fisheries Task Force 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program (Jan. 1991), p. 1-6. Available at <http: //www.krisweb.com/biblio/gen_usfws_kierassoc_1991_lrp.pdf> on July 11, 2005.

Klamath Tribes 1995. Upper Klamath and Agency Lakes water quality assessment and inflow nutrient budget and endangered species restoration program support. Progress report. Natural Resources Department, Chiloquin, Oregon.

Klamath Tribes. 1996. A synopsis of the early life history and ecology of catostomids, with a focus on the Williamson River Delta. Unpublished manuscript. Natural Resources Department, Chiloquin, Oregon. 19 p.

Klamath Water Users Association (KWUA), 2003. Klamath Water Users perspective on functions of Klamath River dams, and consequences of dam removal
from KWUA Weekly Update of March 19, 2003. Accessed at http: //www.klamathbasincrisis.org/Poweranddamstoc/kwuadamremoval081404.htm on July 16, 2007.

Koch, D.L. and G.P. Contreras 1973. Preliminary survey of the fishes of the Lost River system including Lower Klamath Lake and Klamath Strait drain with special reference to the Shortnose (Chasmistes brevirostris) and Lost River suckers (Catostomus luxatus). Center for Water Resources Research, Desert Research Institute, University of Nevada, Reno, Nevada. 45 p.

Korson, Chuck, Chief, Water Quality Division, Bureau of Reclamation

Kuwabara, J.S., D.D. Lynch, B.R. Topping, F. Murphy, J.L. Carter, N.S. Simon, F. Parchaso, T.M. Wood, M.K. Lindenberg, K. Wiese, and R.J. Avanzino. 2007. Quantifying the benthic source of nutrients to the water column of Upper Klamath Lake, Oregon: U.S. Geological Survey Open File Report 2007-1276. 24 p.

LaMarche, J. 2001. Water Imports and Exports Between The Rogue and Upper Klamath Basin. Prepared for: Klamath Alternative Dispute Resolution Hydrology Steering Committee. Feburary 22, 2001. 7 pages

Ron Larson, USFWS, Klamath Falls Ecosystem Restoration Office, Fisheries Biologist. 2007, pers. comm.

Laenen, A., and A.P. LeTourneau. 1996. Upper Klamath basin nutrient-loading study —Estimate of wind-induced resuspension of bed sediment during periods of low lake elevation: U.S. Geological Survey Open-File Report 95-414. 11 p.

Leeseberg, C.A., P.M. Barry, G. Whisler, and E. Janney. 2007. Monitoring of Lost River (*Deltisies luxatus*) and shortnose (*Chasmistes brevirostris*) suckers in Gerber and Clear Lake reservoirs: Annual report 2004. U. S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 24p.

Loftus, M.E. 2001. Assessment of potential water quality stress to fish. Supplement to: Effects of water quality and lake level on the biology and habitat of selected fish species in Upper Klamath Lake. Report prepared for Bureau of Indian Affairs, Portland, OR.

Logan, D.J., and D.F. Markle. 1993. Fish faunal survey of Agency Lake and northern Upper Klamath Lake, Oregon. In C. Campbell (ed.) Environmental Research in the Klamath Basin, Oregon -1992 Annual report. Bureau of Reclamation Technical Report R-93-16. 341 p.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bull. Am. Meteorol. Soc. 78: 1069–1079.

Marine, K.R., and M. Gorman. 2005. Study report: Monitoring and evaluation of the A-canal fish screen and bypass facility. North State Resources, Inc. Redding, CA. Prepared for U.S. Bureau of Reclamation, Klamath Falls, OR. 20p.

Markle, D.F. 2007. Opinion on the effects of lake elevation management on year class formation in Upper Klamath Lake suckers. Communication dated 27 June 2007. 6p.
National Research Council (NRC). 2004. Endangered and threatened fishes in the Klamath River basin: Causes of decline and strategies for recovery. The National Academy Presses, Washington, D.C. 397p.

Markle, D.F., M.R. Cavalluzzi, T.E. Dowling and D. Simon. 2000 (Annual Report). Ecology of Upper Klamath Lake Shortnose and Lost River suckers: 4. The Klamath basin sucker species complex. Annual report: 1999. Oregon State University, Department of Fisheries and Wildlife, Corvallis and Arizona State University, Department of Zoology, Tempe, Arizona.

Markle, D.F., M. Cunningham, and D.C. Simon. 2000 (Sampling). Ecology of Upper Klamath Lake Shortnose and Lost River suckers—1. Adult and larval sampling in the Lower Williamson River, April-August 1999. Annual report: 1999. Oregon State University, Department of Fisheries and Wildlife, Corvallis, Oregon. 24 pp.

Markle, D.F., M.R. Cavalluzzi, and D. Simon. 2005. Morphology and taxonomy of Klamath Basin suckers (*Catostomidae*). Western North American Naturalist 65(4): 473-489.

Markle, D.F., and K. Clauson. 2006. Ontogenetic and habitat-related changes in diet of late larval and juvenile suckers (*Catostomidae*) in Upper Klamath Lake, Oregon. Western North American Naturalist 66(4): 492-501.

Markle, D.F., and M. Cooperman. 2002. Relationship between Lost River and shortnose sucker biology and management of Upper Klamath Lake. In: Water Allocation in the Klamath Reclamation Project, 2001: An Assessment of Natural Resource, Economic, Social and Institutional Issues in the Upper Klamath Basin. W.S. Braunworth, Jr., T. Welch and R. Hathaway (eds.). Oregon Sate University Extension Service, Corvallis, Oregon.

Markle, D.F., and L.K. Dunsmoor. 2007. Effects of habitat volume and fathead minnow introduction on larval survival of two endangered sucker species in Upper Klamath Lake. Transactions of the American Fisheries Society 136: 567-579.

Markle, D.F. and D.C. Simon. 1993. Preliminary studies of systematics and juvenile ecology of Upper Klamath Lake suckers. Annual report. Oregon State University. Department of Fisheries and Wildlife, Corvallis, Oregon. 129 p.

Markle, D.F. and D.C. Simon. 1994. Larval and juvenile ecology of Upper Klamath Lake suckers. Annual report. Oregon State University. Department of Fisheries and Wildlife, Corvallis, Oregon. 70 pp.

Markle, D.F., S.A. Reithel, J. Crandall, T. Wood, T.J. Tyler, M. Terwilliger, and D.C. Simon. 2007 (Juvenile). Larval fish retention, the role of marshes, and the importance of location for juvenile fish recruitment in Upper Klamath Lake, Oregon. Canadian Journal of Fisheries and Aquatic Sciences.

Martin, B.A. and M.K. Saiki. 1998. Effects of ambient water quality on the endangered Lost River sucker in Upper Klamath Lake, Oregon. Transactions of the American Fisheries Society 128: 953-961.

McAllister and Leonard 1997, Washington State Status Report for the Oregon Spotted Frog. Washington Department of Fish and Wildlife Wildlife Management Program

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42. 156 p.

McMahon, T.E., and L.B. Holtby. 1992. Behavior, habitat use, and movements of coho salmon smolts during seaward migration. Can. J. Fish. Aquat. Sci. 49: 1478-1485.

Meehan, W. R., editor. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Miller, R.R. and G.R. Smith. 1981. Distribution and evolution of Chasmistes (Pisces: *Catostomidae*) in Western North America. Occasional papers of the Museum of Zoology, University of Michigan, Ann Arbor. 696: 1-46.

Miller, W.E. and J.C. Tash. 1967. Upper Klamath Lake Studies, Oregon: Interim report. Pacific Northwest Water Laboratories, Federal Water Pollution Control Federation, Water Pollution Control Research Series No. WP-20-8. 37 p.

Morace, J.L. 2007. Relation between selected water-quality variables, climatic factors, and lake levels in Upper Klamath and Agency Lakes, Oregon, 1990-2006: U.S. Geological Survey Scientific Investigations Report 2007-5117. 54 p.

Moyle, P. B. 2002. Inland fishes of California. Berkeley, CA: University of California Press. 502p.

Mulligan, T.J., and H.L. Mulligan. 2007. Habitat utilization and life history patterns of fishes in Upper Klamath National Wildlife Refuge Marsh, Fourmile Creek and Odessa Creek, Oregon: Final Report June 2007. 259p.

National Academy of Science (NAS) 2004. National Academy of Science, National Research Council, 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. Washington, DC: 2004.

National Marine Fisheries Service (NMFS). 2000 VSP. Viable salmon populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42.

National Marine Fisheries Service (NMFS). 2001 Status Review. Status review update for coho salmon (*Oncorhynchus kisutch*) from the Central California Coast and the California portion of the Southern-Oregon/Northern California Coasts evolutionarily significant units. (Prepared by the Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, CA 95060.)

National Marine Fisheries Service (NMFS). 2002 Biological Opinion. Biological Opinion, Klamath Project Operations, dated May 31, 2002. 105 pages.

National Marine Fisheries Service (NMFS). 2005 Status Review. NOAA Technical Memorandum NMFS-NWFSC-66 Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead, dated June 2005. 512 pages plus appendices.

National Marine Fisheries Service (NMFS). 2006 Historical Populations. Historical Population Structure of Coho Salmon in the Southern Oregon/Northern California Coasts Evolutionarily Significant Unit. Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-390. 72 pages.

National Marine Fisheries Service (NMFS). 2007 Recovery Plan. Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan. Dated July 10, 2007. (Prepared by the Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, CA 95060.)

National Research Council (NRC). 2002. Scientific evaluation of biological opinions on endangered and threatened fishes in the Klamath River Basin: Interim report. 26 p.

National Research Council (NRC). 2004. Endangered and threatened fishes in the Klamath River Basin: causes of decline and strategies for recovery. National Academies Press. Washington, D.C. 397p.

North Coast Regional Water Quality Control Board (NCRWQCB). 1998. Transmittal letter for Clean Water Act Section 303(d) List of Water Quality Limited Waterbodies for California's North Coast Region. January 14, 1998.

Oregon Department of Environmental Quality (ODEQ). 1998. Oregon's final water quality limited streams - 303(d) list. Oregon Depart of Environmental Quality, Portland.

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake drainage total maximum daily load and water quality management plan. 188 p.

Oregon Natural Heritage Information Center (ORNHIC). 2007. *Astragalus applegatei* (Applegate's milk-vetch) relocation and status summary for 2007. Draft unpublished report submitted to Klamath Falls Fish and Wildlife Office.

Pacific Fishery Management Council (PFMC) 2003. Review of 2002 Ocean Salmon Fisheries, Published February 2007 Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Pacific Fishery Management Council (PFMC) 2004. Review of 2003 Ocean Salmon Fisheries, Published February 2007 Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Pacific Fishery Management Council (PFMC) 2005. Review of 2004 Ocean Salmon Fisheries, Published February 2007 Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Pacific Fishery Management Council (PFMC) 2006. Review of 2005 Ocean Salmon Fisheries, Published February 2007 Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

Pacific Fishery Management Council (PFMC) 2007. Review of 2006 Ocean Salmon Fisheries, Published February 2007 Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

PacifiCorp. 1997. Final report of fish trapping activities at Klamath hydroelectric project. Prepared by PacifiCorp Environmental Services. June 1997.

Parrish, R. 2007 (draft). 2006 Screwtrap monitoring report. USFWS, Klamath Basin Ecosystem Restoration Office. 5p.

Peck, B. 2000. Radio telemetry studies of adult Shortnose and Lost River suckers in Upper Klamath Lake and tributaries, Oregon. Unpublished report. Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon. 18 p.

Perdue, E.M., Lytle, C.R., and M.S. Sweet. 1981. The chemical and biological impact of Klamath Marsh on the Williamson River, Oregon: Project A-047-ORE. Oregon State University, Corvallis, Oregon, Water Resources Research Institute, WRRI-71.

Perkins, D.L. and G.G. Scoppettone. 1996. Spawning and migration of Lost River suckers (*Deltistes luxatus*) and Shortnose suckers (*Chasmistes brevirostris*) in the Clear Lake drainage, Modoc County, California. National Biological Service, California Science Center, Reno Field Station, Reno, Nevada. 52 p.

Perkins, D.L., G.G. Scoppettone, and M. Buettner. 2000 Biology. Reproductive biology and demographics of endangered Lost River and shortnose suckers in Upper Klamath Lake, Oregon. Report to the Bureau of Reclamation. October 2000. 40p.

Perkins, D.L., J. Kann, and G.G. Scoppettone. 2000 Water Quality. The role of poor water quality and fish kills in the decline of endangered Lost River and Shortnose suckers in Upper Klamath Lake. Final report. U.S. Geological Survey, Biological Resources Division, Western Fisheries Research Center, Reno Field Station, Reno, Nevada.

Phinney, H.K., C.A. Peek, and J.L. McLachlan. 1959. A survey of the phytoplankton problems in Klamath Lake: Report to the supporting agencies. Oregon State University, Department of Botany, Corvallis, Oregon. 52 p.

Piaskowski, R. and M. Buettner. 2003. Review of Water Quality and Fisheries Sampling Conducted in Gerber Reservoir, Oregon with Emphasis on the Shortnose Sucker and its Habitat Needs. Bureau of Reclamation. 90 p.

Powers, K., B Baldwin, E. Buck, and B. Cody, 2005. Klamath River Basin Issues and Activities: An Overview, dated September 22, 2005. Congressional Research Service Report for Congress. 39 pages. Available at <http: //www.energy.ca.gov/Klamath /documents/CRS_REPORT_RL33098.PDF>

Quigley, D. 2005. Scott River watershed adult coho spawning ground surveys: November 2004 – January 2005. Report prepared for USFWS and CDFG by the Siskiyou RCD. 148 pp.

Reclamation See Bureau of Reclamation

Reiser, D.W., M. Loftus, D. Chapman, E. Jeanes, and K. Oliver. 2001. Effects of water quality and lake level on the biology and habitat of selected fish species in Upper Klamath Lake. Prepared for the Bureau of Indian Affairs.

Reithel, S.A. 2006. Patterns of retention and vagrancy in larval Lost River and shortnose suckers from Upper Klamath Lake, Oregon. M.S. thesis, Oregon State University, Corvallis, OR. 73p.

Risley, J.C., and A. Laenen. 1999. Upper Klamath Lake basin nutrient-loading study-Assessment of historic flows in the Williamson and Sprague rivers: U.S. Geological Survey Water-Resources Investigations Report 98-4198. 22 p.

Rushton, K. 2007. CDFG, August 1, 2007, pers. comm.

Salmon and Steelhead Hatchery Assessment Group (SSHAG). 2003. Hatchery broodstock summaries and assessments for chum salmon, coho salmon, Chinook salmon, and steelhead stocks within evolutionarily significant units listed under the Endangered Species Act. 12 May 2003. National Marine Fisheries Service Northwest and Southwest Fisheries Science Centers. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Sanville, W.D., C.F. Powers, and A.R. Gahler. 1974. Sediments and sediment-water nutrient interchange in Upper Klamath Lake, Oregon. Report EPA-660/3-74-015. U.S. Environmental Protection Agency, Pacific Northwest Environmental Research Laboratory, National Environmental Research Center, Corvallis, Oregon. 45 p.

Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest," dated June 2004. <http: //inr.oregonstate.edu/reports_environment.html> Accessed June 9, 2007. The statement is signed by 50 Ph.D.-level scientists with expertise on the impacts of climate change in the Pacific Northwest. Names of the signatories appear within the document. 17 pp.

Scoppettone, G.G., S. Shea, and M.E. Buettner. 1995. Information on population dynamics and life history of shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*) in Tule and Clear Lakes. National Biological Service, Reno Field Station. 78 pp.

Scoppettone, G. C., and C. L. Vinyard 1991. Life history and management of four lacustrine suckers. Pages 369-387 in Minckley, W.L. and J.E. Deacon. Battle against extinction - native fish management in the American west. The University of Arizona Press, Tucson, Arizona.

Shively, R.S., M.F. Bautista, and A.E. Kohler. 2000 (Shoreline). Monitoring of Lost River and shortnose suckers at shoreline spawning areas in Upper Klamath

Lake, 1999. Completion report. U.S. Geological Survey, Biological Resources Division, Klamath Falls Duty Station, Klamath Falls, Oregon. 26 pp.

Shively, R.S., A.E. Kohler, B.J. Peck, M.A. Coen, and B.S. Hayes. 2000 (Subbasin). Water quality, benthic macroinvertebrate, and fish community monitoring in the Lost River sub-basin, Oregon and California, 1999. Annual Report 1999. USGS, Biological Resources Division, Klamath Falls, OR, and Bureau of Reclamation Klamath Falls, OR.

Simon, D.C., G.R. Hoff, and D.F. Markle. 1995. Larval and juvenile ecology of Upper Klamath Lake suckers. Annual report. Oregon State University, Department of Fisheries and Wildlife, Corvallis. 49 p.

Simon, D.C., G.R. Hoff, D.J. Logan, and D.F. Markle. 1996. Larval and juvenile ecology of Upper Klamath Lake suckers. Annual report: 1995. Oregon State University, Department of Fisheries and Wildlife, Corvallis, OR. 60 p.

Simon, D.C., and D.F. Markle. 1997. Larval and juvenile ecology of Upper Klamath Lake suckers, annual report: 1996. Department of fisheries and wildlife, Oregon State University, Corvallis, OR.

Simon, D.C. and D.F. Markle. 2001. Annual survey of abundance and distribution of age 0 shortnose and Lost River suckers in Upper Klamath Lake. Annual report. Oregon State University. Department of Fisheries and Wildlife, Corvallis, OR. 59 p.

Simon, D.C., and D.F. Markle. 2004. Larval and juvenile ecology of shortnose and Lost River suckers: data summaries of annual surveys of Upper Klamath Lake, 1995-2003. In Terwilliger, M.R., D.C. Simon, and D.F. Markle. 2004. Larval and juvenile ecology of Upper Klamath Lake suckers: 1998-2003. Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR. Final report to Bureau of Reclamation, Klamath Falls, OR, under contract HQ-97-RU-01584-09.

Simon, D.C., M.R. Terwilliger, P. Murtaugh, and D.F. Markle. 2000. Larval and juvenile ecology of Upper Klamath Lake suckers: 1995-1998. Final report. Oregon State University. Department of Fisheries and Wildlife. Corvallis, OR. 108 p.

Sinnen, W. 2002. Annual report: Trinity River basin salmon and steelhead monitoring project, 2001-2002 season. Task 3: Survival and spawner escapements made by coho salmon produced at the Trinity River Hatchery. 11 p.

Sinnen, W., M. Currier, M. Knechtle, and S. Borok. 2005. Trinity River Basin salmon and steelhead monitoring project, 2003-2004 season. California Department of Fish and Game, Redding, CA.

Sinnen., W., M. Currier, M. Knechtle, and S. Borok. 2006. Trinity River Basin Salmon and Steelhead Monitoring Project — 2004-05 Annual Report. CDFG.

Smith, O.R. 1939. Placer mining silt and its relation to salmon and trout on the Pacific Coast. Trans. Am. Fish. Soc. 69: 135-139.

Spindor, J. 1996. Yulalona. Unpublished report.

Snyder, D.T. and J.L. Morace. 1997. Nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath and Agency Lakes, Oregon: U.S. Geological Survey Water-Resources Investigations Report 97-4059. 67 p.

Sondergaard, M. 1988. Seasonal variations in the loosely sorbed phosphorus fraction of the sediment of a shallow and hypereutrophic lake. Environ. Geol. Water Sci. 11(1): 115-121.
Steenhof, K. 1976. The ecology of wintering bald eagles in southeastern South Dakota. M.S. Thesis. University of Missouri, Columbia, MO. 148 pp.
Stocking, R. W. and J. L. Bartholomew. 2007. Distribution and habitat characteristics of Manayunkia speciosa and infection prevalence with the parasite, Ceratomyxa shasta, in the Klamath River, OR-CA, USA. Journal of Parasitology 93: 78-88

Stocking RW, RA Holt, JS Foott, and JL Bartholomew. 2006. Spatial and temporal occurrence of the salmonid parasite Ceratomyxa shasta in the Oregon-California Klamath River Basin. Journal of Aquatic Animal Health 18: 194 – 202.

Sullivan, K., T. E. Lisle, C. A. Dolloff, G. E. Grant, and L. M. Reid. 1987. Stream channels: the link between forests and fishes. Pages 39-97 in Salo and Cundy (1987).

Sutton, R. 2004. Lost River fishery habitat survey. Reclamation Technical Memorandum. November 2004. 16p.

Sutton, R. 2007. Klamath River thermal refugia study, 2006. Technical Memorandum No. 86-68290-01-07. Bureau of Reclamation. U.S. Department of the Interior.

Sutton, R., and C. Morris. 2005. Instream flow assessment of sucker spawning habitat in Lost River upstream from Malone Reservoir. Reclamation Technical Memorandum. September 2005. 23p.

Sutton, R.J., S.K. Tanaka, M.L. Deas, T. Soto, and A. Corum. 2007. Salmonid observations at a Klamath River thermal refuge under various hydrological and meteorological conditions. River Research and Applications. 23: 775-785.

Terwilliger, M. 2006. Physical habitat requirements for Lost River and shortnose suckers in the Klamath Basin of Oregon and California: Literature review. 40p.

Terwilliger, M.R., D.C. Simon, and D.F. Markle. 2003. Larval and juvenile ecology of Upper Klamath Lake suckers: 1998-2003. Final report for contract HQ-97-RU-01584-09, submitted to U.S. Bureau of Reclamation, Klamath Falls, OR. 217p.

Terwilliger, M.R., D.C. Simon, and D.F. Markle. 2004. Larval and juvenile ecology of Upper Klamath Lake suckers: 1998-2003. Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR. Final report to Bureau of Reclamation, Klamath Falls, OR, under contract HQ-97-RU-01584-09.

Tranah, G.J., and B. May. 2006. Patterns of intra- and interspecies genetic diversity in Klamath River basin suckers. Transactions of the American Fisheries Society 135: 305-316.

Traxler, G. S., J. Richard, and T. E. McDonald. 1998. *Ichthyophthirius multifiliis* (Ich) epizootics in spawning sockeye salmon in British Columbia, Canada. J. Aqua. Animal Health 10: 143-151.

Trails.com, nd. Eagles Everywhere: Klamath Basin Bald Eagle Conference <http: //www.trails.com/tcatalog_trail.asp?trailid=XFA028-051> accessed October 17, 2007

Trihey and Associates. 1996. Instream Flow Requirements for Tribal Trust Species in the Klamath River. Prepared on behalf of the Yurok Tribe. March. 43 p.

Tyler, T.J., E.C. Janney, H. Hendrixson, and R.S. Shively. 2004. Monitoring of Lost River and shortnose suckers in the Lower Williamson River. In “Monitoring of adult Lost River suckers and shortnose suckers in Upper Klamath Lake and its tributaries, Oregon: Annual Report 2003.” U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 121p.

Tyler, T.J. 2007. Link River 2006 screw trap assessment. Bureau of Reclamation, Klamath Falls, OR. 12p.

Tyler, T.J., C.M. Ellsworth, S.P. VanderKooi, and R.S. Shively. 2007. Riverine movements of adult Lost River, shortnose, and Klamath largescale suckers in the Williamson and Sprague rivers, Oregon: Annual Report 2004. U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 29p.

U.S. Army Corps of Engineers (USACE). 1982. Upper Klamath Lake, Oregon water resources development project (Potential eutrophication control measures for Upper Klamath Lake, Oregon: data evaluation and experimental design): Contract No. DACW07-81-C-0045. Prepared by Entranco Engineers, Bellevue, Washington for U.S. Army Corps of Engineers, San Francisco District. 284 p.

U.S. Bureau of Land Management (BLM). 2000. Summary of Gerber tributary spawning success surveys, 1993-1999. Unpublished data. Klamath Falls Resource Area, Klamath Falls, Oregon.

Bureau of Reclamation, See Bureau of Reclamation

U.S. Fish and Wildlife Service, nd. Bald Eagle Viewing at the Klamath Basin Refuges <http: //www.fws.gov/klamathbasinrefuges/eagle.html> accessed October 17, 2007.

US Fish and Wildlife Service. 1983. Northern States Bald Eagle Recovery Plan. USFWS, Denver, Colorado. 120 pp.

U.S. Fish and Wildlife Service (USFWS). 1988. Endangered and threatened wildlife and plants: Determination of endangered status for the shortnose sucker and Lost River sucker. Federal Register, Vol. 53, No. 137: 27130-27134.

U.S. Fish and Wildlife Service (USFWS). 1993 (Sucker). Lost River and shortnose sucker recovery plan. Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 1993 (Milk-vetch). Endangered and Threatened wildlife and plants; determination of Endangered status for the plant *Astragalus applegatei* (Applegate's milk-vetch). U.S. Fish and Wildlife Service. Final rule. 5 pp.

U.S. Fish and Wildlife Service (USFWS). 1997. Klamath River (IGD to Seiad) Life History Periodicities for Chinook, Coho, and Steelhead. U.S. Fish and Wildlife Service, Coastal California Fish and Wildlife Office, Arcata, California. 45 pp.

U.S. Fish and Wildlife Service (USFWS). 1998. Recovery Plan for the Applegate's milk-vetch (*Astragalus applegatei*). 41 pp.

U.S. Fish and Wildlife Service (USFWS). 2001. Biological/conference opinion regarding the effects of operation of the Bureau of Reclamation 's Klamath Project on the endangered Lost River sucker (*Deltistes luxatus*) endangered shortnose sucker (*Chasmistes brevirostris*) threatened bald eagle (*Haliaeetus leucocephalus*) and proposed critical habitat for the Lost River/shortnose suckers. California/Nevada Operations Office, Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2002. Biological/Conference Opinion Regarding the effects of Operation of the Bureau of Reclamation's proposed 10 year operation for the Klamath Project and its effect on endangered Lost River sucker (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes breviorostris*), threatened bald eagle (*Haliaeetus leucocephalus*) and proposed critical habitat for the Lost River/shortnose suckers, May 2002. Klamath Falls, OR.

U.S. Fish and Wildlife Service (USFWS). 2003 (News Release). New U.S. Fish and Wildlife Service study says "combination of factors" caused salmon die-off in Klamath River in 2002. November 18, 2003. News Release and Questions and Answers: Klamath River Die-off 2003 Reports. <http: //www.fws.gov/sacramento/ea/News_Releases/ 2003%20News%20Releases/Klamath%20River%20new%20USFWS%20Salmon %20die-off%20study%202002%20.NR.htm>. Accessed on October 16, 2007:

U.S. Fish and Wildlife Service (USFWS). 2003 (Amendment). Amendment to 2002 Biological Opinion on the effects of the 10-year operations plan for the Klamath Project (FWS #1-10-02-F-121), as it relates to operation of Clear Lake and Gerber Reservoir. US Fish and Wildlife Service Memorandum #1-10-03-I-075, Klamath Falls, Oregon. 3p.

U.S. Fish and Wildlife Service (USFWS). 2003 (Opinion). Biological opinion and conference report on the effects of the Bureau of Reclamation's operation of Agency Lake Ranch water storage project during 2003 on endangered Lost River and shortnose suckers and their proposed critical habitat. February 25, 2003. Klamath Falls, Oregon.

U.S. Fish and Wildlife Service (USFWS). 2007 (LRS). Lost River sucker (*Deltistes luxatus*) 5-year review summary and evaluation. Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon. July 2007. 38p.

U.S. Fish and Wildlife Service (USFWS). 2007 (SNS). Shortnose sucker (*Chasmistes brevirostris*) 5-year review summary and evaluation. Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon. July 2007. 39p.

U.S. Fish and Wildlife Service (USFWS). 2007 (Spawning). 2006 sucker spawning in the lower Lost River, Oregon. U.S. Fish and Wildlife Service, Klamath Falls Fish and Wildlife Office. March 23, 2007. 18p.

U.S. Fish and Wildlife Service (USFWS). 2007 (Section 7). Formal Endangered Species Act (ESA), Section 7 consultation for the collection, examination, and treatment for pathogens and parasites of juvenile Lost River and shortnose suckers taken from Klamath County, Oregon (1-10-07-F-0090). Klamath Falls, Oregon. 16p.

U.S. Fish and Wildlife Service (USFWS). 2007 (Quarterly Report). U.S. Fish and Wildlife Service, Arcata Fish & Wildlife Office Fisheries Program, Quarterly

Accomplishment Report, Winter 2007. Accessed at http: //www.fws.gov/arcata/fisheries/ on July 9, 2007. 7 pages.

U.S. Fish and Wildlife Service (USFWS). 2007 (Opinion). Draft letter dated October 6, 2007 with attached draft biological opinion. Letter from the Yreka Fish and Wildlife Office 1829 South Oregon Street Yreka, California 96097 and addressed to Honorable Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission. p. 147.

U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 1998. The USFWS/NMFS Endangered Species Consultation Handbook (March, 1998)

United States Geological Survey (USGS) Bald eagle nest locations in Oregon. <http: //fresc.usgs.gov/bdpmetadata/fre00124.htm>. accessed October 17, 2007

VanderKooi, S. P., and K. A. Buelow. 2003. Near-shore habitat use by endangered juvenile suckers in Upper Klamath Lake, Oregon. Annual Report 2001. Report of U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station to U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Falls, OR.

VanderKooi, S. P., H. A. Hendrixson, B. L. Herring, and R. H. Coshow. 2006. Near-shore habitat use by endangered juvenile suckers in Upper Klamath Lake, Oregon. Annual Report 2002 – 2003. Report of U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station to U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Falls, OR.

Wahle, R. J., and R. E. Pearson. 1987. A listing of Pacific coast spawning streams and hatcheries producing Chinook and coho salmon with estimates on numbers of spawners and data on hatchery releases. U.S. Dept. of Commer. NOAA Tech. Memo. NMFS F/NWC-122.

Walker, W.W. 1995. A nutrient –balance model for Agency Lake, Oregon. Report prepared for the U.S. Department of Interior, Bureau of Reclamation, Denver, Colorado. 97 p.

Walker, W.W. 2001. Development of a phosphorus TMDL for Upper Klamath Lake, Oregon. Prepared for the Oregon Department of Environmental Quality. 81 p.

Watercourse Engineering, Inc. 2003. Klamath River Water Quality 2000 Monitoring Program.

Watercourse Engineering, Inc. 2007. E-mails to J. Hicks, Bureau of Reclamation, August 16, 2007 and August 21, 2007.

Watson, James W., Kelly R. McAllister, D. John Pierce (2003) Home Ranges, Movements, and Habitat Selection of Oregon Spotted Frogs (*Rana pretiosa*).

Weddell, B.J. 2000. Relationship between flows in the Klamath River and Lower Klamath Lake prior to 1910. Report for: USDOI, USFWS, Klamath Basin Refuges.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Dep. Commer., NOAA Tech Memo. NMFS-NWFSC-24, Northwest Fisheries Science Center, Seattle, Washington. 258 pages.

Welch, E.B. 1992. Ecological effects of wastewater: applied limnology and pollutant effects. 2nd. Edition. Chapman and Hall, New York, New York.

Welch, E.B. and T. Burke. 2001. Relationship between lake elevation and water quality in Upper Klamath Lake, Oregon: Interim summary report. R2 Consultants, Redmond, Washington, Report prepared for the Bureau of Indian Affairs. 126 p.

Wildung, R.E., R.L. Schmidt, and R.C. Routson. 1977. The phosphorus status of eutrophic lake sediments as related to changes in limnological conditions - phosphorus mineral components. J. Environ. Qual. 6(1): 100-104.

Wood, T.M., and R.T. Cheng. 2006. Use of UnTrim to investigate dissolved oxygen transport in Upper Klamath Lake, Oregon. Proceedings of the 7th International Conference on HydroScience and Engineering, USA. September 10-13, 2006.

Wood, T.M., G.J. Fuhrer, and J.L. Morace. 1996. Relation between selected water-quality variables, and lake level in Upper Klamath and Agency Lakes, Oregon: U.S. Geological Survey Water-Resources Investigations Report 96-4079. 57 p.

Wood, T.M., G.R. Hoilman, and M.K. Lindenberg. 2006. Water-quality conditions in Upper Klamath Lake, Oregon, 2002-04: U.S. Geological Survey Scientific Investigations Report 2006-5209. 52 p.

Yurok Tribal Fisheries Program. 2002. Data submitted 12 April 2002 by Dave Hellemeier, Yurok Fisheries Program Manager, to the National Marine Fisheries Service. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Ziller, J.S. 1985. Summary of sucker studies in Williamson and Sprague Rivers. Letter to C. Bienz, Klamath Tribes. 10 Oct. 1985. 5p.